SOIL & WATER CONSERVATION PRACTICES IN ARKANSAS COTTON – INTERACTIONS WITH CULTURAL CONTROL TACTICS IN IPM

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Abstract

Host plant resistance is the most important cultural control tactic used in integrated pest management (IPM) programs for cotton. It is an ideal management tactic for both disease and insect pests. Reduced tillage and/or use of winter cover crops can impact physical and chemical properties of soil affecting the overall cotton cropping environment. Resulting abiotic and biotic alterations may affect cultivar performance including host plant resistance and tolerance to attack by arthropod pests and disease-causing organisms. This field experiment was conducted in association with a long-term tillage study established in 2007 at the Judd Hill Foundation Research Farm in Northeast Arkansas to assess agronomic and environmental impacts of conservation tillage systems. In component studies in 2017, we evaluated performance of three cultivars in established no-till, cover crop/ low till, and conventional tillage systems, with and without protective foliar insecticides. Cultivars, selected based on maturity, yield potential, host plant resistance (HPR) ratings were Stoneville 5289 GLT, Stoneville 4946 GLB2, and Stoneville 5115 GLT, with moderately high, medium, and moderately low rankings for HPR to tarnished plant bug (*Lygus lineolaris* (Palisot de Beauvois)), respectively. These cultivars also had differential susceptibility rankings for Verticillium wilt, a vascular wilt disease caused by *Verticillium dahlia*. Extensive monitoring through the season included plant development, soil moisture, and insect pest densities; verticillium wilt disease ratings also were made. Rainfall was slightly below normal in 2017, and soil moisture monitoring results indicated increased infiltration after rain events in no-till compared to other tillage systems. There was no supplemental irrigation. Insect pest pressure was low season long, and applications of preventive insecticide applications had no impact on earliness, yield, or fiber quality. Verticillium wilt disease pressure was unusually high in 2017, and disease was the dominant factor affecting productivity. Verticillium wilt symptoms became apparent during the effective flowering and boll maturation growth stages. There were significant cultivar (P=0.001) and tillage*cultivar ((P=0.02) differences in late season wilt ratings made at 99 days after planting. Highest disease ratings were recorded for ST 4946. Other cultivars had increased disease in no-till and cover crop systems compared to conventional tillage. For lint yield assessments, there were significant differences among cultivars (P=0.01), and there was a tillage*cultivar interaction (P=0.02). Highest lint yields were associated with conventional tillage practices and the cultivars ST 5289 and ST 5115. Cultivar ST 4946 uniformly had lowest yields in all tillage systems. Fiber quality parameters generally were reduced in plots with highest incidence of disease. Fieldprint calculator results indicate improved sustainability rankings for no-till compared to cover crop and conventional tillage treatments.

Introduction

Cultural controls in pest management are agronomic practices to reduce pest abundance and damage below that which would have occurred if the practice had not been used. Host plant resistance (HPR) is one of several cultural control methods used in integrated pest management (IPM) programs for pest arthropods and pathogens. Use of HPR tactics with cultivars that are adapted to a particular production region should be considered a cornerstone in any IPM strategy for cotton (Lincoln et al. 1975, Luttrell et al 2015). The approach is both economically efficient and environmentally sound.

When cotton producers adopt soil and water conservation practices, complex changes in the crop environment arise. Soil and air temperatures will be impacted. Plants may have greater protection from blowing sand and wind. Soil chemical and physical properties affecting nutrient and soil moisture availability will vary. Plant rooting capacity may improve. Changes in the crop environment also affect pest and pathogen abundance. These complex abiotic and biotic interactions can affect cultivar performance including host plant resistance and tolerance to attack by arthropod pests and disease-causing organisms.

The objective in this 2017 experiment was to quantify cultivar performance in three tillage systems. We selected three cultivars that had been identified as having a range of HPR properties (Bourland et al., 2016). Cultivars were grown in no-till, cover crop/ low till, and conventional tillage systems with and without protective insecticide sprays. We hypothesized that growing conditions could impact plant resilience to stress including resistance and tolerance to feeding injury by insect pests. Unexpectedly, plant disease became an important factor in 2017, so we made in-season adjustments and included assessments for Verticillium wilt.

Materials and Methods

The small plot study was conducted on Judd Hill Foundation Research Farm near Trumann, Arkansas in a long term tillage trial. The experiment was a split-split-plot design, 3*3*2 factorial (tillage*protection*cultivar), with 3 replications. Main plots extended the length of the field, 450 feet, and were 16 rows wide with 38-inch row spacing. Soil was classified as Dundee silt loam.

Tillage main plots were: 1) conventional, 2) terminated winter wheat cover crop with reduced tillage, and 3) no-till. The tillage treatments were established in **fall 2007** and had been maintained continuously since that time. Cultivar sub-plots were randomized within main plots and were 120 feet long, separated by 10 feet alleys. Cultivars were 1) ST 5289 GLT, 2) ST 4946 GLB2, and 3) ST 5115GLT with high, medium, and low rankings for HPR to tarnished plant bug, respectively. Insect pest protection sub-sub-plots 1) un-sprayed check 2) protectant (automatic) insecticide for tarnished plant bug. Sub-sub plots were 120 ft long, 8 rows wide. Pest and plant monitoring activities were limited to rows 3&4 and with rows 5&6 used for harvest. Rankings for HPR were based on results reported in the Arkansas Cotton Variety Tests (Bourland et 10 2016).

Tillage practices in the conventional and cover crop treatments in fall 2016 consisted of using disk bedders to re-form beds after stalks were shredded following the previous season's cotton crop. Wheat was broadcast planted at 10 lb seed/ac in the cover crop treatment main plots in mid-October. After seeding, a field cultivator (do-all) was used to smooth the tops of beds in the cover crop treatment. In April and May 2017, broadcast applications of the herbicides glyphosate/paraquat were made across the entire experiment to "burndown" winter weeds and terminate the winter cover crop. In-season production practices were similar across all tillage treatments with the following exceptions used only in conventional tillage treatment: disk bedders were used to re-form beds and tops of beds were flattened with a field cultivator just prior to planting. There was no further tillage. Cotton was seeded using a no-till planter on 16 May, and planter settings were adjusted for each tillage treatment to ensure uniform seed depth and good soil-seed contact. Seeding rate was set at 3 seed/ft and was similar across all tillage treatments. Additional production details are listed in Table 1.

