U.S. Cotton Grower 2015 Natural Resource Survey Results

White Paper

Cotton Incorporated

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Introduction

In 2008, a Natural Resource Survey was conducted of U.S. cotton producers to self-assess cotton's impact on the environment and to collect data to support a global life cycle assessment project. The 2008 results were released in a white paper and used in life cycle inventory data sets such as ones used by Gabi and SimaPro. A similar survey was administered in 2015 to examine the changes in growing practices in the past six years as well as other more current trends.

Updated agriculture and natural resource data is needed to understand the efficacy of certain education initiatives, technology adoption, and current trends in farming practices. This survey generated the most current and comprehensive dataset surrounding Natural Resource Use and examines the relationships between farming practices and reported yields, resource use efficiency, and other measures surrounding the performance of agriculture systems.

The explicit goals of the 2015 survey were to:

1. Provide additional data to support Cotton LEADS™.
2. Facilitate participation in the Field to Market Field Print Calculator™ by collecting data used by the calculator, which could allow future export of the data in order to build the calculator's cotton database.
3. Support data needs related to U.S. production systems by updating the cotton global LCA data set.
4. Maintain an accurate understanding of growers' research needs.

Some of these goals are addressed within this document; however, others involve data not released, but rather integrated into current agriculture models and calculators, and integrated in other studies. The goals of this document are to:

1. Provide a summary of the Natural Resource Survey results.
2. Determine changes in survey results from the 2008 to the 2015 survey years.
3. Provide insights into the implications of the adoption of agricultural technologies.
4. Provide documentation of the U.S. cotton production data supplied to the global LCA.
5. Provide growers insight into what practices they are adopting that appear to have a positive impact on resource use efficiency, productivity, or both.

Growth Regions

Cotton is grown all over the world in different climates and with different technologies. This report focuses on the U.S. cotton production, which involves roughly 13% of the world production from 2010 to 2014 (USDA, 2015). U.S cotton is commonly divided in to four distinct regions due to weather patterns, climate, soil type and other factors influencing cotton cultivation methods and plant productivity. The following are the regions commonly used to group cotton growing states:

- **Southeast**: Virginia, North Carolina, South Carolina, Georgia, Alabama, and Florida
- **Mid-south**: Mississippi, Louisiana, Tennessee, Missouri, and Arkansas
- **Southwest**: Texas, Oklahoma, and Kansas
- **Far West**: California, Arizona, and New Mexico

To further highlight the difference between these regions, Figure 1 shows precipitation and Figure 2 soil types throughout the U.S. In examining these images, it is clear that the Southeast and Mid-south receive more precipitation than the Southwest and Far West. Additionally, farming practices are influenced by the dominant soil types that are generally found in each region: Southeast- Ultisols; Mid-south- Alfisol; Southwest- Mollisols; and Far West- Aridisols.

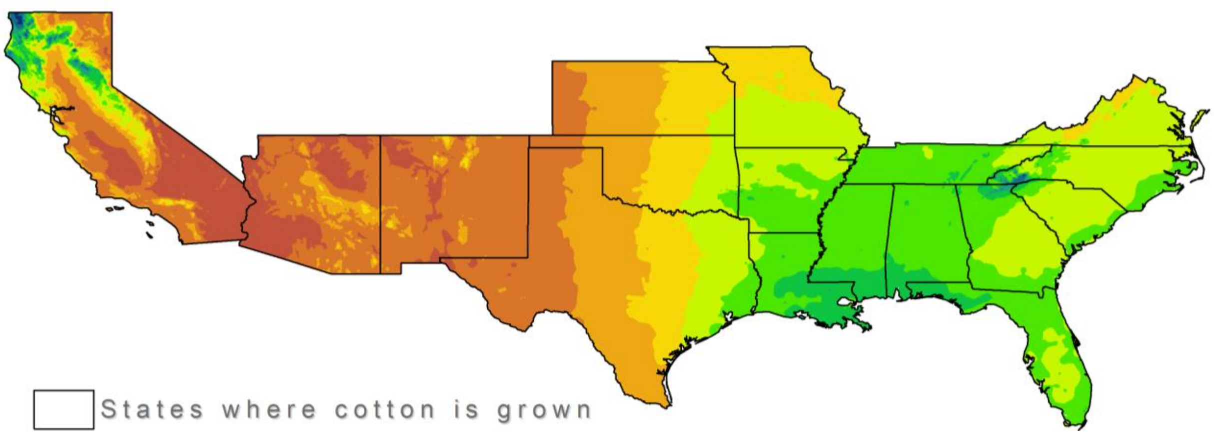
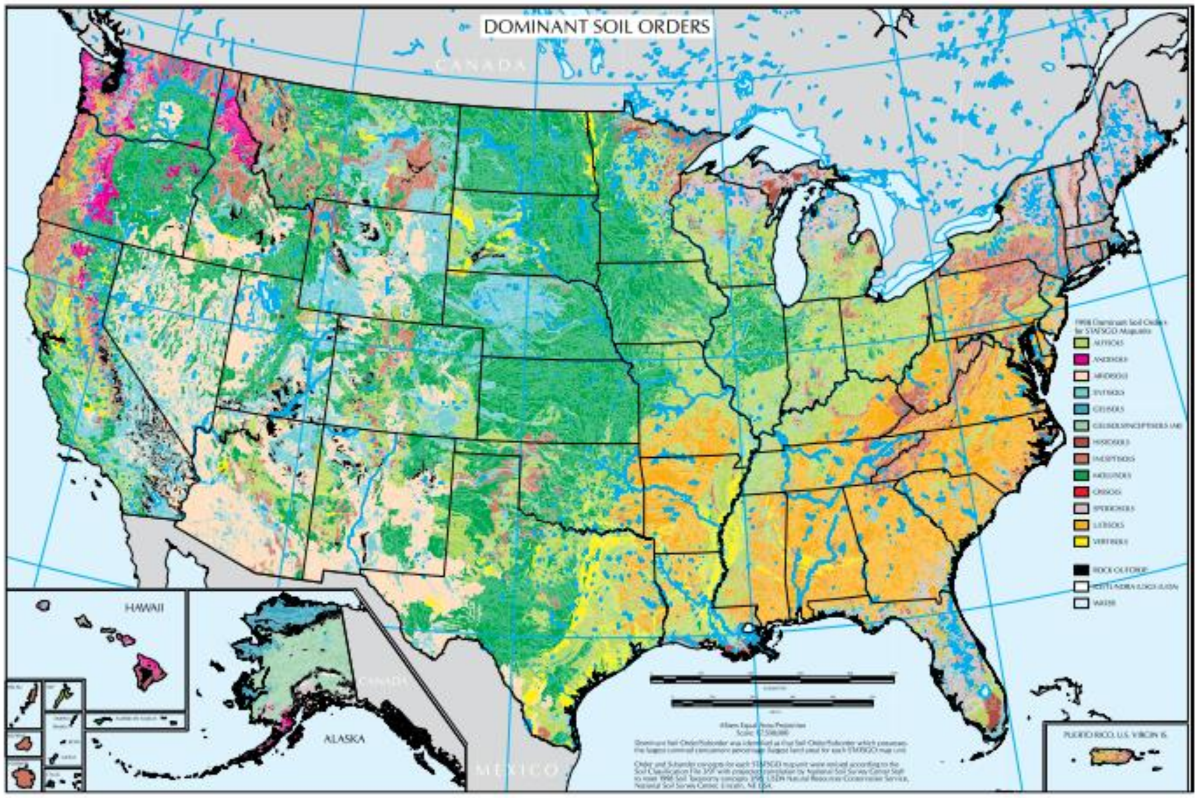


Figure 1: 30-year average rainfall 1971 to 2000 in cotton producing states (rainfall data from USDA, 2010).



Source: National Soil Service Center (1998) Dominant Soil Orders. USDA National Resources Conservation Services, Lincoln, NE *ftp://ftp-fc.sc.egov.usda.gov/NSSC/pub/orders/soil_orders_98.pdf*

Figure 2: Dominant soil orders for the U.S.

Surveying growers from all regions as well as getting a proportional survey response to region production was important for data representativeness, allowing for more meaningful analysis and conclusions. Additionally, by examining independent variables such as growing practices and technology adoption, relationships between dependent variables such as field productivity (yield), resource use efficiency (Nitrogen use efficiency and water use efficiency), and perceived concerns can be established (Figure 3). These relationships, however, should be interpreted carefully, as there are many variables and conditions that each farmer experiences that can affect the field performance. As such, trends and the possible relationships between independent growing variables and dependent field performance variables are acknowledged. These relationships are carefully stated to demonstrate a possible link without stating the causal nature of the relationship. This work will fill the knowledge gap between the connection of farming practices and their implications at the national level for all growing regions in the U.S., and could help guide further research and outreach efforts.

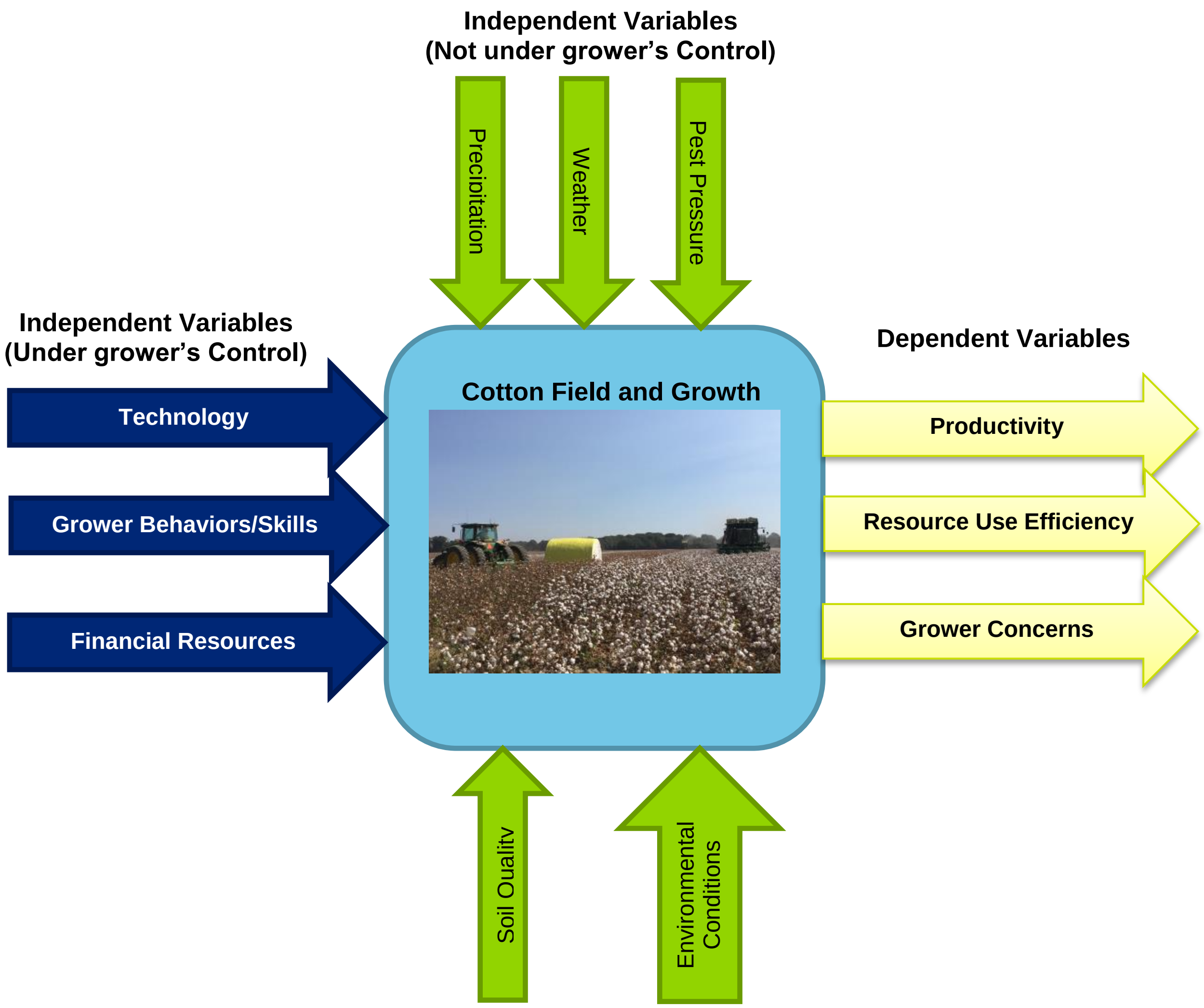


Figure 3: Cotton growing production system simplified model with independent variables labeled in blue (under the grower's control) and green (out of grower's control) and the corresponding dependent variables represented in the yellow arrows.

Methods

Survey Method

A market research firm, Bellomy Research, assisted in the execution of the 2015 survey. 12,000 post cards were mailed by the Cotton Board to all the farmers that produced cotton in 2014. Post cards were mailed on the dates of March 6, April 6, and May 25 of 2015. In addition to post cards, 1,800 emails were sent to cotton producers just prior to the post card mailing on March 5 and June 3. A total of 4,300 emails were sent soliciting a survey response. As a way to track communication channels, different survey links were provided in the post card and emails. To avoid extraneous responses, no external links to the survey were made available from a public website – the links were only provided through the postcard or email. In Figure 4, responses were tracked based on date submitted. Three distinct slope changes can be observed, all soon after the different communication dates.

The survey asked 66 questions in total, some of which had multiple parts. These survey questions gathered information on farmer demographics, general grower practices, grower concerns, and average field level growth and management data. In the results analysis, the average field data was used to find correlations between general growing practices and field performance. The full survey is provided in the appendix. A very similar survey was conducted of U.S. cotton producers in 2008 (Reed et al., 2009); therefore, some responses in this report are compared to the 2008 results.