Table 1. Production details including dates of planting and harvest and application dates for insecticide, plant growth regulator, and harvest aid compounds--2017, Judd Hill, AR.

Operation	Date	Days After Planting
Date of planting	16 May	
Insecticide	12, 25 July (1.75 and 2.5 oz/ac Transform WG)	57, 70
Irrigation	none	
Mepiquat chloride	29 June, 19 & 26 July	44, 57, 70
Defoliation/boll opener	19 & 27 September	126, 134
Harvest	16 October	154

The study included monitoring of soil environment, insect pest, and plant development. Soil temperatures in early season were monitored in the three tillage systems using WatchDog B100 temperature loggers (Spectrum Technologies, Aurora, IL). The sensors were located on top of the bed, one at the soil surface with a radiation shield and at depths of 2 and 5 inches below the soil surface. Measurements were made in each main-plot across 3 replications from 14 days before planting to 46 days after planting (DAP).

Soil Moisture was monitored using Watermark Sensors (Irrometer, Riverside, CA) and Irrometer dataloggers. Soil moisture sensing stations were installed in each of the tillage treatments in two sites per main plot in one replication. For each station, there were two watermarks placed depths of 6 and 12 inches below the soil surface between plants in the top of the bed.

Early season plant monitoring included evaluations of plant stand density made 7, 15, and 26 DAP by counting the emerged plants in 3 feet of row in two transects across 8 rows of each sub-plot. First fruiting node was recorded for 10 consecutive plants in the center rows at three sites across tillage main plots on 15 June (40 DAP). In-season plant monitoring was initiated during squaring node development. Standard COTMAN Squaremap sampling protocols included counts of number of main stem squaring nodes, first position square and boll retention and plant height (Oosterhuis and Bourland, 2008). In weekly sampling, scouts inspected two sets of 5 consecutive plants located on adjacent rows in designated rows in the center portion of sub-plots. By the second week of flowering, scouts also began recording nodes above white flower (NAWF). Ten plants with first position white flowers were selected in the two sample rows weekly, and numbers of main stem squaring nodes determined. Days from planting to physiological cutout (mean NAWF = 5) calculations were derived from standard output of the COTMAN software. End-of-season final plant mapping was performed after defoliation using the COTMAP procedure on 5 consecutive plants in two adjacent rows (Bourland & Watson, 1990).

Insect pest monitoring included evaluations of thrips (*Frankliniella* spp) abundance in early season followed by weekly assessments for tarnished plant bug (*Lygus lineolaris*) during squaring node development through effective flowering. For thrips sampling, ten whole plants were collected on 12 June (27 DAP) from each tillage main plot. Plants were carefully placed in plastic collection bags in ice chests and transported back to the laboratory for alcohol wash. In the lab, the alcohol wash solution was filtered, and numbers of thrips larvae and adults were counted under a dissecting microscope. For plant bug sampling, drop cloths were used weekly to sample 1.5 feet on 2 adjacent rows in each plot for a total of 3 feet of row per drop cloth sample.

Yield determinations were made using a 2-row research cotton picker in designated harvest rows (to avoid confounding effects from thigmonasty, plants in these rows were not avoided by scouts during the in-season sampling). For fiber quality evaluations, 40 bolls were hand-picked from consecutive plants on consecutive fruiting sites from harvest rows in each treatment plot. Samples ginned with laboratory gin, and sent for HVI fiber quality analysis at the Fiber and Biopolymer Research Institute at Texas Tech University. Data were analyzed using PROC MIXED (SAS, Cary, NC). Sustainability assessments were completed using the Fieldprint Calculator (https://calculator.fieldtomarket.org/fieldprint-calculator/). Output from the tool was used to summarize sustainability metrics associated with the changes in soil conservation practices.

Results and Discussion

The 2017 season was characterized by below average rainfall in June and July and higher than average rainfall amounts in August (Table 2). Soil temperature monitoring results showed lower mean soil temperature for the soil surface for conventional tillage compared to cover crop and no-till treatments. Temperatures recorded by the sensors buried at 2 and 5-inch depths showed higher temperatures for no-till compared and cover crop compared to the conventional tillage treatments. Differences likely were related to insulating properties of residue on the soil surface (dried vegetation) associated with cover crop and no-till systems compared to relatively clean soil surface of the conventional system. Temperature differences among tillage systems were apparent when cumulative DD60s for each treatment were plotted against time (Figure 1).

Table 2. Monthly precipitation (inches) measured at the study site for the 2017 season compared with 30 year average for the county.			
Month	30 year Average	2017 Rainfall	Departure
	----------------------inches----------------------		
May	5.37	3.36	-0.14
June	3.99	2.90	-2.17
July	4.04	2.97	-3.08
August	2.36	4.86	2.48
Total	15.76	14.09	-1.67

Plant stand density was at agronomically acceptable levels in all treatments; however, it did vary among cultivar and tillage treatments. We observed reduced stand density in the no-till and cover crop compared to conventional system (*P*=0.001) (Figure 2). Despite use of a no-till planter, the unevenness of no-till beds and cover crop residue likely reduced soil-seed contact which contributed to the reduced plant stand densities. Higher stand counts were also observed in ST 4946 compared to either ST 5289 or ST 5115 (*P*=0.001).

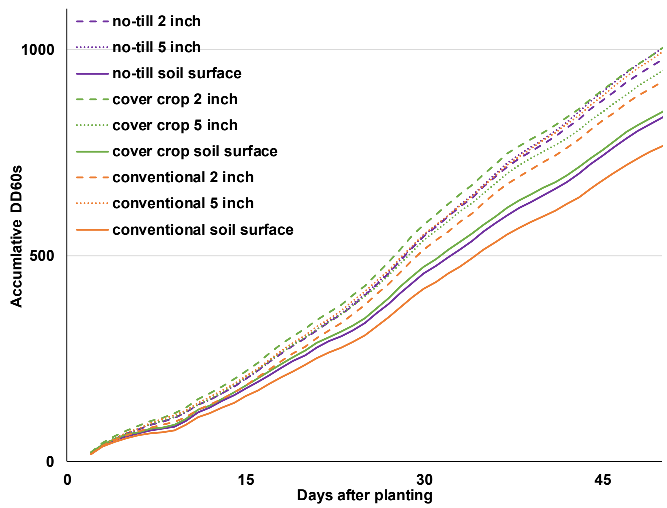

Figure 1. Cumulative DD60s measured with soil temperature sensors positioned at soil surface (enclosed in radiation shield) and 2 and 5 inches below soil surface for conventional, cover crop, and no-till tillage systems--2017, Judd Hill, AR.