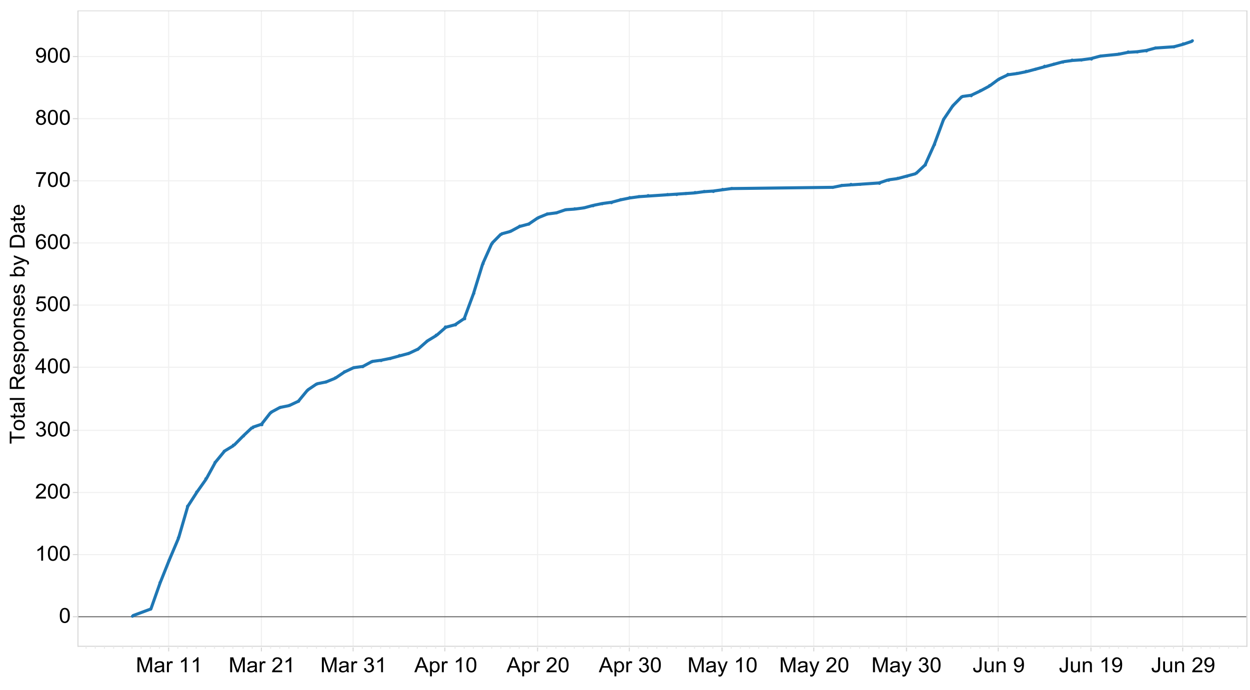


Figure 4 Cumulative number of responses by date.

Respondent Demographics and Data Representativeness

In total, 925 responses were recorded, of which 88% came from those who entered the web address provided on the postcard. Reponses from the cotton growing states were proportional to cotton growing area of the states, with the highest concentration of respondents in Texas and Georgia, as seen in Figures 5 and 6.

Most of those participating were experienced cotton growers, with 91% having more than five years growing cotton, and more than half (54%) having grown cotton at least 21 years. A majority of respondents (79%) had some post high school education, and 46% had at least a bachelor degree. There was a fairly uniform distribution of ages for respondents with the exception of those 20 to 30 years old at 9%, 31 to 40: 20%; 41 to 50: 17%; 51 to 60: 33% and greater than 60: 21%.

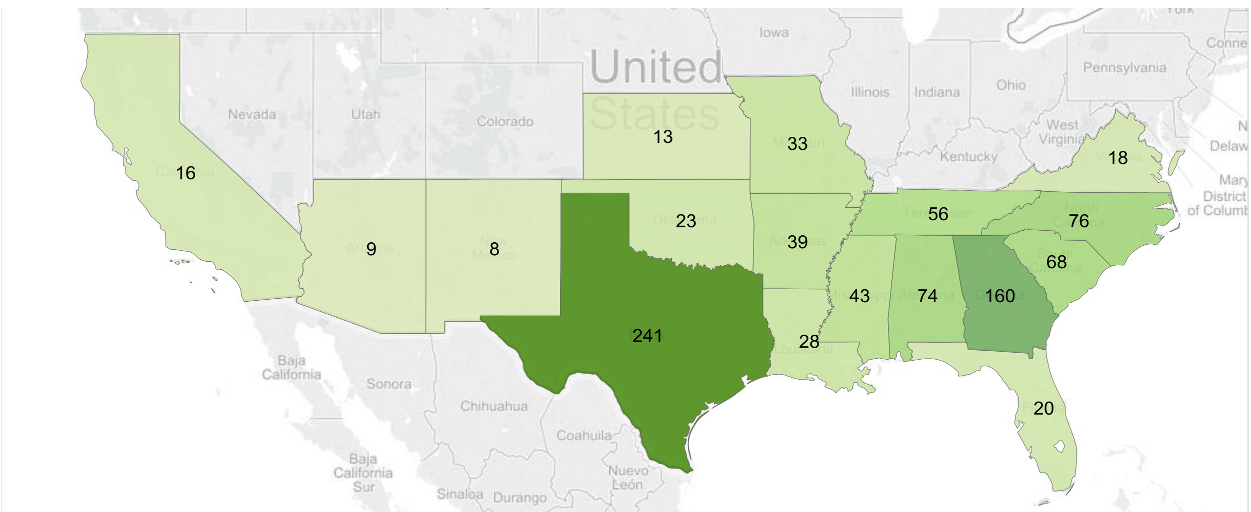


Figure 5: Respondents by state for the 2015 survey

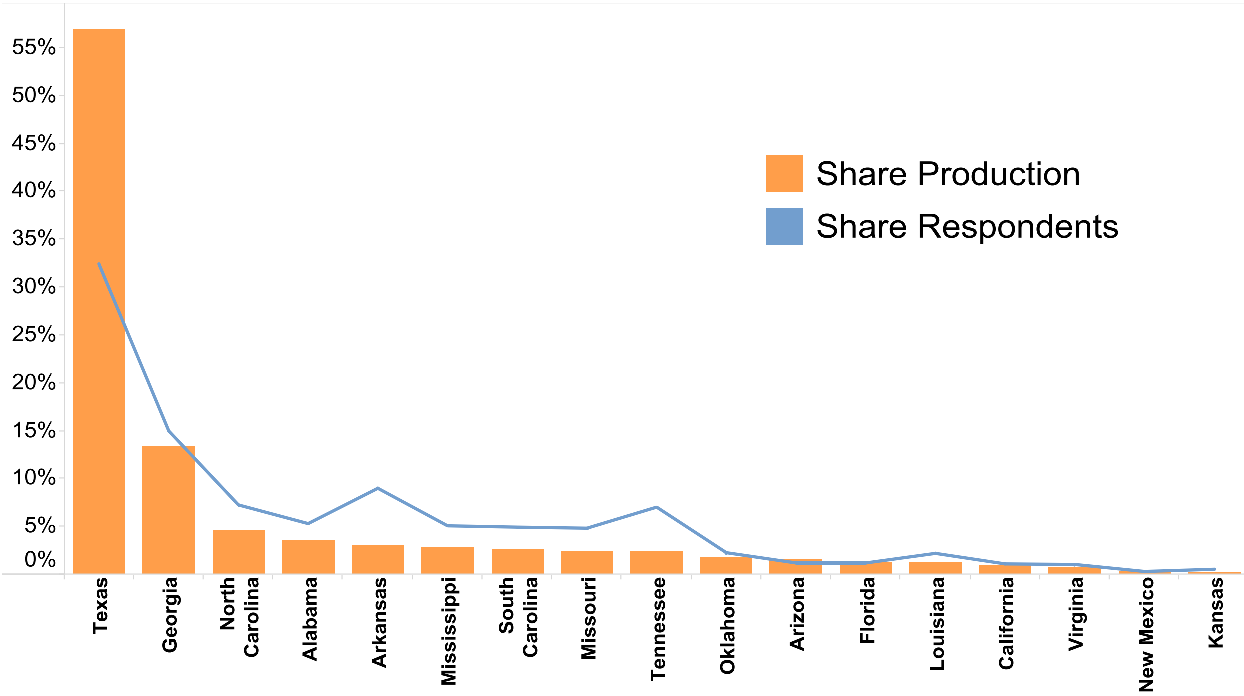


Figure 6: Percent of U.S. acres grown in each state during 2013/2014 and the percentage of acres by state from survey participants.

Data Analysis

The results as received from Bellomy Research were analyzed using Microsoft Excel, Tableau, and SPSS. Tableau enabled many conditional comparisons between demographics, farming practices, region and the resulting field productivity, and efficiencies. Before performing the analysis in Tableau, data formatting and cleaning was required to enable the program to analyze the data correctly. Once formatted, Tableau enabled hundreds of methods or lenses to quickly analyze the data using the program interface. Using an advanced data visualization program such as Tableau added depth and rigor to the analysis provided herein. SPSS provided insight into the statistical relevance of results, and to make some additional comparisons.

Energy Use and Greenhouse Gas (GHG) Emission Calculations

The energy usage and GHG emissions for cotton production were calculated on a cradle to gin gate basis as illustrated in Figure 7. Both energy and GHG emissions were examined using a functional unit of one pound of fiber ready to be shipped from the ginner [lb CO2/lb fiber, and BTU/lb fiber]. In the survey, questions on energy use were not explicitly asked. Instead, the responses were used to estimate energy use based on tillage system, number of tractor passes through the field, and amount of chemical applications. Energy use for irrigation was estimated based on total lift (pumping depth to ground water plus distance to the water outlet), outlet pressure, volume of water applied and energy source based on the procedures of Hoffman et al. (1992). For operations involving tractors or other field equipment, grower survey data was combined with ASABE (2011) procedures to estimate fuel use. Data reported in Faulkner et al. (2011) was used to document fuel use in cotton strippers; data from Willcutt et al. (2009) was used for modern spindle harvesters to estimate fuel use in harvest operations. Data for ginning electrical energy use was based on survey data reported by Valco et al. (2015), and dryer fuel used was based on data measured by Hardin and Funk (2014). Energy content for fuels used was taken from the DOE (2015).

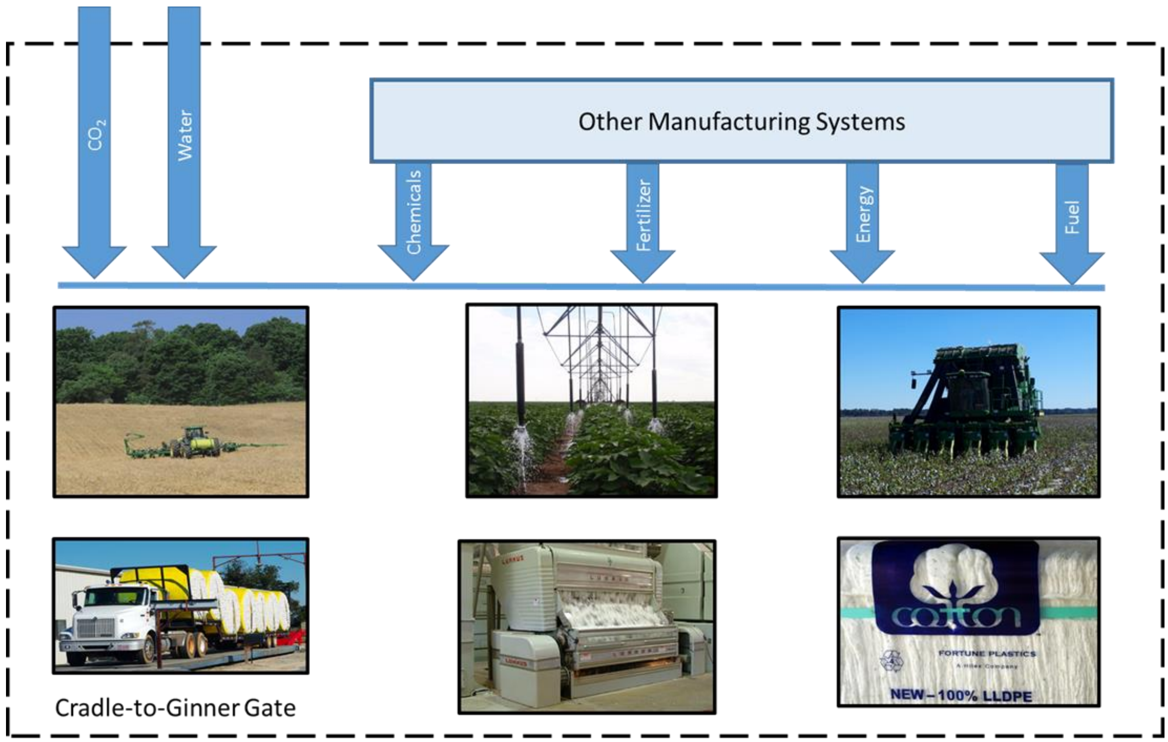


Figure 7: GHG and energy usage cradle-to-ginner gate system boundary.

Data presented by Pradhan et al. (2011) was used to estimate the energy embedded in all farm chemicals except for fertilizers. As the survey only asked about the number of application trips, data from USDA (2010) was used to determine an average active ingredient (AI) application rate for U.S. cotton (0.5 kg AI per ha). Embedded energy and GHG emissions associated with fertilizer and agricultural chemical manufacturing was based on current factors used in the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model (Wang, 2007). Greenhouse gas emissions for fuel use were estimated using data from EIA (2013a). GHG emissions associated with electrical energy use was based on a U.S. national average reported by EIA (2013b). The Intergovernmental Panel on Climate Change (IPCC) assumption that 1% of nitrogen applied to soil is emitted as N_2O was applied in this study. Snyder and Fixen (2012) discuss the high uncertainty associated with the IPCC assumption. A full life cycle assessment, including cotton production, is currently underway and will be released in 2016.

Results

Cotton Producer Concerns

As part of the Natural Resource Survey, respondents were asked to review 27 randomly presented concerns presented concerns or challenges and score whether each was a Major, Moderate or Not an Issue on their Not an Issue on their farm. An indication of data quality was the fact that only 3% said "Cotton Production "Cotton Production Input Costs" were "Not an Issue," as this is clearly a top concern expressed by cotton expressed by cotton producers in all personal interviews. As seen in

Table 1, consumer attitudes made the biggest jump in producer priority, from 31st place, reported in 2011 in a previous survey that only surveyed producer concerns, to 7th place in 2015, likely reflecting the strong emphasis that Cotton Incorporated has placed on Cotton LEADS[TM], sustainability metrics, Field to Market, and competition with manmade fibers.

Table 1: A summary ranking of responses for all 2015 grower concerns.

How would you rate the following cotton production concerns or challenges on your farm?	Major	Moderate	Not an Issue	2011 Rank	2015 Rank	Δ
Cotton production cost	81%	16%	3%	1	1	0
Weed resistance to herbicides	69%	25%	6%	5	2	3
Weed control	64%	31%	5%	4	3	1
Cottonseed value	51%	40%	8%	7	4	3
Spread of plant disease and weeds	42%	43%	14%	New	5	N/A
Seedling vigor and stand establishment	42%	40%	18%	6	6	0
Consumer attitudes about Ag's impact on the environment	**40%**	**38%**	**22%**	**31**	**7**	**24**
Cotton's tolerance to heat and drought	39%	48%	13%	3	8	-5
Efficient use of fertilizer	37%	43%	20%	19	9	10
Adequate water supply	37%	35%	28%	15	10	5
Variety selection	34%	43%	23%	2	11	-9
Plant bug control	32%	44%	24%	9	12	-3

Grower Communication Methods

In order to continue to supply producers with new information to continue to improve their production efficiency, it is important to understand where producers receive their information on new technologies and practices. The survey participants were asked to rank 12 information sources on how much they depended on them as: none; slightly, moderately or greatly. The percent selecting moderately or greatly important are shown in Figure 8, with the most highly rated in 2015 at the top of the chart. The 2015 results were fairly consistent with what was reported in 2008. Producers tend to prefer face-to-face interaction composed of other producers, consultants, and extension agents.