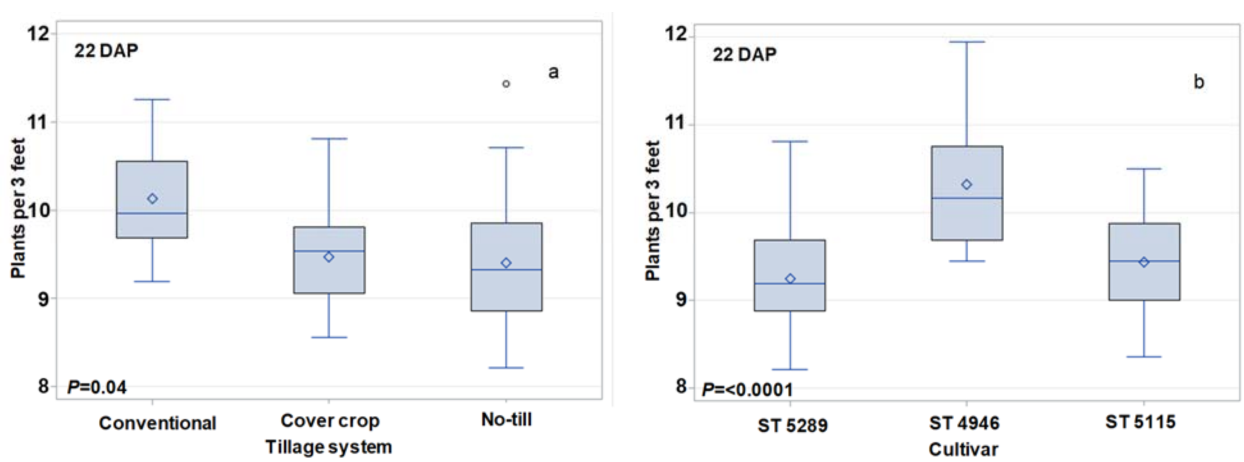

Figure 2. Plant stand density for tillage (a) and cultivar (b) treatments determined 7 June (22 DAP). Boxes represent 50% quartile; diamonds within the box depict means, and the line is the median value--2017, Judd Hill, AR.

COTMAN growth curves prior to 50 DAP show the rate of squaring node development followed the standard target development curve (TDC) (Figure 3). The standard curve shows main stem squaring nodes through a season, ascending at a pace of one node each 2.7 days through first flower, expected by 60 days after planting. The rate of squaring node development after first flower declines in response to an increasing boll load until physiological cutout. This post-flower decline in terminal growth is measured as NAWF (nodes above white flower). In our 2017 study, rainfall was limited between 52 and 85 DAP. With no supplemental irrigation, effects of increasing water deficits became apparent by the 3rd week of squaring with slowing of squaring node development and lower than optimal main-stem sympodial development by first flowers which were observed in sampling at 64 DAP. Values for nodes above white flower (NAWF) declined rapidly for cultivar ST 4946 in all tillage systems and for ST5289 and ST5115 in the conventional tillage. Physiological cutout, defined as the flowering date of the last effective boll population, was recorded when the sampled plant population reached an average of NAWF = 5 (Oosterhuis and Bourland 2008).

Days to cutout values typically are related to cultivar (e.g. long season vs short season), growing conditions (e.g. shortened with water deficits) and/or boll loading stress. Loss of fruiting forms (e.g. square sheds associated with pre-flower insect feeding or small boll sheds associated with physiological factors) will result in reduced boll loading stress which can result in delayed maturity. Square sheds were low for all varieties and tillage systems for the 2017 season (Figure 4). Small boll shed reflected patterns associated with boll loading stress leading to physiological cutout (Figure 5). Cutout was delayed for ST5289 and ST5115 in no-till and cover crop systems. These maturity differences are apparent when comparing mean no. days from planting to physiological cutout (NAWF=5) for cultivars and tillage systems (Table 3).

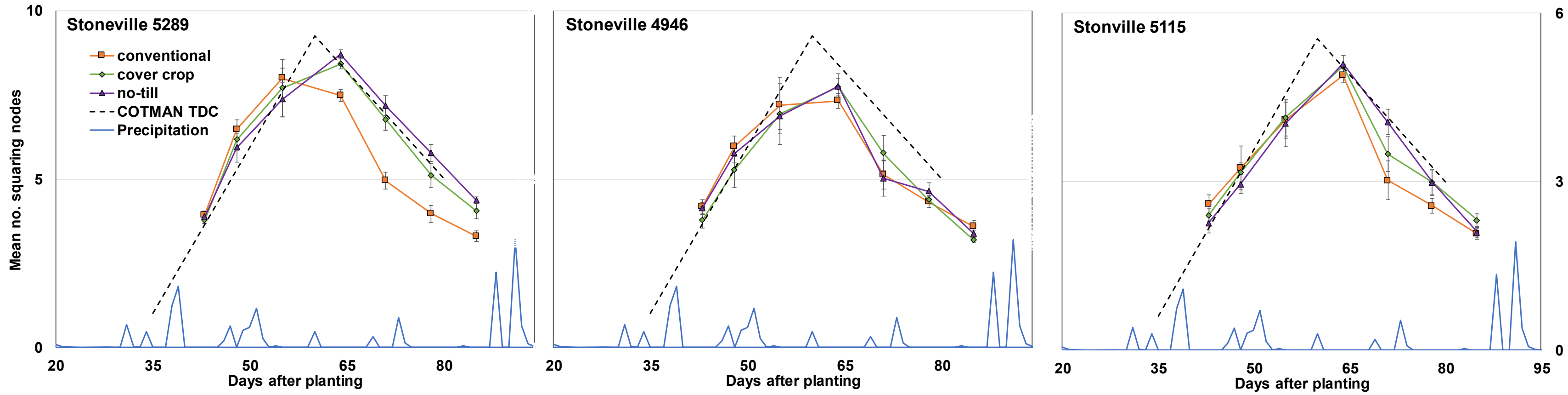

Figure 3. COTMAN growth curves for the three cultivars in each tillage system treatment; daily precipitation during the growing season is also shown --2017, Judd Hill, AR.

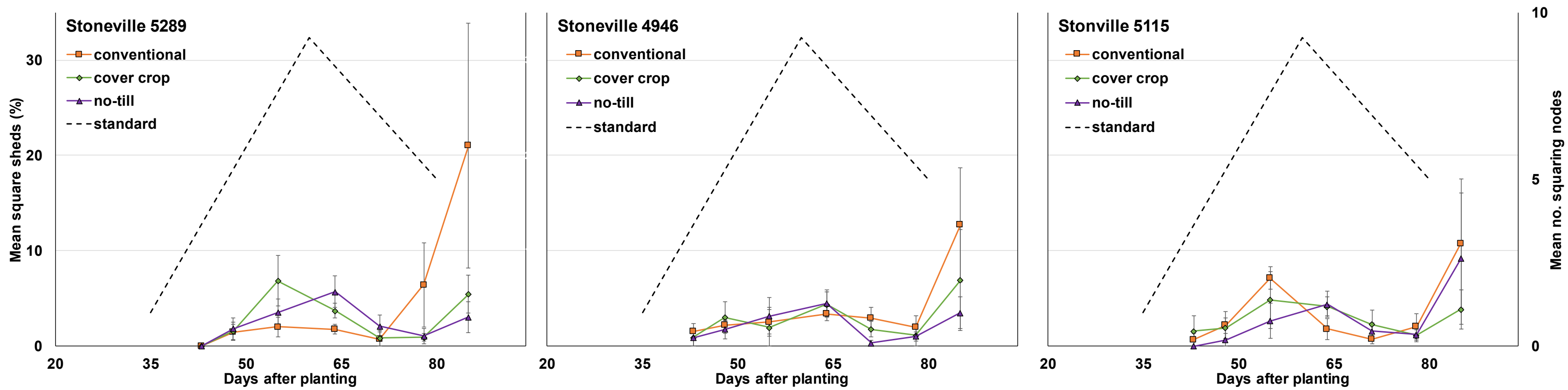

Figure 4. Mean (±SEM) first position square shed (%) for cultivars grown in three tillage systems; the COTMAN growth curve (mean no. squaring nodes) is shown for reference - 2017, Judd Hill, AR.

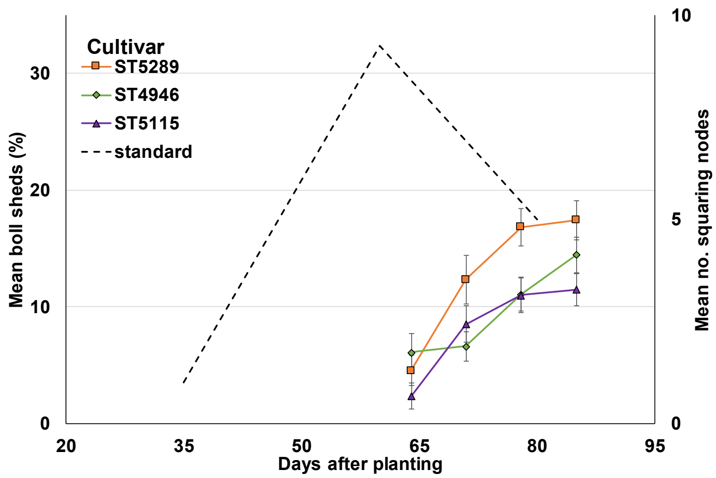

Figure 5. Mean (±SEM) first position small boll shed (uppermost 3 main-stem boll nodes) among three cultivars in 2017, Judd Hill, AR.

Table 3. Mean no. days from planting to physiological cutout (NAWF=5) for the three cultivars in insecticide untreated or treated tillage treatments[1]—2017, Judd Hill, AR.

Tillage System	ST 5289	ST 4946	ST 5115
Conventional	76	76	73
Cover Crop	80	78	79
No-till	84	78	79

[1]Cultivar effect was significant (*P*=0.02); there were no significant interactions.

Readings from Watermark sensors positioned at 6 and 12 inches below the soil surface generally showed adequate soil moisture through the first 2 weeks of squaring. A prolonged drying period followed, resulting in soil water deficits above 60 centibars across all tillage systems during the effective flowering period (Figure 6). There was a 0.53-inch rain event at 72 DAP, and by that time, reference ET_0 deficits exceeded 4.5 inches. That rain event was apparent in Watermark sensor measurements at both the 6 and 12-inch depths in the no-till treatment; however response was not apparent in sensor readings in the conventional tillage system, and it registered only at the 6-inch depth in the cover crop treatment. We interpret these measurements as an indication of increased infiltration in the no-till compared to the other tillage systems. Similar observations on reduced infiltration due to soil sealing in conventional and cover crop treatments compared to no-till have been noted in previous years in this long term study (Mann et al 2017).

Tillage and cultivar selection did not affect abundance of either plant bugs or thrips in 2017. Thrips infestation levels did not exceed the action threshold (data not shown), and no foliar insecticides were applied for thrips infestations other than at-planting seed treatments (Aeris-treated seed). Tarnished plant bug numbers were below the action levels throughout the season (Figure 7). Extension recommendations in pre-cutout cotton suggest an action threshold of a field average of 3 tarnished plant bugs per drop cloth sample (5 ft of row). Following cutout, the action threshold increases to 6 plant bugs per sample (Studebaker 2016). Automatic applications of insecticides for tarnished plant bug had no apparent negative effect on other secondary pests such as spider mites or caterpillar pests.

Verticillium wilt disease pressure was unusually high in 2017. Symptoms of widespread incidence of Verticillium wilt became apparent by the third week of flowering. Results from disease assessments made at 99 DAP (maturity at this date ranged from 301 to 699 DD60s after NAWF=5) indicated significantly (*P*=0.001) higher %wilt observed with the ST 4946 compared to other cultivars (Table 4). There also was a significant tillage*cultivar ((*P*=0.02) effect. Overall, lowest disease ratings were associated with conventionally grown ST5289 and ST 5115; however, these cultivars had increased incidence of disease in no-till and cover crop systems.