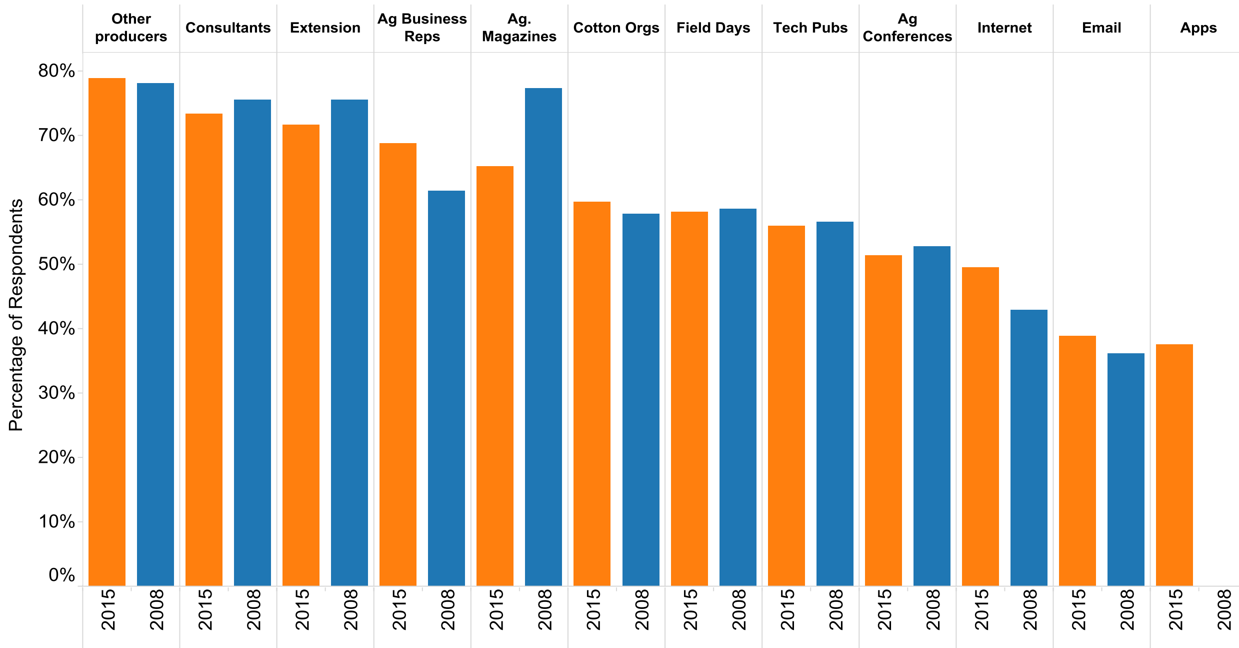


Figure 8: Preferred information sources – percent ranking source as "greatly" or "moderately" useful.

There was a slight decline in interest in magazines, and slight increase in the Internet as a preferred source of information. Apps are not of significant interest at this time, but that may improve as more cotton specific apps are released.

Farm Characteristics

Land and management practices and characteristics were examined by using multiple questions within the natural resource survey. The average field size was one parameter surveyed since field size can impact some of the practices it is feasible for producers to adopt, especially where field size is smaller. To understand the changes in average field size, it was compared by region for 2015 and 2008, as illustrated in Figure 9. All regions reported similar average field sizes in 2015 and 2008. Field size in the Far West is often limited by the irrigation system design; in order to achieve effective water distribution the length of fields has to be restricted. In the Southeast, field size is often limited by topography, such as established tree lines and wetland areas.

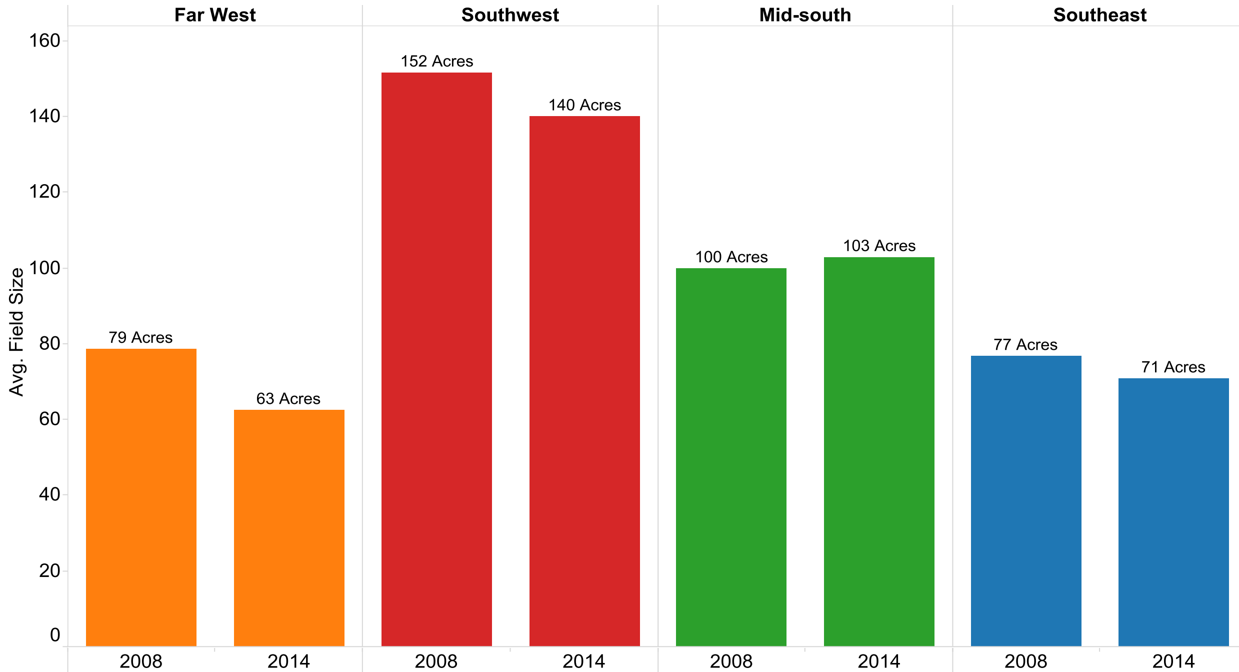


Figure 9: Average field size by region for 2008 and 2015 survey data.

Land Use

A total of 1,675,911 crop acres were represented by those responding to the survey, with 49% (818,804 acres) composed of cotton fields. This represents 10% of the cotton planted in the United States in 2015. Of the cotton acres, 45% were capable of receiving irrigation water. In addition to crop land, the respondents also reported a total of 217,113 acres of natural land on their farming enterprise. A great majority (86%) indicated they grew more than cotton (82% in 2008). Additional crops grown by respondents and percent respondents growing them are in Table 2, which were similar to the results in 2008.

Table 2: Percentage of the 925 respondents indicated they commercially produced the crop listed.

Crop	% Grown 2008	% Grown 2015
Alfalfa	7%	4%
Corn	48%	46%
Hay	19%	15%
Pasture	21%	16%
Peanuts	18%	27%
Rice	4%	3%
Sorghum	25%	19%
Soybeans	37%	39%
Orchards	6%	3%
Vegetables	6%	5%
Vines	1%	1%
Wheat	47%	40%
Natural Vegetation	22%	17%
Other		9%
None of the above		3%

Crop Rotation and Cover Crops

In the cotton offseason, the land can be used for various crops that can increase revenue as well as create benefits to the land. The survey polled farmers to understand the use of the land in the offseason. This data was used in conjunction with the field level yields to gain further insight, as shown in Figure 10. In Figure 10, the average field yield (cotton fiber with no seed) is on the Y axis and the off season use is listed on the X axis. The percentage labeled at the top of each bar chart represents the percent difference from the no winter crop scenario and the width of the bar indicates the number of growers using the scenario method. This analysis indicates that farmers using winter crops/cover produced higher cotton yield, especially with native vegetation and planted cover crops, which resulted in 4% and 5.2% increase in average plot yield compared to no winter crop farm plots. Note that it is not uncommon to have lower cotton yields when double cropping if the winter crop results in a later than optimal planting date for cotton.

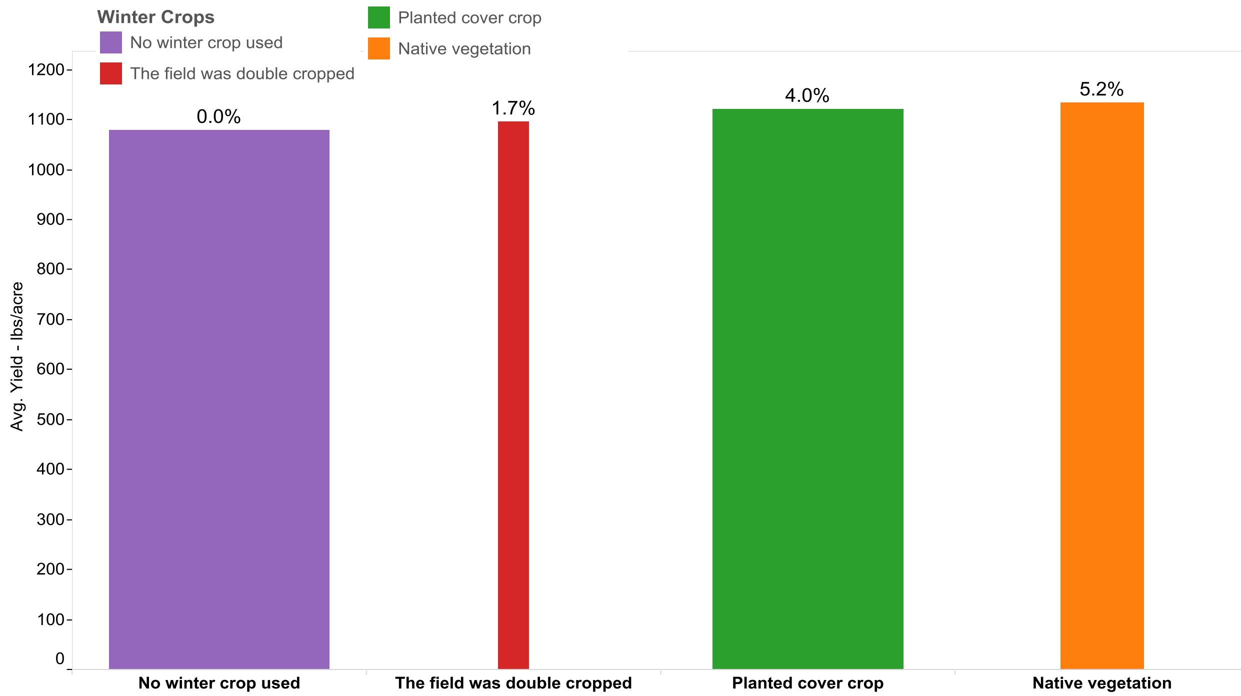


Figure 10: Winter and cover crops use in relation to average plot yield.

Tillage Practices

Cotton Incorporated has been emphasizing the benefits of conservation and no-till practices for more than 20 years (e.g., McClelland et al., 1993). The benefits from no-tillage systems are numerous and well documented, including reduced soil erosion, increased soil organic matter, and reduced fuel use (e.g., Triplett and Dick, 2008). From 2008 to 2015, conventional tillage remained fairly constant; however, conservation tillage decreased as no-till/strip-till increased by a similar amount of 9%, as shown in Figure 12. This change in tillage practices suggests that the education and outreach surrounding this management practice motivated some field-level changes.

Figure 11:Cotton being planted into a no-tillage field with cover crop residue.

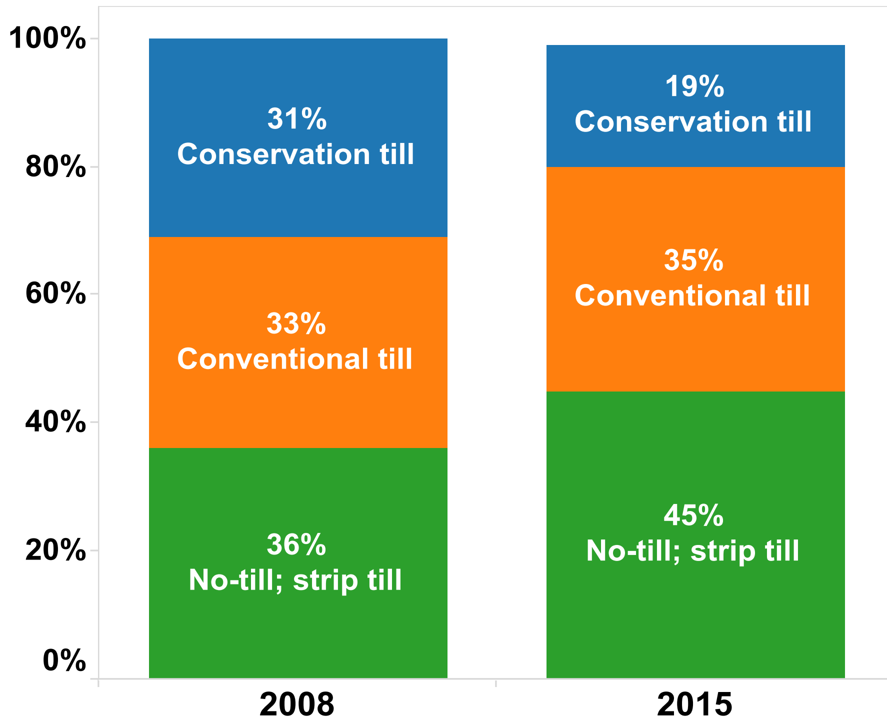


Figure 12: Tillage systems use identified in the 2008 and 2015 surveys.

The move from conventional tillage practices to no-till/strip-tilling has the potential to save the grower money, as less time and energy is required; however, many growers fear this move may reduce cotton yields. To understand the relationship of tillage practices to cotton yield, the yield for each tillage practice was plotted for each U.S. region, as shown in Figure 13.

Examining the Far West first, the conventional till was most commonly used and the farmers using this method reported the highest yields. The Far West was the only region where the conventional tillage method had the highest reported yields. In the Mid-south and Southwest, the conservation tillage method had the highest reported cotton yields, with over 60 reported yields for both regions. Interestingly, the Southeast was unique with no-till/strip-till reported yields as the highest of the three practices, and the most common with over 280 reported yields. This supports that farmers in the Southeast have adopted the less intensive tillage practices while maintaining yields higher than other tillage practices in the region. No-till/strip-till did have the lowest reported yields in the Mid-south and second lowest in the Southwest and Far West. With less intensive tillage practices, some loss in yield can be acceptable; however, the loss of production should be compared to the savings generated by less intensive tilling practices.

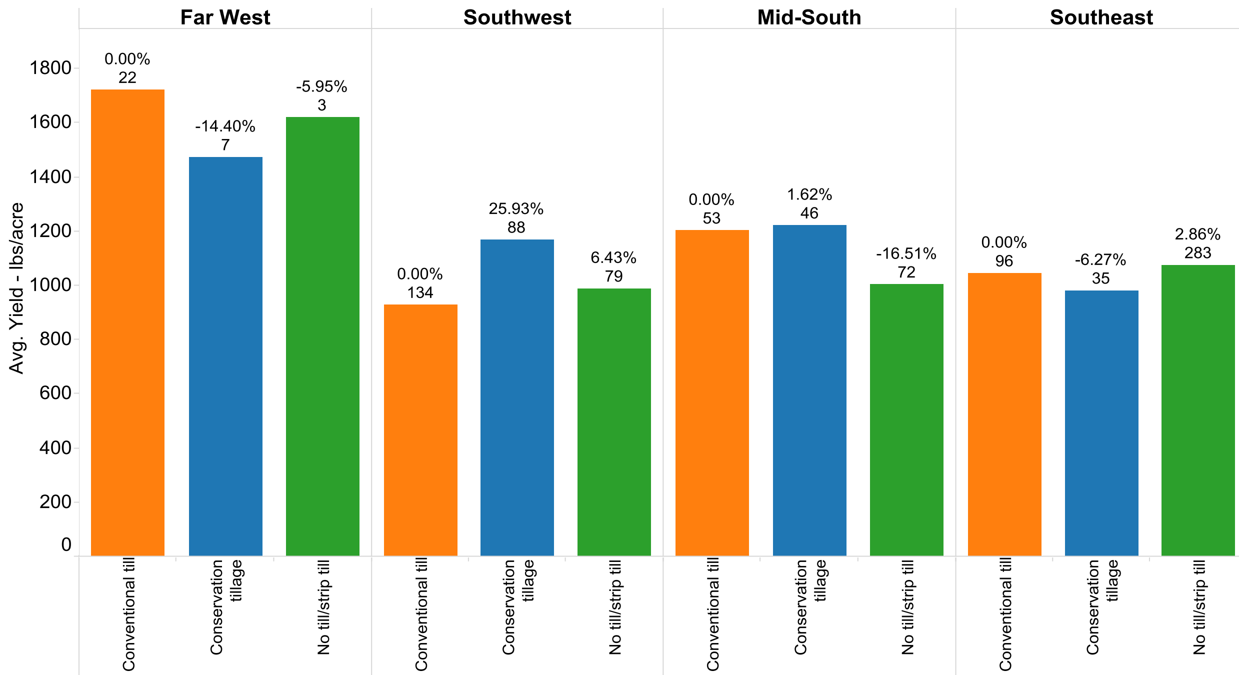


Figure 13: U.S. Cotton yields based on tillage method and region. The labeled number indicates the number of respondents in the region using the tillage method and the labeled percentage is the percent difference from the respondents using conventional tillage methods.

Soil Management

In the 2015 results, 94% of respondents identified at least one of 10 different practices listed to reduce soil erosion. The percentage of those using specific practices did not change greatly between 2008 and 2015, with two exceptions. In 2008, 71% of respondents indicated they maintained grown and surface cover in their fields, while in 2015 the number fell to 50%. This may be due to increased education by the Natural Resource Conservation Service and the cooperative extension service on what constitutes “residue.” However, in 2008, 39% indicated the use of winter cover crops, and that number increased to 48% in 2015.

There continues to be a high rate of soil sampling to determine fertilizer application rates; 80% of producers indicated soil sampling at least once every 2 years in 2015 (75% in 2008). Only 5% indicated they did not do soil fertility testing, which may be acceptable for low yield conditions where minimum inputs are used. Other factors also used as part of the fertilizer evaluation process were: consultant recommendations (49%), yield goals (61%), spatial data sets (soil and yield maps, 18%), and petiole or leaf tissue samples (24%). Sixty-three percent (46% in 2008) indicated some form of organic matter was used to enhance soil health, including use of cover crops (48%) and animal manures (30%).

The precision in fertilizer management is illustrated in Figure 14 by showing the nutrient use efficiencies for nitrogen, phosphate and potash by region (mass of cotton fiber produced per mass of nutrient applied). The consistent value near 10 kg of fiber per kg of nitrogen across all regions is encouraging, as that is very close to the current extension recommendations for cotton, which were recently verified by Main et al. (2014). As nitrogen is removed from the field in the cottonseed, it has to be consistently replaced. However, many soils are naturally rich in phosphate and/or potassium, and little of these nutrients are removed during cotton harvest, thus the greater variability by region.

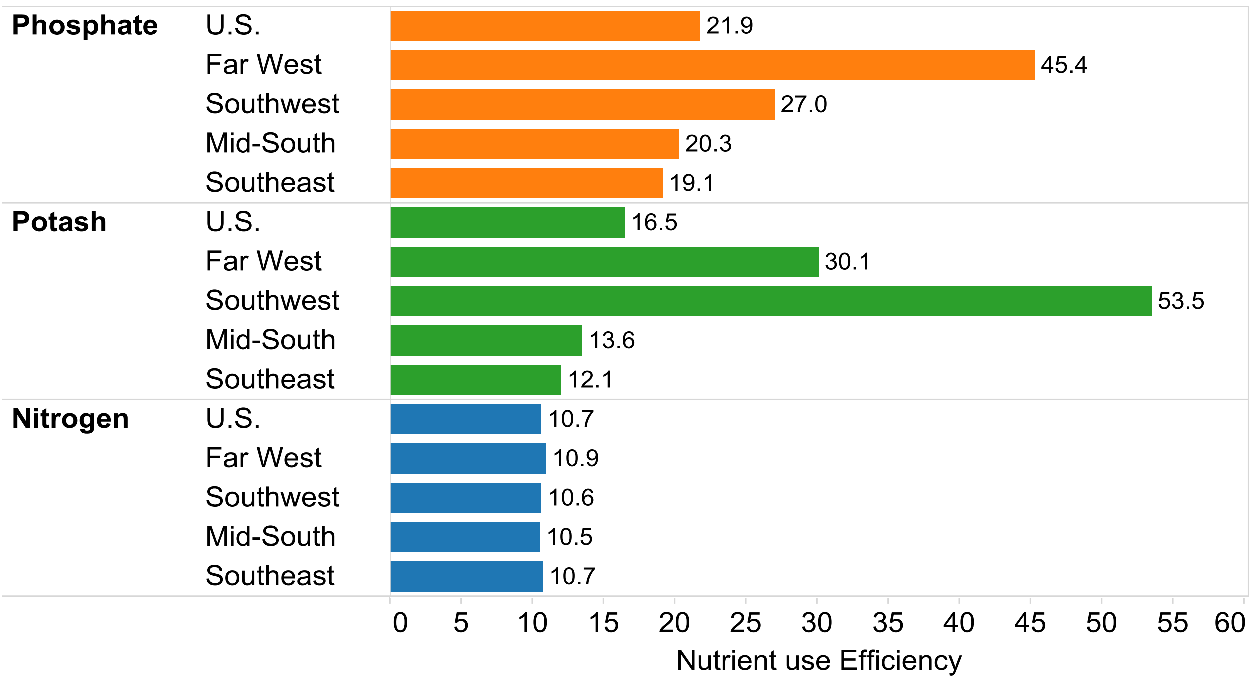


Figure 14: Nutrient use efficiency by cotton growing region.

Eighty-six percent indicated fertilizer rates were based on soil test recommendations. There is evidence of this in the high nutrient use efficiency values shown previously. Nitrogen (N) application methods included 33% injecting N into the soil profile, 14% applying a band to the surface, 36% broadcasting, and 14% broadcasting followed by incorporation. In more arid regions, it is important to inject or incorporate nitrogen to limit losses to volatilization. On average, two trips were made during the season to apply fertilizer, increasing the probability it is available to the crop when needed. Sixty-two percent are applying micro-nutrients, while 60% report applying lime.

Irrigation and Water

Upon examining irrigation practices further, for the entire cropland examined (not just cotton), 63% indicated they had at least some irrigated land in their enterprise, with 40% of the total cropped acres capable of receiving irrigation. Irrigation methods are an important factor for conserving water resources and maximizing water use efficiency. When comparing survey results from 2008 to 2015, there has been a trend towards less use of surface irrigation, as indicated in Figure 15. In general, the change to pressurized systems results in higher water use efficiencies, as pressurized systems are easier to precisely control and operate. However, a well-designed surface system can be just as efficient as a center pivot.

In 2015, furrow irrigation represented 35% of the irrigation systems reportedly used. The use of tail water in these irrigation systems can reduce nutrient runoff, lower sedimentation in streams, and decrease water usage requirements. Sixty-two percent of the respondents using furrow irrigation systems reported using a tail water recovery system (i.e., a way to manage any water running off the end of the field). These methods ranged from: holding ponds (10%), pumping systems to return the water back to the top of the field (21%), and routing of runoff to other fields (16%). More than 70% who were furrow irrigated reported they designed their irrigation system (flow rates and field slope) to minimize irrigation runoff.

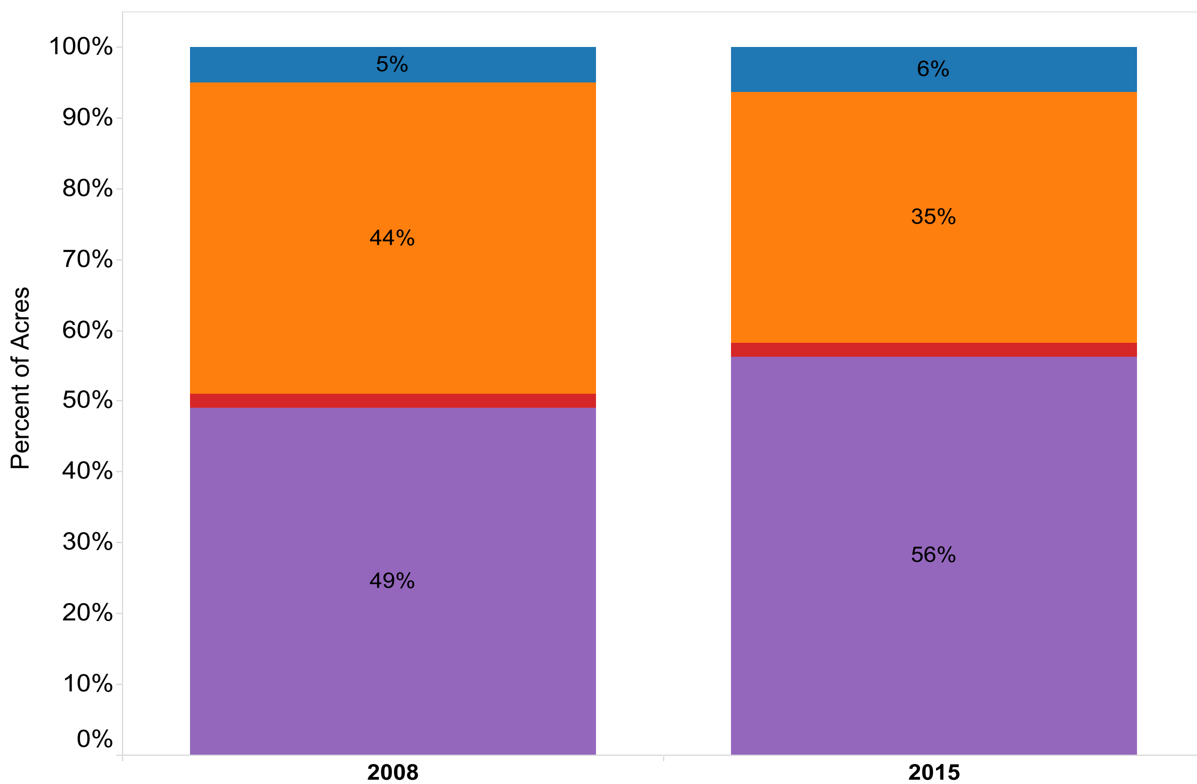


Figure 15: Irrigation systems used in 2008 and 2015

The water sources used for cotton irrigation were primarily well water with 91% of the respondents reporting its use. In addition to well water, 28% and 9% of the respondents reported using on farm surface water and off surface water, respectively. Surface water was often used in conjunction with well water.

An area for possible improvement of irrigation water is to increase the use of flow measuring devices to track the volume of irrigation water used, as only 59% reported using such a device. It appears many producers assume the system is delivering the volume of water it is designed to. While this is often a reasonable assumption, several factors can result in an irrigation system not performing as intended, such as fluctuations in the depth to the water table, aging pumps, and worn, leaking or clogged sprinklers. A flow meter is a good tool to verify an irrigation system is working properly. Some may not install meters in fear that it could become a regulatory requirement.

Precision Farming Technology Farm Level Impacts

Further examination of the survey data suggests that yield monitoring, autosteer and GPS guidance systems increased dramatically from 11% to 20% and 46% to 69% from the 2008 to the 2015 survey years. Grid soil sampling use was not surveyed in 2008, however, 46% of the respondents in 2015 indicated its use, as shown in Table 3. The minimal use of hand-held GPS is likely a reflection of the fact that almost all smart phones now have an integrated GPS receiver and an independent GPS receiver is no longer needed. It will be interesting to see if the use of imagery increases significantly once the FAA allows more extensive commercial use of unmanned aircraft systems.

Table 3 Precision technologies used in 2008 and 2015

Technology Used	2008	2015
Yield Monitor	11%	20%
Autosteer or GPS guidance	46%	69%
Hand-held GPS	10%	9%
Imagery	12%	13%
Soil map	31%	37%
Grid soil sampling	N/A	46%

The survey results and literature show that technology is being adopted; however, the increased value created by these new technologies is not always clear. The collected survey data enables a comparison of using several farming techniques and technologies to the plot level yields. In Figure 16, irrigation scheduling, moisture monitoring, and nitrogen soil testing practices were compared to field level yields. The recorded plot level yields and water use efficiency (WUE) were higher for growers using irrigation scheduling. Similarly, the yield and WUE were higher for growers using moisture monitoring programs. The data suggests that the use of these techniques not only reduces the strain on water resources, but may also increase cotton yield, creating a direct benefit to the grower.

Most (84%) respondents indicated they determined when to irrigate by visual assessment of the crop. The remaining respondents used other scheduling approaches similar to results found in the 2008 survey: 14% used real-time evapotranspiration models and 19% used sensor-based scheduling. There was an increase in the consultation of weather forecasts in 2015, compared to 2008 (45% versus 25%), and a slight decrease in the use of plant monitoring techniques that fell from 40% in 2008 to 34% in 2015. There has been an increase in cotton water management research since the 2008 survey and better recommendations for infield monitoring have been developed (e.g., Perry and Barnes, 2012). It is clear that now the focus needs to be on technology transfer, such as grower related publications, like that from Leib et al. (2015).

Increased field monitoring also had benefits in regards to nitrogen use. Growers using nitrogen testing reported higher yields and nitrogen use efficiencies (NUE) in most scenarios. There were two exceptions to the previous statement: in the Far West the yield was actually slightly lower (or not significantly different between the two data points) for growers using nitrogen testing, and in the Southwest, where the NUE were the same for farmers who didn’t do soil testing. In the Southwest, many of the non-irrigated producers are low input producers and fertilizers may not be applied if there is not a sufficient reserve of soil moisture at the beginning of the season. If it does rain more than expected, these fields can become nitrogen limited and result in high NUEs.