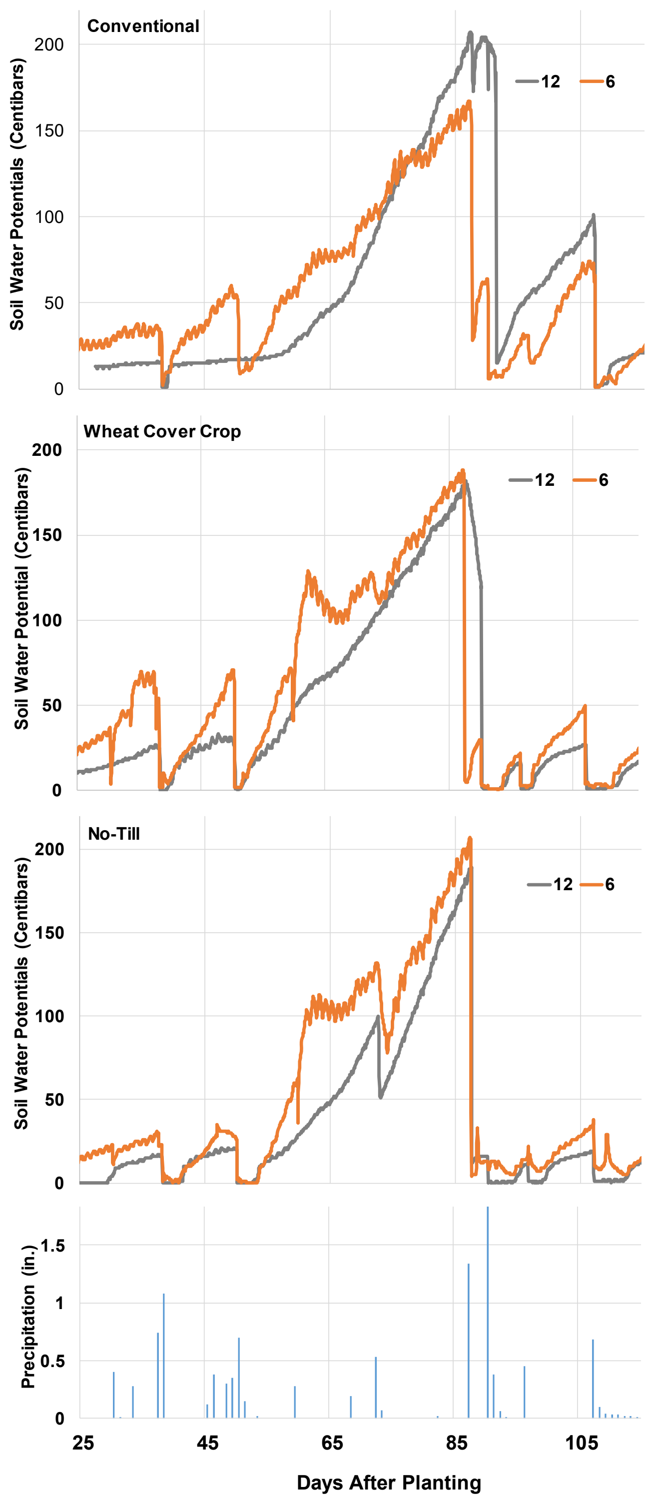

Figure 6. Soil moisture monitoring results from Watermark sensors positioned at two depths (6 and 12 inches) between plants in the top and center of each bed in the no-till, cover crop, and conventional tillage main plots. Precipitation also is shown--2017, Judd Hill, AR.

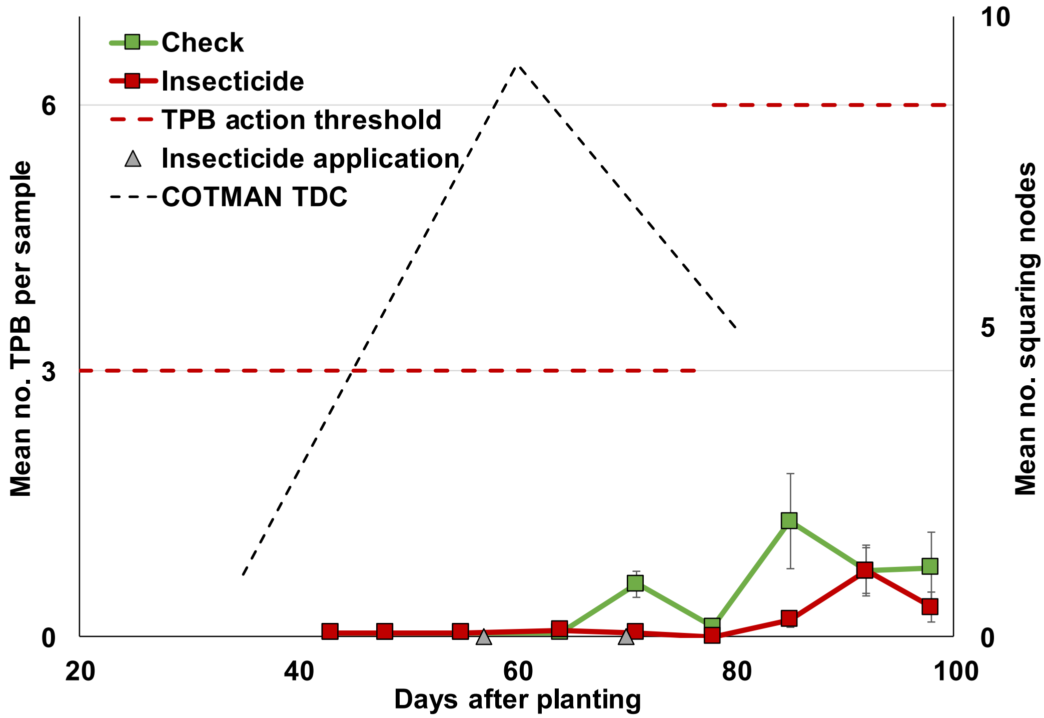

Figure 7. Mean no. tarnished plant bugs (± SEM) through the season in sprayed (=protected with insecticide) and unsprayed treatment plots. Pest densities never exceeded action thresholds in 2017.

Table 4.Verticillium wilt ratings made at 99 DAP (23 Aug) – mean % wilt for the three cultivars in tillage treatments.

Cultivar	Conventional	Wheat CC	No-Till
ST 5289 GLT	11.0	27.4	31.8
ST 4946 GLB2	71.9	59.3	45.8
ST 5115 GLT	36.6	58.3	44.6
Significant cultivar and tillage*cultivar interactions (*P*=0.01).			