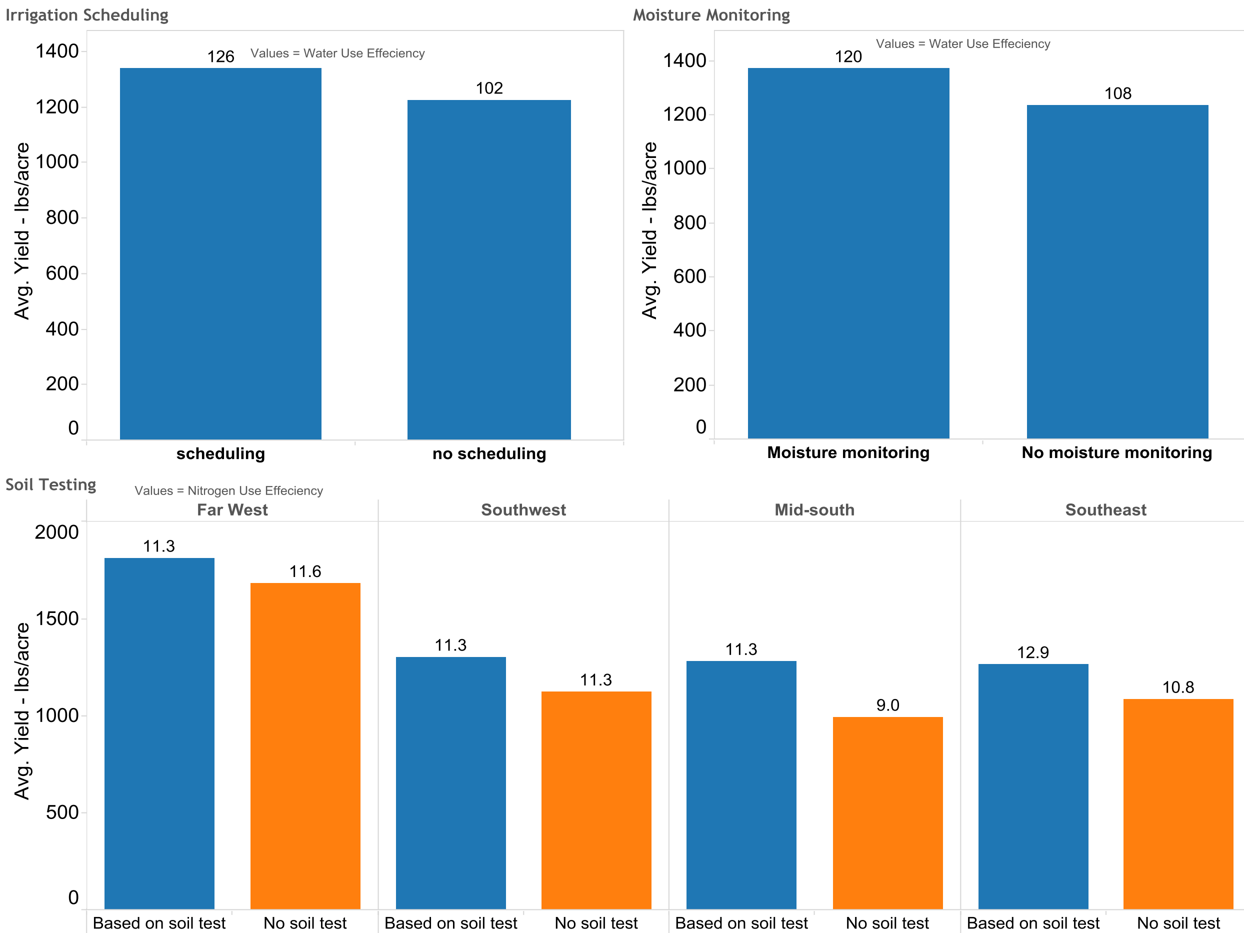


Figure 16: Yields for plots with field monitoring for Nitrogen and moisture and irrigation scheduling

Crop performance was also measured as a function of the use of other precision agriculture technologies such as GPS, yield monitoring, autosteer GPS, and imaging. Differences observed in yields as a function of technology adoption does not indicate that if the technology was adopted that a farmers yield would necessarily increase; however, it does indicate that farmers using the technology have higher yields, for example, but these increased yields are affected by many other aspects beyond technology use. With this interpretation precautionary note, Figure 17 indicates that farmers in most regions who adopted the examined technologies reported higher yields. In Figure 17, the average cotton yield is located on the Y axis and the width of each bar and the number at the top of each bar correspond to the number of respondents in each yes or no category. This analysis provides the viewer with both the sample number for each category and the corresponding average yield.

Farmers reporting the use of GPS systems had resulting yields higher than those who did not in all regions except the Southeast. The Southeast, interestingly, also had the most respondents reporting the use of GPS systems. The Mid-south and Far West reported the largest difference in yields for the adoption of GPS systems; however, the number of respondents in the Far West was small (4) and making this larger change less meaningful due to the small sample size. Overall, few growers use GPS systems and the ones that do use it, generally report higher cotton yields.

Real time yield monitoring has rapidly become more common on many cotton pickers with the progression of computer and sensor technologies. Other research has shown that many cotton pickers have the ability to monitor yield; however, growers do not use this feature due to varying reasons. Growers using real time yield monitoring have reported higher average cotton yields for all growing regions. These results could highlight the benefit of yields from yield monitoring, such as granular data surrounding crop performance in certain field regions, which can help inform and improve management strategies. The overall trend indicates that few farmers are using the real time yield monitoring, with the highest adoption in the Mid-south at 38%, but the growers using this technology report higher average yields for all regions. Additional outreach and education around the benefits of yield monitoring as well as assisting growers with integrating real time yields monitoring could increase its use and may increase average cotton yields.

Grower adoption of autosteer systems was overwhelming in all regions, with more than 60% adoption in all growing regions. The average reported yields for all regions were higher for growers using autosteer, except in the Far West, where there was little change. Field imaging was far less implemented among growers, but also showed similar yield results, with the average reported yields for growers using imaging higher for all regions. The Southeast reported the highest use of imaging among all regions, with 14% of the farmers using this technology. Given the relatively low use of this technology and the possible benefits to field productivity, more outreach and education to promote imaging could have positive effects on cotton yields. The future application of drones in agriculture may also make imaging technology more widely available, cost effective, and timely, compared to satellite or manned aircraft.

Farmers using precision agriculture technologies generally reported higher field performance based on resource efficiencies and yields. The reported difference could be resulting from many variables; however, increased technology adoption could lead to increased field performance. In the eyes of the cotton grower, the potential increased field performance must create savings or increase revenue enough to justify the capital and manpower to implement these technologies. Organizations such as Cotton Incorporated can help reduce the manpower and startup difficulties surrounding the technology adoption, although the financial burden falls solely on the grower at this point.

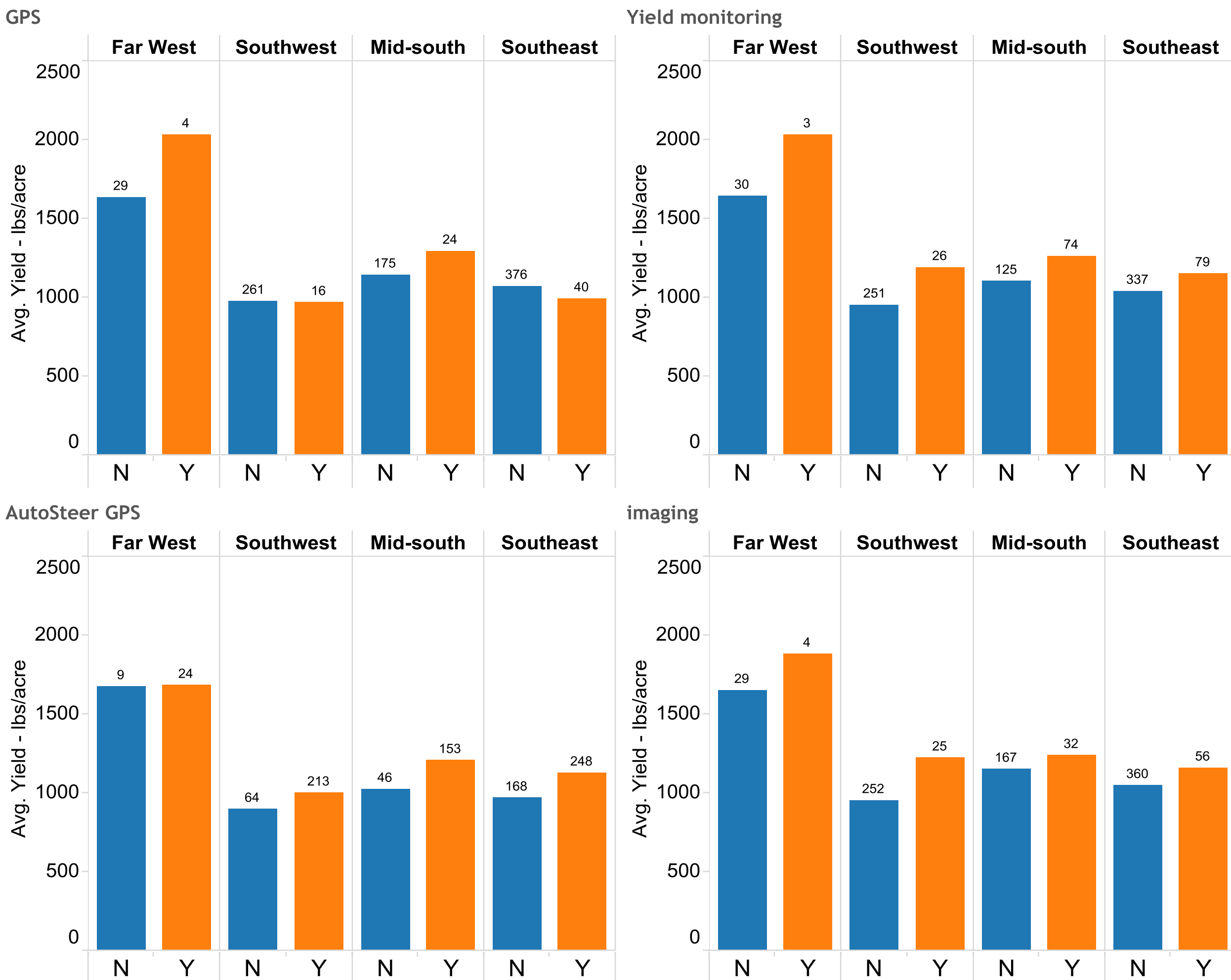


Figure 17: Precision agriculture use by region and corresponding reported yields. Labeled values correspond to number of respondents.

A clear concern for cotton producers is herbicide resistant weeds, as evidenced by the fact that 72% indicated they check for weed escapes (76% in 2008), 82% used a pre-emergent herbicide (70% in 2008), 79% alternated herbicide modes of action (62% in 2008) and 66% reported hand hoeing (not asked in 2008). Producers are also taking advantage of new technologies to be more precise in their application with 92% reporting at least one upgrade in the last 10 years. This includes adding GPS-based swath control (51% in 2015; 32% in 2008), guidance systems (64% in 2015; 44% in 2008) and real-time flow control (60% in 2015; 55% in 2008). Most applications are done with a ground rig (85%) as opposed to aerial (similar results in 2008). 71% indicated they use a professional consultant to advise them when to treat with a foliar insecticide, and less than 6% indicated using a calendar based spray schedule. Thirty-three percent indicated they had fields that received no foliar insecticides during the season (29% in 2008). The estimated acres not treated with an insecticide were a total of 174,795 (21% of reported cotton acres).

On average, producers made six trips across the field to apply herbicides, insecticides, growth regulators and harvest aids during the year. In these applications, growers reported an average of two products mixed, such as two herbicides with different modes of action to minimize weed resistance. For the insecticide applications, there were similar distributions of target pest in 2008 and 2015, with a noticeable increase in thrips in 2015, detailed in Table 4 and 5. There have been reports of thrips developing resistance to certain seed applied insecticides, and one product that controlled thrips was removed from the market, so managing them has become more difficult.

Table 4: Target pest for 2008 and 2015

	2008					2015				
What are your target pests?	**FW**	**SW**	**MS**	**SE**	***U.S.***	**FW**	**SW**	**MS**	**SE**	***U.S.***
Thrips	13%	27%	59%	29%	*35%*	**33%**	**64%**	**78%**	**70%**	**69%**
Stink Bugs	6%	13%	49%	73%	*39%*	18%	24%	57%	87%	59%
Aphids	40%	29%	51%	25%	*35%*	58%	51%	62%	44%	50%
Plant bugs	7%	7%	87%	36%	*36%*	18%	13%	88%	53%	47%
Bollworm/Budworm	8%	17%	36%	39%	*28%*	6%	18%	39%	27%	26%
Spider Mites	37%	5%	35%	5%	*16%*	55%	11%	41%	20%	23%
Cotton Fleahopper	4%	23%	5%	3%	*11%*	6%	50%	8%	4%	18%
Fall Armyworm	4%	3%	8%	15%	*8%*	3%	5%	14%	20%	14%
Grasshoppers	0%	3%	1%	6%	*3%*	6%	14%	5%	13%	11%
Beet Armyworm	12%	5%	4%	9%	*6%*	18%	9%	5%	13%	10%
Cutworms	5%	1%	16%	5%	*6%*	9%	3%	21%	11%	10%
Lygus	49%	9%	18%	3%	*13%*	**64%**	5%	14%	5%	9%
Boll Weevil	2%	9%	6%	4%	*6%*	9%	9%	3%	8%	7%
Loopers	8%	1%	6%	7%	*5%*	6%	1%	9%	9%	7%
Banded Winged Whitefly	4%	1%	1%	2%	*2%*	18%	0%	2%	4%	3%
Pink Bollworm	7%	3%	1%	2%	*3%*	9%	3%	5%	3%	3%
Silverleaf Whitefly (Bemesia)	26%	1%	0%	2%	*3%*	30%	1%	1%	3%	3%
Southern Armyworms	0%	1%	3%	4%	*2%*	0%	0%	4%	5%	3%
European Cornborer	0%	1%	1%	2%	*1%*	0%	0%	3%	2%	2%
Cotton Leaf Perforator	1%	1%	1%	2%	*1%*	6%	1%	2%	1%	1%
Saltmarsh Caterpillars	4%	0%	1%	0%	*0%*	3%	1%	1%	0%	1%
None						0%	3%	0%	0%	1%
Other mentions						0%	1%	1%	0%	0%

Table 5: Cotton grower target pest by region and U.S. average. Values shown are the difference between 2008 and 2015 data (2015-2008).