Results from final, end-of-season plant mapping using COTMAP sampling indicated significant differences among cultivars in measures of final plant structure, boll retention and boll distribution (Table 5). These structural differences were likely related to Verticillium wilt effects. There were no differences in mean first main-stem sympodial node (first fruiting node) associated with tillage treatment; however, ST 5289 produced squares earlier than compared to ST 4946 and ST 6182 (*P*=0.01). Cultivar ST 4946 produced fewest total sympodia, effective sympodia,and sympodia with at least two positions. Highest early boll retention (lowest 5 mainstem sympodia, 1st & 2nd positions) was observed in the conventional tillage system (*P*=0.05), but there was a significant tillage *cultivar interaction (*P*=0.02). There were no significant insecticide spray effects (*P*=0.29). (Figure 8).

Table 5. Results from final, end-of-season plant mapping using COTMAP; cultivar sub-plots-- 2017, Judd Hill, AR.

	Mean[1] per plant for Cultivar effects				
Category	ST 5289	ST 4946	ST 5115	*P>F*	*LSD$_{05}$*
1st main-stem sympodial node	5.8	6.3	6.5	*0.01*	*0.3*
No. of monopodia	1.1	1.1	1.7	*0.001*	*0.2*
Highest sympodia with 2 positions	12.8	9.8	10.4	*0.001*	*1.1*
Plant Height (inches)	32.5	32.0	34.3	*0.05*	*1.9*
No. of effective sympodia	8.5	6.7	7.4	*0.02*	*0.8*
No. of sympodia	15.7	12.6	12.9	*0.001*	*1.1*
Total bolls/plant	8.3	6.8	8.4	*0.002*	*0.7*
% Total bolls in 1st position	73.3	77.8	70.7	*0.005*	*4.1*
% Total bolls in 2nd position	15.6	12.2	19.3	*0.001*	*3.2*

% Total bolls in outer position	0.0	0.1	0.0	*0.43*	
% Total bolls on monopodia	3.3	3.4	5.5	*0.23*	
% Total bolls on extra – axillary	7.9	6.5	4.6	*0.05*	*2.6*
% Boll retention - 1st position	39.1	42.1	45.8	*0.003*	*3.5*
% Boll retention - 2nd position	10.5	8.4	15.6	*0.001*	*2.7*
% Early boll retention	45.0	45.9	50.8	*0.005*	*3.6*
Total nodes/plant	20.4	17.8	18.4	*0.001*	*1.1*
Internode length (inches)	1.6	1.8	1.9	*0.001*	*0.09*

[1]means of 10 plants per plot.

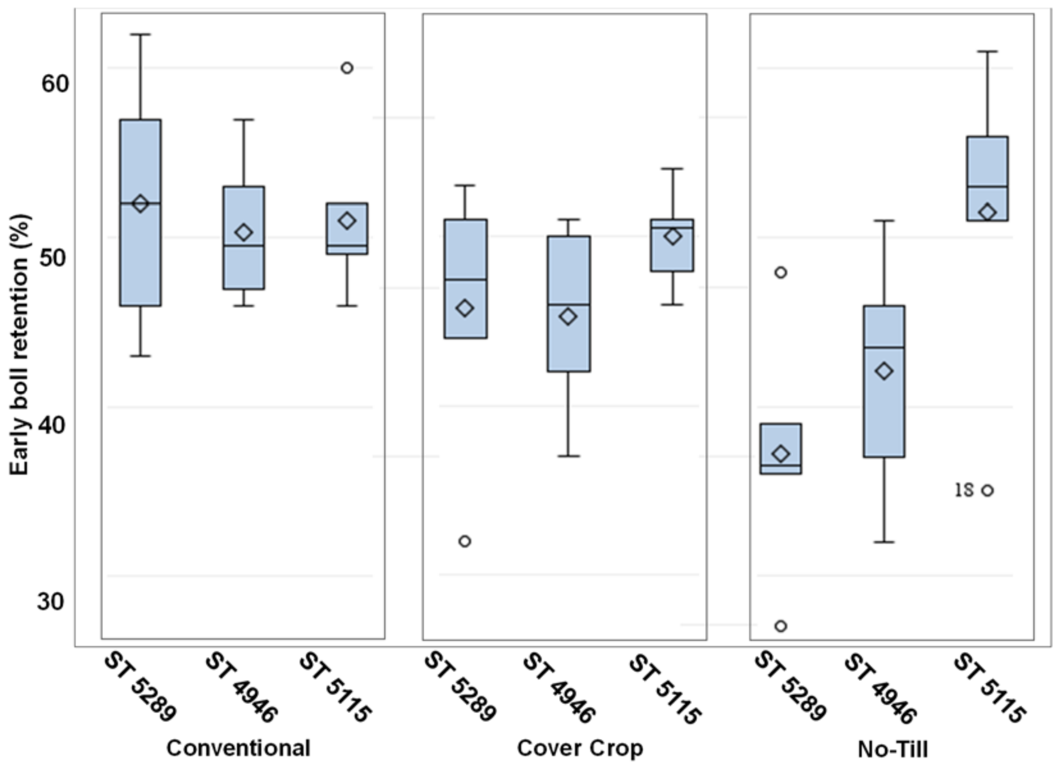

Figure 8. Results from final, end-of-season plant mapping with COTMAP for early boll retention (% retention of first and second position bolls in the lowest 5 mainstem sympodia) indicate significant cultivar*tillage interactions with highest overall retention in the conventional tillage system (P=0.001). Boxes represent 50% quartile; diamonds depict means, and the line is the median value.

Yields were influenced by cultivar (P=0.01), but there were no significant tillage (P=0.17) or insecticide spray effects (P=0.78). There was a significant tillage*cultivar interaction (P=0.002) (Figure 9). Highest yields were observed using conventional tillage practices with cultivars ST 4946 and ST 5115. The cultivar with the highest Verticillium wilt ratings, ST 4946, produced lowest lint yield; yield was negatively correlated with Verticillium wilt ratings [r = -0.41, n =53, P=0.002] (PROC Corr, SAS 9. 4, Cary, NC).

For yield components, weight per boll calculations based on 40-boll collections indicated a significant tillage effect (P=0.01) with highest weight per boll associated with conventional tillage (Figure 10). Mean weight for conventional, cover crop and no-till tillage treatments were 4.64 g, 4.04g and 3.99g, respectively. There were no significant differences among cultivars or insecticide sprays. Results from HVI fiber quality assessments indicated significant differences in micronaire, uniformity, strength and elongation among cultivars (Table 6).

Sustainability indices for tillage treatments were generated using the Field Print Calculator (Figure 11). Indices for the tillage practices showed significant improvement on soil conservation and water quality with cover crop and no-till compared to conventional tillage. No-till also showed an additional benefit with enhanced soil carbon index.

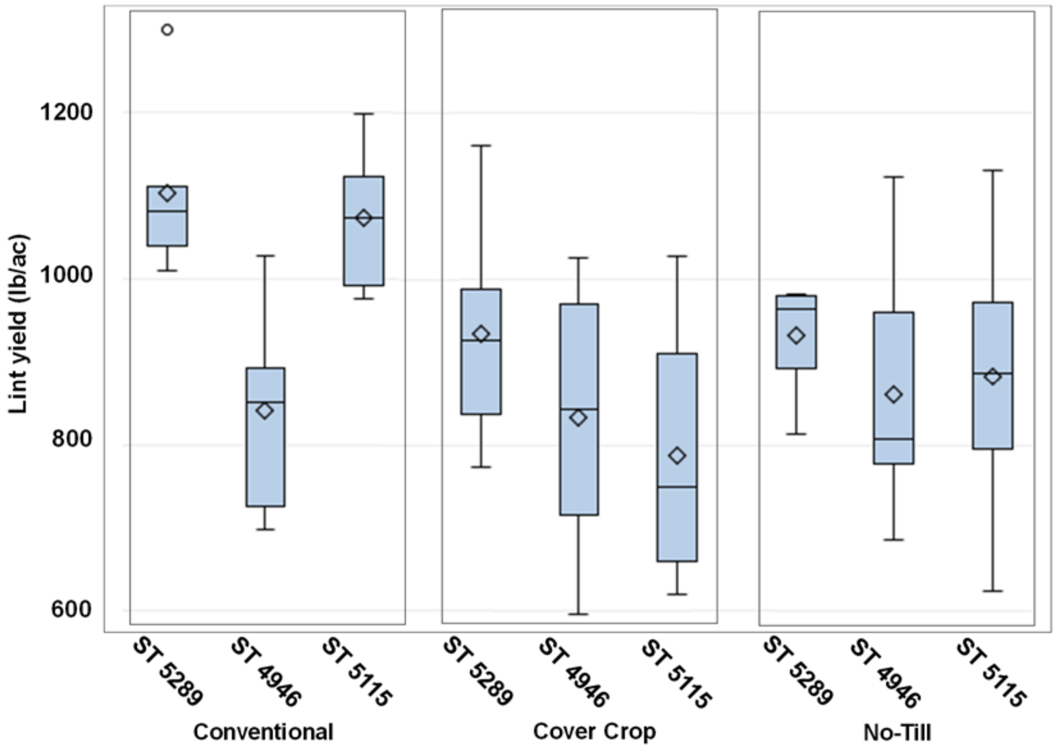

Figure 9. Lint yield (lbs/acre) for cultivar effects (*P*=0.004) and cultivar*tillage interactions were significant (*P*=0.05). Boxes represent 50% quartile; diamonds depict means, and the line is the median value.

Table 6. Fiber quality assessments (HVI[1]) for 40-boll collections for tillage and cultivar interactions[2]--2017, Judd Hill, AR.

Tillage	Cultivar	Micronaire	Length	Uniformity	Strength	Elongation
Conventional	ST 5289	4.82	1.19	83.13	31.25	6.25
	ST 4946	3.90	1.22	84.25	34.60	7.20
	ST 5115	3.84	1.16	83.32	33.18	6.92
Cover crop	ST 5289	3.65	1.21	82.57	31.05	5.55
	ST 4946	3.24	1.23	84.57	35.95	6.83
	ST 5115	3.14	1.20	82.70	34.00	6.85
No-till	ST 5289	3.51	1.20	82.53	31.45	5.57
	ST 4946	3.86	1.21	84.25	34.70	7.00
	ST 5115	2.92	1.20	82.67	33.13	6.70
Tillage	*P>F*	*0.02*	*0.30*	*0.45*	*0.44*	*0.05*
Cultivar	*P> F*	*0.001*	*0.003*	*0.001*	*0.001*	*0.001*
*Tillage*Cultivar*	*P> F*	*0.005*	*0.40*	*0.70*	*0.65*	*0.17*

[a] HVI assessments made at the Fiber and Biopolymer Research Institute, Texas Tech University, Lubbock, TX.
[b]No significant treatment interactions for insecticide spray effects.

Conclusions

The objective of this 2017 experiment was to quantify the impact of tillage system on performance of three cultivars with a range of HPR properties. We hypothesized that growing conditions could impact plant resilience to stress including water deficit tolerance and/or insect pest susceptibility. Insect pests were not a limiting factor in this study year. Tarnished plant bug population density and pre-flower first position square shed were low for all treatments season long. Thrips numbers were low and below action threshold. Boll retention variability observed in late-season was not related to insect induced square shed or boll damage.