	(2015-2008 data)				
What are your target pests?	**Far West**	**Southwest**	**Mid-south**	**Southeast**	***U.S.***
Thrips	**20%**	**37%**	**19%**	**41%**	**34%**
Stink Bugs	**13%**	**11%**	**8%**	**14%**	**20%**
Aphids	18%	23%	11%	18%	16%
Plant bugs	**12%**	**6%**	**1%**	**17%**	**11%**
Grasshoppers	**6%**	**11%**	**4%**	**7%**	**8%**
Cotton Fleahopper	**2%**	**27%**	**2%**	**1%**	**8%**
Spider Mites	**18%**	6%	6%	**15%**	7%
Fall Armyworm	-1%	3%	5%	5%	6%
Cutworms	4%	2%	5%	6%	4%
Beet Armyworm	6%	4%	1%	4%	4%
Loopers	-2%	1%	3%	2%	2%
Boll Weevil	7%	1%	-3%	4%	1%
Banded Winged Whitefly	14%	-1%	1%	2%	1%
Pink Bollworm	2%	1%	3%	0%	1%
Southern Armyworms	0%	0%	1%	1%	1%
European Cornborer	0%	0%	2%	0%	1%
Saltmarsh Caterpillars	-1%	1%	0%	0%	0%
Cotton Leaf Perforator	5%	0%	1%	-1%	0%
Silverleaf Whitefly (Bemesia)	4%	0%	0%	1%	0%
Bollworm/Budworm	-1%	1%	3%	-12%	-1%
Lygus	**15%**	-4%	-4%	1%	-4%

Additional Field Productivity Analysis

Field productivity is an important measure that can drive grower profitability. In 2014, the average U.S. cotton yield was 838 pounds per acre based on USDA data compared to the average of 1079 pounds per acre in this survey. Two possible explanations for the differences are that 1) producers tended to report on their better fields – not the “typical” field as requested; and 2) the producers willing to report data in this survey are likely above average agronomic managers and, as already noted, had extensive experience growing cotton.

One goal of this report was to compare how crop performance has changed since the previous survey. The yields, on average, for 2014 were 37 lb. per acre higher than the 2008 survey results. Yield increasers were observed in all regions except the Southwest, with the Southeast having an 18% increase compared to 2008 data, illustrated in Figure 18. Many factors can influence the average yields, such as rainfall and other climate considerations making it difficult to determine the causes of yield changes from year to year.

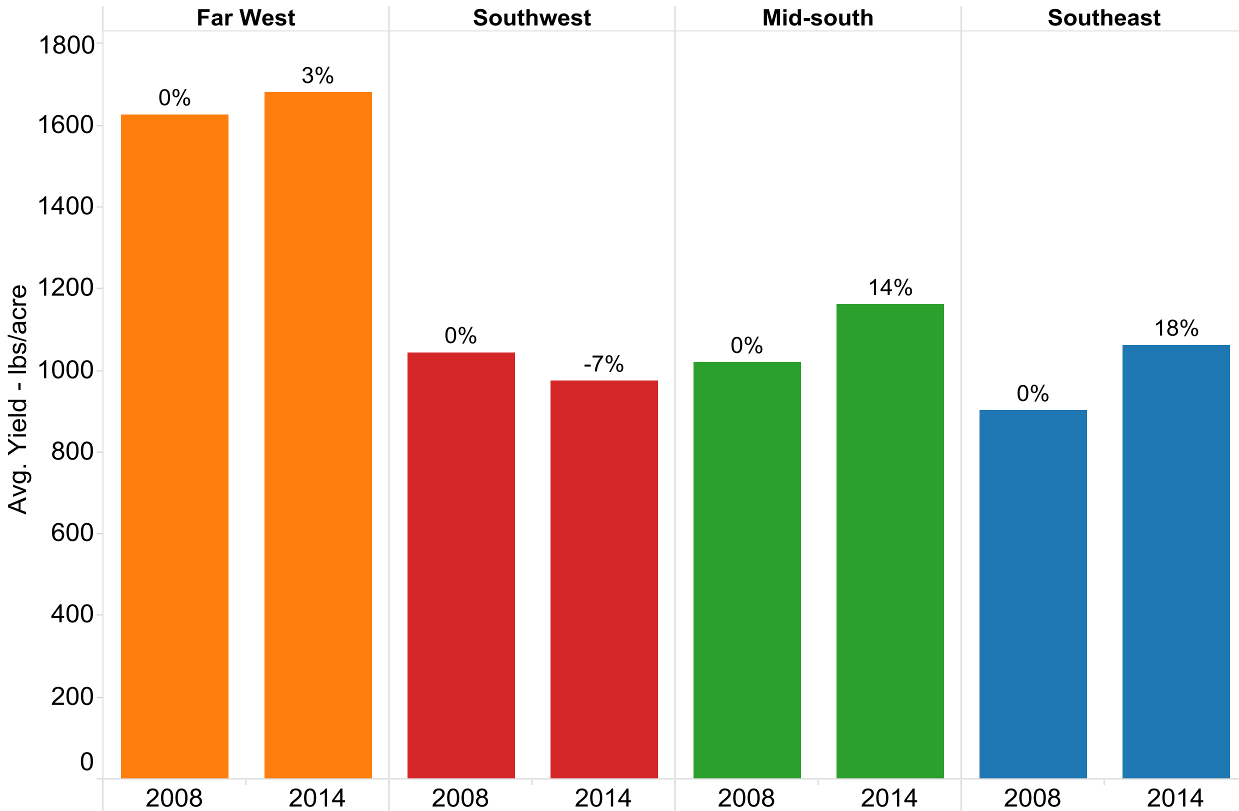


Figure 18: Average yield by region for 2008 and 2014. Labeled values represent percent change from 2008 yields.

An analysis was also performed to determine average yields based on survey response dates and education. One hypothesis tested was that early responders to the survey are more proactive and would have proactive growing methods that would result in higher yields. The data collected in this survey did not support this hypothesis. There were no real trends to suggest that the respondents completing the survey earlier had higher yields.

A second hypothesis was that growers with higher education levels would report higher yields. The respondent data did not support this hypothesis either as there were no significant improvements in yield with higher education levels, depicted in Figure 19. It is worth noting that bachelor degrees were most commonly held by growers and these growers generally performed higher than most of the other education levels with a few exceptions.

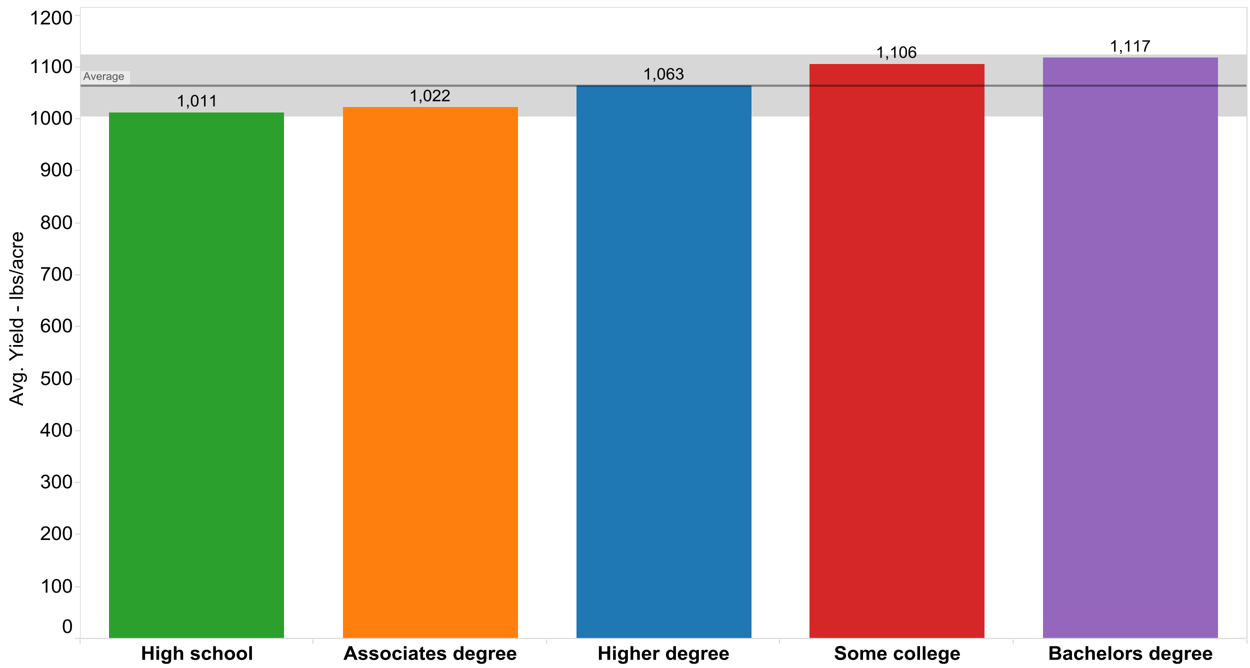


Figure 19: Average yields by education level.

Conservation Practices and Natural Habitat Management

Conservation practices play an important role in minimizing the environmental impacts of cotton growth and preserving the environment, which is needed to sustain continual cotton production into the future. To understand the adoption of certain practices, the survey asked growers to indicate which if any conservation practices that is used on their farm. Of the conservation practices listed, 69% of the growers indicated using at least one of the practices. The top three implemented practices were field borders, conservation cover, and grass waterway, with more than 20% adoption for all three practices.

Table 6: Percent using listed conservation practice.

Conservation Practice	Respondent Use
Field borders	26%
Conservation cover	21%
Grass waterway	20%
Vegetative border	14%
Recycle farm plastic (pesticide containers, poly pipe…) and/or paper and cardboard	14%
Drop pipes for erosion control	10%
Precision leveled	10%
Field strip cropping	6%
Contour strip cropping	5%
Riparian forest buffer	4%
Water and sediment control basin	4%
Filter strip	3%
Sediment basin	2%
Contour buffer strip	2%
Riparian herbaceous cover	1%
Stream habitat improvement	1%
None of the above	31%

Natural habitat management practices were also surveyed to gain an understanding of what growers do to preserve land for ecological reasons. Of the 66% of producers who indicated they have riparian areas on their farm, 74% indicated they leave the riparian areas undisturbed, compared to 53% in 2008. Also, 68% of respondents indicated they make efforts to improve the wildlife habitat on their farm (58% in 2008). For example 41% indicated they maintain field borders so they are conductive for wildlife habitat, and 32% indicated they preserve forested areas for wildlife.

Detailed Field Specific Data

Producers were asked about specific production practices for a cotton field that represents typical conditions on their farm. For example, if most of the farm is irrigated, then they were instructed to report on an irrigated field. A majority of the responses (86%) were for the 2014 crop year, and 12% for 2013. Due to climatic differences, planting and harvest dates ranged by region. Typical planting occurred in April or May and harvest in October or November for most of the U.S. Some of the field specific responses are summarized by region in **Table 7.** Of the fields selected, 45% were irrigated, which is slightly higher than the U.S. average of 40%. On average the fields were 18 miles to the gin. Only 6% provided the latitude and longitude of their fields, but 65% did provide their email to get a custom report.

Table 7: Regional averages based on field specific questions for 2015

Measure	U.S.	Southeast	Mid-south	Southwest	Far West
Yield	1079	1062	1161	974	1681
Percent Irrigated	45%	28%	55%	56%	100%
Tillage Passes	2.17	1.37	2.67	2.66	5.18

As noted earlier, there is room for improvement on water management, as 45% of those reporting on an irrigated field did not know (or want to report) the amount of irrigation applied. As mentioned previously, only 38% of respondents indicated that the fields were equipped with a flow meter. Fifty percent reported a pumping depth of less than 175 feet. Twenty one percent reported they did not have a pressure gage on the pump or system and 31% did not know an operation pressure. For the pressures reported, more than 50% had an operating pressure under 30 psi. A majority of irrigation pumps were electric (67%) followed by diesel (24%).

Energy Use and Greenhouse Gas (GHG) Emissions

Energy Hotspot Analysis

Similar to the 2008 analysis of energy use and greenhouse gas emissions, cotton's footprint from field to gin continued to be dominated by fertilizer use for both irrigated and non-irrigated production systems, illustrated in Figure 20. The primary fertilizer impact is associated with the energy intensive nitrogen production process. Figures for GHG distribution are not shown as they were closely correlated to energy, with the exception of nitrogen, which becomes even more dominate due to assumed in-field nitrous oxide emissions. Since the 2008 survey Cotton Incorporated has conducted extensive research into nitrogen management recommendations for modern cotton varieties (Main et al., 2013). The 2015 survey data shows that producers are achieving nitrogen use efficiencies very close to university recommendations across the Cotton Belt, indicating that producers are aware of the importance of good nitrogen management. Progress has also been made in developing tractor-mounted sensors to vary nitrogen application rates to match the crop needs in the field real-time. Such advancements should continue to improve nitrogen use efficiencies and lower cultivation energy requirements.

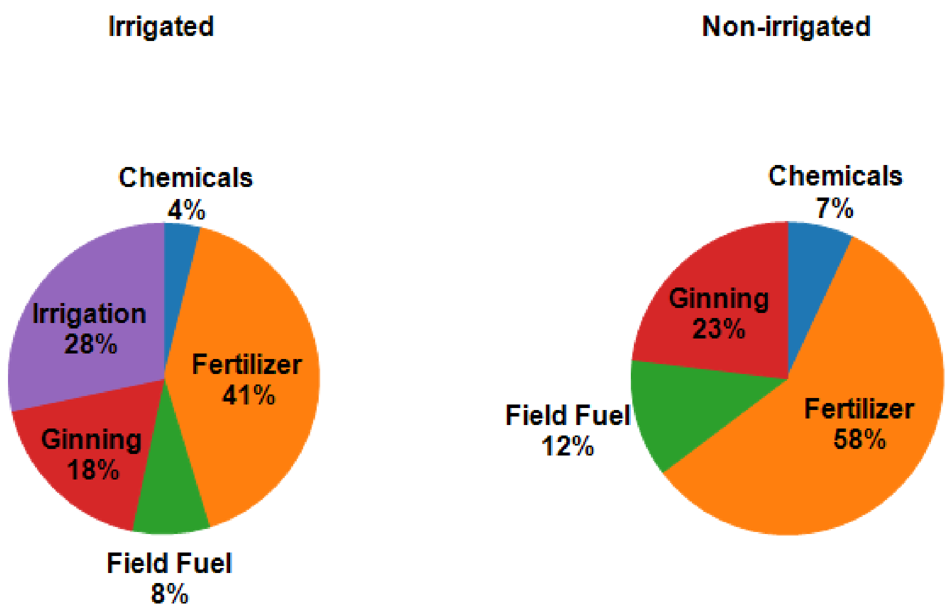


Figure 20: Energy use distribution for irrigated and non-irrigated production systems.

Field performance and GHG emissions

Using the respondent data of crop performance and field practices, additional analysis was performed to find correlations and trends between 1) GHG emissions and energy use, and 2) field practices and performance. Tillage practices have a significant impact on cost, and to an extent on energy use, representing 8% and 14% of the overall energy use for the irrigated and non-irrigated production systems. In Figure 21, field energy use is reported by tillage systems for each region. This analysis indicates that conventional tillage uses the most energy followed by conservation (-18%), and strip-till/no-tillage methods (-49%). These results are consistent with what should be observed in practice and highlight the energy and related expense savings of the less intensive tillage systems.

When performing a similar analysis, but using GHG emissions per pound of cotton as the dependent variable, fuel usage from less intensive tillage practices did not correlate to reduced GHG emissions per pound of cotton. In Figure 22, the data does not show a clear decrease in GHG emissions based on tillage methods. Since fertilizer was the largest contributor to GHG, the fertilizer usage is also listed for each tillage system; however, there was no clear trend related to tillage practice and nitrogen use. This indicates that other factors are driving the GHG emission per lb. of cotton, such as productivity. Since conservation and no-till practices result in lower yields, the GHG emissions savings produced from the tillage practice are negated, which effectively increases all inputs and emissions per unit of cotton.