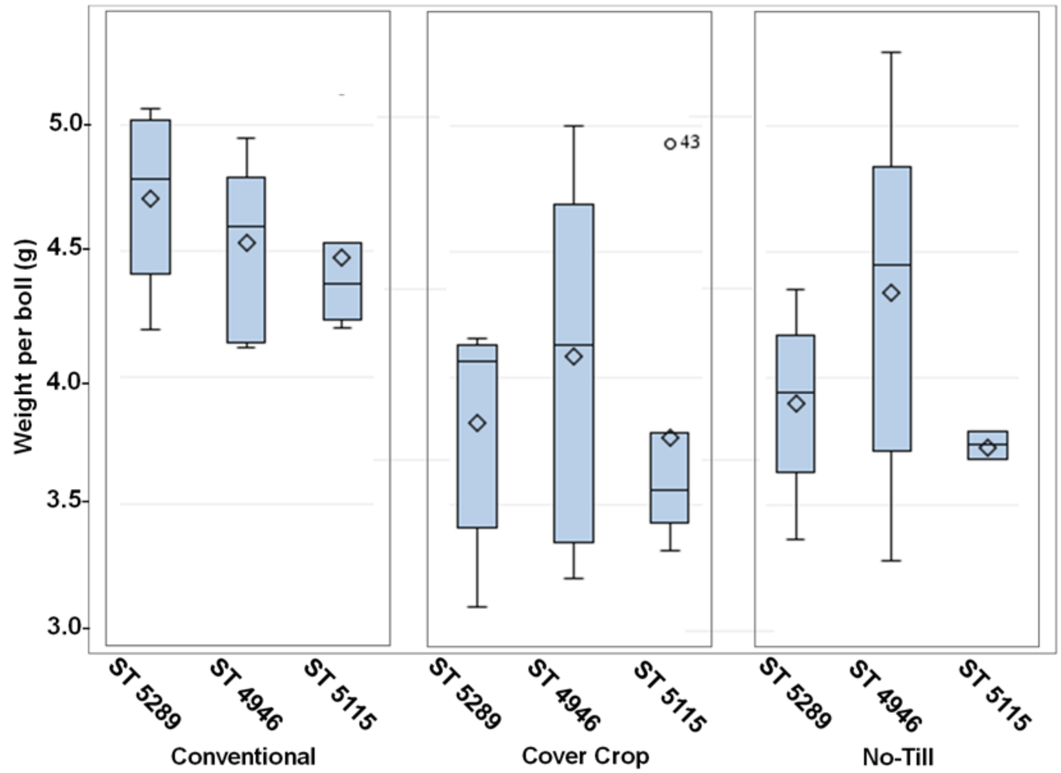

Figure 10. Boll weight were affected by tillage system (P=0.03) but not among cultivar (P=0.14) or cultivar*tillage effects not significant (P=0.55)

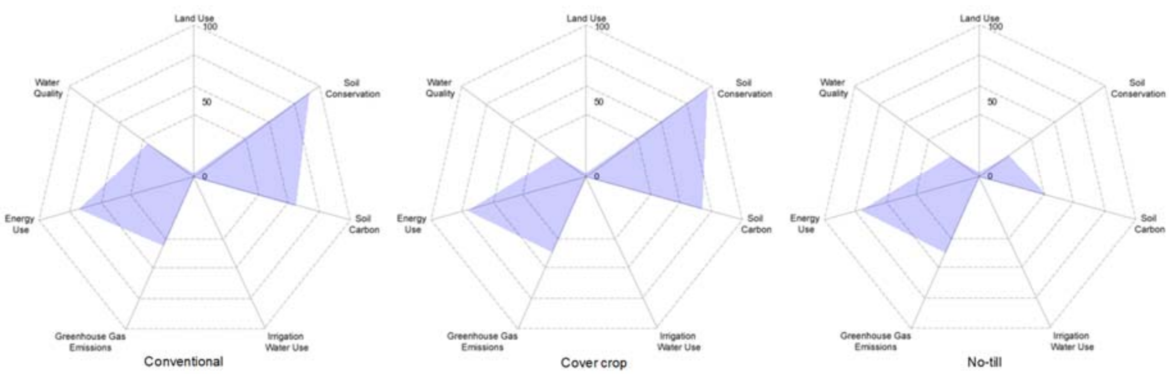

Figure 11. Output from the Fieldprint Calculator for the three tillage systems. Spidergrams provide relative indices on a scale of 1 to 100 that represent the resource use or impact per unit of output in each of five resource areas. Lower values closer to the center of the spidergram indicate a lower impact on each resource. The smallest total area of the Fieldprint was observed for the no-till system reflecting a smaller the overall resource impact.

Verticillium wilt was the dominant factor affecting yield, earliness and fiber quality among tillage systems in 2017. Disease incidence varied among the three cultivars, and there also was evidence of differential plant and pathogen response to the growing environment in each tillage system The semi-resistant cultivars, ST 5289 and ST 5115 produced highest yields when grown with conventional tillage practices. These treatment combinations had lowest incidence of verticillium wilt. Disease symptoms were most apparent in ST 4946; yields were uniformly poor across all tillage systems for this cultivar.

The soilborne fungus, *Verticillium dahliae*, infects through the roots, invading the vascular system and disrupting the plant's nutrient and water transport systems. The *Verticillium* fungus has a broad host range and can survive extended periods in the soil as microsclerotia. Factors influencing disease development include cultivar susceptibility, inoculum density (microsclerotia in soil), and environmental conditions (cool & wet) (Woodward and Wheeler 2012). Cultural control practices are the only management tactics available for disease control. Recommended practices to reduce disease severity includes crop rotation to non-hosts (e.g. grain crops) to reduce disease inoculum and severity. In continuous cotton systems, selection of a partially resistant (or tolerant) cultivar is considered the most important management tool for Verticillium wilt (Land et al. 2017). Agronomic practices that increase reduce surface residues and increase soil temperatures and drainage have been shown to reduce the impact of Verticillium wilt (Raper et al 2017). This includes tillage and planting on raised beds. After the onset of disease, irrigation can improve yields because infected plants are more susceptible to water deficit stress due to the presence of *V. dahliae* hyphae in the xylem which inhibits water flow (Xiao and Subbarao 2000).

For this long term tillage trial, raised beds were reformed prior to planting in the conventional tllage system. In the cover crop treatments, beds were reformed in fall 2016, and planting was in stale seed-bed. For the no-till treatment, beds had not been reformed in 10 years. We measured early season temperature differences among tillage treatments but saw only minor differences among systems. Water infiltration differences among tillage systems tended to show greater soil moisture availability in the no-till system. There was no supplemental irrigation in the 2017 field trail; and soil moisture measures indicated increased infiltration in no-till following rain events. This suggest greater access to soil water by infected plants; however, greater soil water availability also can positively influence infection. Wheat in rotation has been shown to reduce disease inoculum, but it is unknown if use of wheat as a terminated winter cover crop followed by cotton has the same outcome.

Understanding how growing environment and production practices interact at a system level will promote use of cultural control practices that will help improve overall cotton performance and yield stability. The experiment will be repeated in 2018 with expanded evaluation of plant disease management tactics as a part of the long term tillage study at the Judd Hill Foundation Farm. This will include assessment of inoculum densities of *V. dahliae* across tillage treatments. Management of diseases such as Verticillium wilt as well as pest arthropods requires the integration of multiple tactics, with a consideration of IPM principles in overall crop management. An IPM approach will allow producers to reduce reliance on costly chemical control and improve cotton sustainability. Use of the Fieldprint Calculator tool can provide helpful benchmarks to document progress.

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