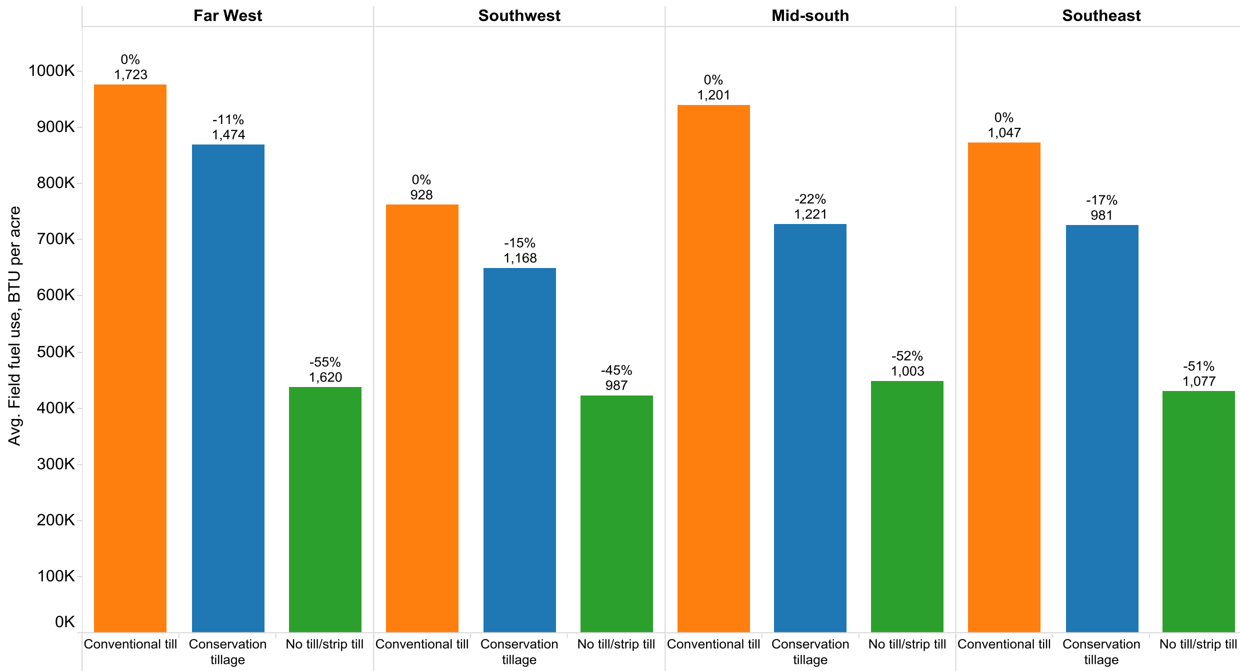


Figure 21: field fuel usage based on tillage practices by region. Percentages represent percent difference from conventional tillage and the number represents average yield for the corresponding data.

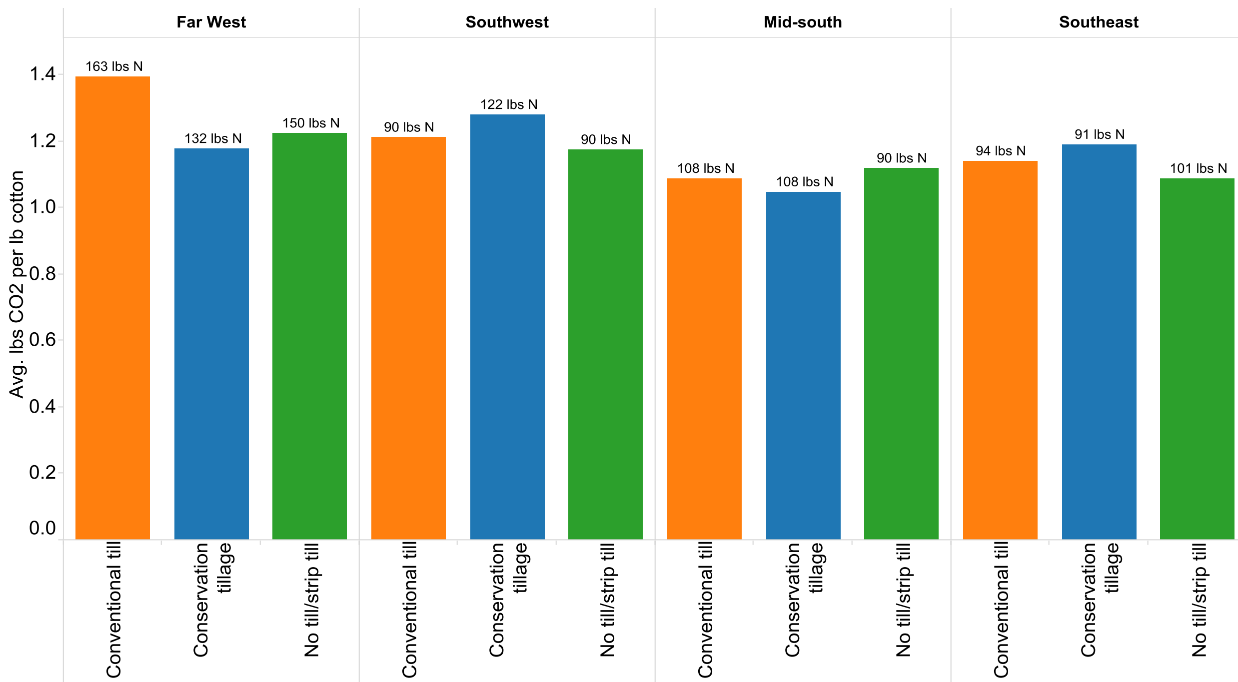


Figure 22: Average GHG emissions as a function of region and tillage methods. The average applied nitrogen for each data group is listed above the bar with units of lbs N per acre.

Productivity (yield), as previously shown, has large influence over the GHG emission per pound of cotton. With increased energy use and production related GHG emission on a per acre basis, yields often increase which decreases the GHG emissions per mass of cotton produced. The relationship between energy use per acre and yield are shown in Figure 23. There is a clear trend showing that increased energy inputs result in higher yields, except in the Far West. The trend lines shown on the plot all have a P-value of less than 0.05, indicating that the trend lines are significant, except for the Far West plot where the P-value was greater than 0.05. The Far West data did not show a clear trend, perhaps due to the low sample size for that region. Examining yield as a function of GHG emissions per acre, Figure 24, displays a similar trend as energy and yield where increased GHG emissions per acre correlate to increased yield, except for the Far West region. While these figures show that increasing yield often requires more energy and creates more GHG emissions per acre, the increased GHG per acres are negated by the increased output per acre when examining the GHG per lb of cotton.

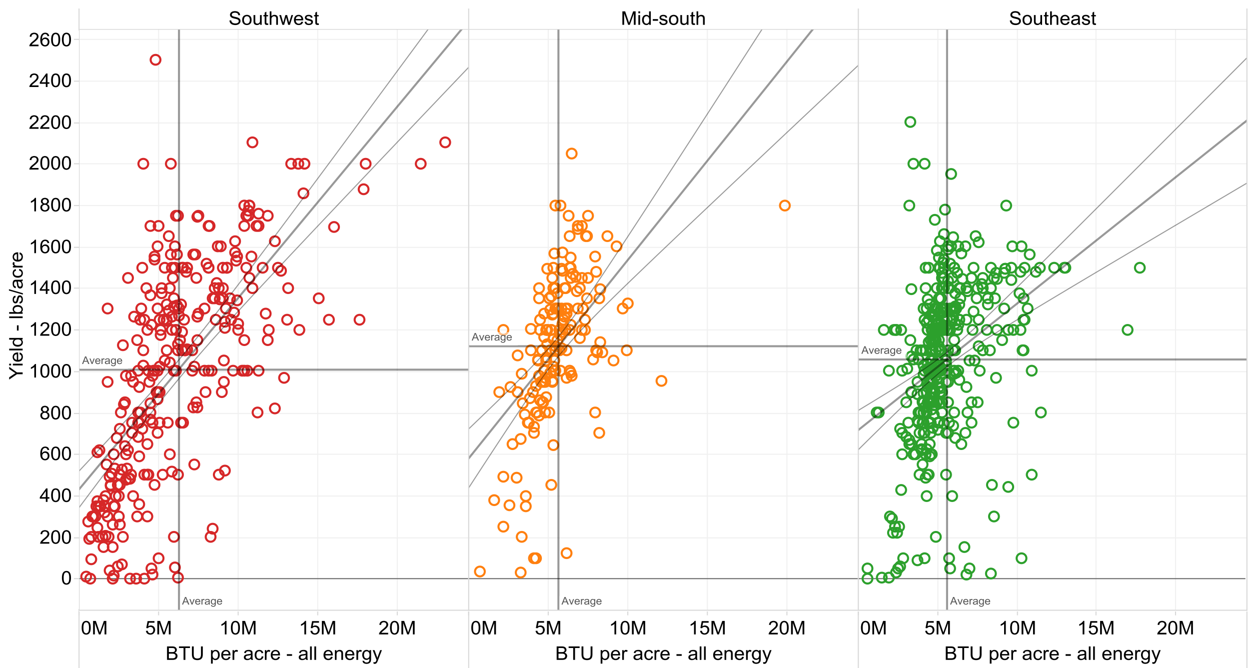


Figure 23: Yield as a function of energy input per acre for each region. Trend lines represented for all regions and have a P-value less than 0.0001 for all regions except the Far West where the trend is not significant, having a P-value higher than 0.05.

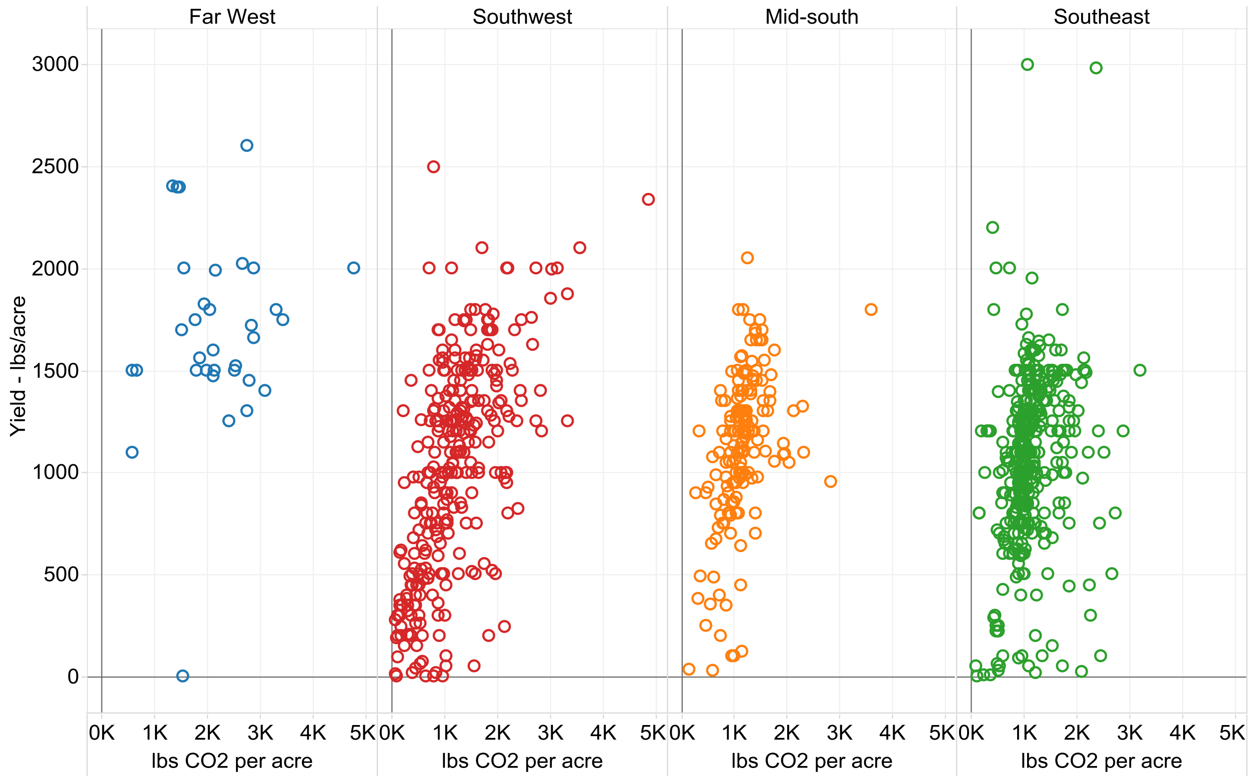


Figure 24: Yield as a function of GHG emissions per acre by region.

The resulting GHG emission averages per region were all similar with an U.S. average of 1.1 lb. of CO2 per lb. of cotton, as depicted in Table 8. Energy use per lb. of cotton was slightly higher in the Southwest and Far West due in part to higher use of irrigation. These values are estimates based on parameters similar to those used in the Fieldprint Calculator.

Table 8: Energy use and GHG emissions per lb of cotton by region

Measure	U.S.	Southeast	Southwest	Mid-south	Far West
BTUs/lb cotton	5667	5,250	6335	5202	7670
Kg CO2 eq. /lb cotton	1.1	1.1	1.2	1.1	1.3

Conclusions

1. The use of an agriculture survey can provide valuable insight into current agriculture systems and track how outreach and technology adoption influences the farming practices over time.

2. The 2015 survey results provided a representative dataset of cotton growers in the U.S.

3. Cotton GHG emissions are highly dependent on variables such as yield, irrigation requirements, and Nitrogen use efficiency.

4. The data consistently suggest that precision agriculture technologies and other advanced field monitor techniques (e.g., soil sampling, sensor-based soil moisture monitoring) may increase field productivity and resource use efficiency.

5. Growers using conservation and no-till/strip-tillage practices reported lower yields; however, they also reported lower field energy usage resulting in lower production costs.

6. Since the 2008 survey, many growers have transitioned to more efficient pivot/sprinkler irrigation methods from furrow/basin methods.

7. Growers reporting the use of cover crops also reported higher yields as compared to no cover crops.

8. Growers are aware of the importance of conservation, with 69% of growers reported using at least one conservation practice on their farms.

9. Grower concerns for environmental impacts of cotton growth have increased in importance from the 31^{st} ranked in 2008 to the 7^{th} most important issue in 2015.

10. Further industry outreach supporting the use of precision agriculture practices can increasingly drive resource-use efficiencies and reduce environmental impacts, which should be measured by additional surveys.

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APPENDIX

Cotton Producer Survey

Cotton Inc.

Cotton Producer Self-Assessment Project

BRI# 15224

Intro

Welcome to the Natural Resources Survey. Your feedback is very important to us!

Please note that to keep this survey completely anonymous, it is not possible to save responses to an incomplete session. Therefore, please be sure you have at least 20 minutes to devote to this survey once you begin. The session will time out after 60 minutes.

Recent Farming

1. Have you grown cotton in the past two years (crop years 2013 and/or 2014)?

   1. 2013
   2. 2014
   3. Both 2013 and 2014
   4. Have not grown cotton in the past two years **[TERMINATE]**

   If Q1=4, Thank you for your time. You have completed the survey.

2. How many acres did your farming business cover in the most recent year that you grew cotton? *Please enter the appropriate crop acreage.*

	№ of Acres
1. Non-irrigated cotton	
2. Irrigated cotton	
3. Crops other than cotton	
4. Non-cropped natural land (this is land not in active farmland and pasture, roads or buildings. This will include CRP, fallow, forestry, field borders, filter strips, and grass waterways.)	
Total farm acres	**AUTOSUM**

If Q2_001 = 0 and Q2_002 = 0, Thank you for your time. You have completed the survey.

IF Q1 IN (2,3) AND Q2_003 = 0 AND Q2_004 = 0, SKIP Q3 AND AUTOPUNCH Q3_003 = 'Y'

3. **[IF Q1 IN (2,3), INSERT "**In addition to cotton, did**"; IF Q1=1 "**Did**"]** you grow any of the following crops commercially in **2014**? *Please check all that apply.*

    1. Alfalfa **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    2. Corn **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    3. Cotton **HIDE; IF Q1 IN (2,3) AUTOPUNCH 'Y'**
    4. Hay **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    5. Pasture **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    6. Peanuts **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    7. Rice **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    8. Sorghum **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    9. Soybeans **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    10. Orchards **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    11. Vegetables **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    12. Vines **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    13. Wheat **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    14. Natural Vegetation – This land is **not** in active farmland and pasture. This will include conservation reserve program, fallow, forestry, field borders, and filter strips. **IF Q1 IN (2,3), ONLY SHOW IF Q2_004 > 0; IF Q1 IN (2,3), IF Q2_004=0, HIDE AND AUTOPUNCH 'N'**
    15. Other **IF Q1 IN (2,3), ONLY SHOW IF Q2_003 > 0**
    16. None of the above

Water Management

4. Please indicate the type and acreage of the irrigation system used on your farm. *Please enter the appropriate crop acreage. Leave a blank space beside the type(s) of irrigation system(s) you do not use on your farm.*

	Acreage
1. Subsurface drip	
2. Surface drip	
3. Furrow using siphon tubes or gated pipe	
4. Basin or flood	
5. Center pivot or linear move (under 30 psi) example: LEPA, LESA	
6. Center pivot or linear move (31-59 psi)	
7. Center pivot or linear move (60 psi or more)	
8. Other type (example: traveling, single gun)	
Total	**AUTOSUM; MUST BE LESS THAN OR EQUAL TO TOTAL AT Q2**

ASK IF Q4_3 > 0; IF Q4_3 = 0, AUTOPUNCH Q5=3 AND SKIP TO Q7

5. If you furrow irrigate, do you manage tailwater to minimize water loss?

    1. Yes **(GO TO Q6)**
    2. No **(GO TO Q7)**
    3. I do not furrow irrigate. **(GO TO Q7)**

ASK IF Q5 = 1

6. What management practices are used to handle tailwater? *Please check all that apply.*

RANDOMIZE 1-5

1. I have a holding pond to capture runoff.
2. I have an irrigation tailwater return system in place.
3. My field and distribution system are designed and operated to minimize runoff (field slope, length and flow rate designed to minimize runoff).
4. Tailwater runoff is routed to other fields.
5. Surge system is used to get even distribution across the field.
6. Other method (please describe): ______________________

7. What is the source of your irrigation water? *Please check all that apply.*

    1. Drilled well(s)
    2. On-farm surface water – *Streams, drainage ditches, lakes, or ponds* ***not*** *delivered by a water organization*
    3. Off-farm surface water – *Public or private water organizations such as US Bureau of Reclamation, Irrigation district, mutual, private, cooperative, neighbor ditches, commercial companies, or community water systems*
    4. None of the above

8. Do you use a flow meter or other device to measure irrigation water volume?

    1. Yes
    2. No

9. How do you schedule irrigations to meet the cotton crop's needs? *Please check all that apply.*

    RANDOMIZE 1-5

    1. I look at the field and make a **visual assessment** of plant vigor, color or wilting or feel the soil for moisture.
    2. I utilize **plant monitoring techniques** such as tracking internode distance, plant height, nodes above white flower or heat unit accumulation.
    3. I use local **real time crop water use** or evapotranspiration (ET) data.
    4. I make applications in response to **local weather forecasts.**
    5. I use soil or plant water **monitoring tools** such as tensiometers, pressure bombs, soil moisture blocks/gypsum blocks or infrared guns.
    6. Other (please describe): ______________________
    7. I do not schedule irrigations

10. Do you have wells on your farm where WATER salinity is a concern?

1. Yes
2. No

Soil Health

11. What practices are used to minimize soil erosion on your farm? *Please check all that apply.*

RANDOMIZE 1-10

1. I maintain **ground cover and surface residue**.
2. I **manage irrigation** to minimize runoff.
3. I use **reduced tillage, strip till, or no till** planting practices.
4. I use **contour terraces or plant rows** along the field contour.
5. I use **grassed water ways** or silt traps.
6. I **level fields**.
7. I design **drains to minimize water velocities.**
8. I plant **winter cover crops.**
9. I plant wheat, or other small grains to serve as **temporary wind strips.**
10. I use **sand-fighters** to minimize wind erosion.
11. Other (please describe): ______________________
12. I do not use any of the practices listed above because erosion is not a problem on my farm.

12. How often do you conduct soil fertility tests on your cotton fields?

1. Never
2. Once or more a year
3. Once every 2 years
4. Once every 3 years
5. Once every 4 or more years

13. Please identify the factors that you use in determining your fertilizer rate. *Please check all that apply.*

RANDOMIZE 1-8

1. Fertilizer costs
2. Soil test recommendations
3. Consultant recommendations
4. Yield goal expectations
5. More efficient application techniques such as sub-soil injection of nitrogen
6. Use of spatial technology such as soil and yield maps
7. Petiole or leaf testing
8. Past experience
9. Other (please describe): ______________________

14. Please indicate the percent of your total crop acreage for which the following methods are used. *Leave blank or enter a zero beside the method(s) below that you do not use. Your responses do not need to sum to 100% if part of your farm does not receive extra organic matter.*

	Percent of Crop Acreage

1. Applied **composted materials** such as gin trash or cotton compost.	
2. Applied **animal manure** such as chicken or cow manure.	
3. Planted **legume cover crops** such as vetch, clover or lupine.	
4. Planted a multispecies cover crop (more than one plant species)	
5. Planted grass, cereal or grain **cover crops** such as wheat, rye, barley, or oats.	
6. Other source of organic matter	

Tillage Methods

15. What is the **primary** tillage method used on your cotton?

1. **No-till/strip-till** - The soil is left undisturbed from harvest to planting except for strips up to 1/3 of the row width (surface residue and soil are disturbed only in the strip).
2. **Conservation tillage including ridge-till, mulch-till or reduced till** (approximately 15% to 30%) or more crop residue is left on the soil surface after planting.
3. **Conventional- tillage** - Full width tillage which disturbs the entire soil surface and is performed prior to and/or during planting. Weeds are controlled by herbicides and mechanical cultivation.
4. Other (please describe): ______________________

Managing Pests and Weeds

16. What are you doing to manage Roundup Ready, Liberty Link and other Herbicide Tolerant Cotton Varieties on your farm? *Please check all that apply.*

RANDOMIZE 1-6

1. I **check** my fields for weeds that have escaped herbicide control.
2. I use **pre-emergent herbicides.**
3. I **use** herbicides which have **different modes of action**.
4. I **plant cover crops** to reduce weed pressure.
5. I **till and cultivate** weeds that have escaped herbicide control.
6. **I hand hoe weeds** that have escaped control
7. I do not grow herbicide tolerant cotton varieties.

17. What changes have you made in ground application techniques over the **last 10 years**? *Please check all that apply.*

RANDOMIZE 1-8

1. I have **added hooded sprayers** to my spray rigs.
2. I have **removed hooded sprayers** from my spray rigs.
3. I use a **sensor-based control system** (e.g., GreenSeeker) for varying application rates.
4. I have equipped my sprayers with **GPS swath controllers.**
5. I use a **variable rate controller** with a GPS receiver for site-specific application of herbicides and insecticides.
6. I have equipped my spray rig with a **guidance system** such as auto steer or light bar.
7. I have added **low-drift spray nozzles.**
8. I use a **flow controller** to match application rate with ground speed.

9. Other (please describe): ____________
10. I have made no changes

18. Understanding that there are many factors to consider when choosing application methods **for insecticides and herbicides,** please indicate the percentage of aerial and ground applications of insecticides and herbicides for the most recent year you grew cotton.

	% of Applications
Aerial	
Ground	
	AUTOSUM TO 100%

□ No insecticides or herbicides applied **BOTH OPTIONS ABOVE MUST BE ZERO TO BE SELECTED**

19. How do you decide you need to apply a foliar insecticide? *Please check all that apply.*

RANDOMIZE 1-3
1. I decide after checking my crop.
2. My scout or consultant makes recommendations
3. I have a set program or calendar spray schedule.
4. Where possible I treat only parts of a field – edges/hotspots.
5. None of the above

20. Were there any cotton fields that **did not** require foliar insecticides in the most recent year you grew cotton?

1. Yes
2. No

ASK IF Q20 = 1

21. Approximately how many cotton acres **DID NOT** require foliar insecticides in the most recent year you grew cotton?

	Acreage
Approximate Acreage	**MIN = 1; MAX = SUM OF Q2_001 + Q2_002**

Management Details

22. Which of the following precision agriculture technologies do you use in your cotton operation? *Please check all that apply.*

RANDOMIZE 1-6
1. I use a **cotton yield monitor** to identify yield variability.
2. I use an **auto steer/guidance system.**

3. I use a **handheld GPS** unit to pinpoint field areas requiring special attention.
4. I make use of **aerial or satellite images** to identify areas needing insecticide, fertilizer or other treatments.
5. I use a **soil map** for management decisions.
6. I use grid or zone **soil sampling**.
7. Other (please describe): ______________________
8. **None** of the above

23. How do you manage riparian land (unfarmed land bordering rivers, wetlands, playas and streams) on your farm? *Please check all that apply.*

    1. Leave undisturbed – not used
    2. Used for extensive/continuous grazing
    3. Fenced for selective grazing
    4. Not grazed
    5. Control pests/weeds
    6. Control vegetation regrowth
    7. Plant native trees, shrubs or grasses
    8. Control vehicle access
    9. Control erosion
    10. Provide alternative watering points for livestock
    11. Maintain filter strips and buffer zones near waterways
    12. Other (please describe): ______________________
    13. Farm does not have river, wetland, playas, streams

24. What efforts are being made on the farm to enhance wildlife habitat? *Please check all that apply.*

    RANDOMIZE 1-7

    1. Some portion of the farm is left unharvested for wildlife feed
    2. Field borders are conducive to wildlife habitat
    3. Manage some field area during the winter to provide wildlife habitat
    4. Forested areas are preserved
    5. Conservation Reserve Program
    6. Wildlife Habitat Incentive Program
    7. Wetlands Reserve Program
    8. Other (please describe):______________________
    9. No special efforts

25. How would you rate the following cotton production concerns or challenges on your farm?

RANDOMIZE; REPEAT HEADER EVERY 9 ROWS	1. Not an Issue	2. Moderate Issue	3. Major Issue
1. Water quality protection from agricultural runoff			
2. Adequate water supply			
3. Water salinity of irrigation wells			
4. Soil salinity			
5. Pesticide drift (herbicides & insecticides)			
6. Efficient use of fertilizer			
7. Weed resistance to herbicides			
8. Insect resistance to insecticides and Bt cotton			
9. Soil erosion			
10. Soil compaction			
11. Dust from harvesting, farming, gins			
12. Effects of agriculture on wildlife			
13. Spread of plant diseases and weeds			
14. Climate change – rainfall & temperature			
15. Consumer attitudes about agriculture's impact on the environment			
16. Cotton production input costs			
17. Variety selection			
18. Cotton's tolerance to heat and drought			
19. Weed control			
20. Seedling vigor and stand establishment			
21. Cottonseed value			
22. Lack of new crop protection products (insecticides, herbicides, etc.)			
23. Plant bug control			
24. Soil sampling and analysis for fertilization			
25. Harvest aid materials and application timing			
26. Stinkbug control			
27. Monitoring cotton's plant growth			

Field Specific

For the next series of questions, please think about **one SPECIFIC cotton field** that represents typical conditions on your farm. For example, a field that has:

- a production practice that is predominant on your farm (if irrigated, select irrigated)
- yield levels representative of your operation (not the "best" or "worst" field)

Answers to the questions about this one specific field should be from the most recent year cotton was planted in that field.

26. What was the production year for the field you selected to use? ____ **[FORCE FOUR DIGITS; MUST BE LESS THAN 2015; IF Q1=1, MUST BE LESS THAN 2014; MUST BE GREATER THAN OR EQUAL TO 2010]**

27. What was the planting date? **[INSERT DROP DOWNS FOR MONTH AND DAY OF MONTH]**

28. Was the field irrigated?

    1. Yes ***(GO TO Q29)***
    2. No ***(GO TO Q37)***

ASK IF Q28=1
29. How many inches of irrigation were applied during the season?

    ____ Inches **MIN=1; MAX = 99**
    □ Don't know

ASK IF Q28=1
30. Do you utilize any of the following to improve irrigation efficiency? *Please check all that apply.*

    RANDOMIZE 1-3
    1. Irrigation scheduling programs
    2. Moisture monitoring equipment
    3. Flow meter
    4. Other tools (please describe): ______________________
    5. None of the above **[EXCLUSIVE]**

ASK IF Q28=1
31. How many irrigation events occurred during the season?

    ____ Events **MIN=1; MAX = 180**
    □ Don't know

ASK IF Q28=1
32. What type of irrigation system was used?

    RANDOMIZE 1-4
    1. Surface (furrow or basin)
    2. Sprinkler with high pressure nozzles
    3. Sprinkler with low pressure drop nozzles
    4. Drip (surface or subsurface)

ASK IF Q28=1
33. If pumping from a well, what was the static water level?

    1. 0- 25 feet
    2. 26-75 feet
    3. 76-125 feet
    4. 126-175 feet
    5. 176 – 225 feet
    6. Greater than 225 feet

7. Don't know
8. Not pumping from a well

ASK IF Q28=1

34. Where is the location of the pressure gauge?

ROTATE 1-2

1. Pump
2. Irrigation system
3. No gauge

ASK IF Q28=1

35. What is the pressure?

1. 0-5 psi
2. 6-10 psi
3. 11-15 psi
4. 16-20 psi
5. 21-30 psi
6. 31-40 psi
7. 41-50 psi
8. 51-60 psi
9. Greater than 60 psi
10. Don't know

ASK IF Q28=1

36. What is the dominant energy source for your pumps?

RANDOMIZE 1-3

1. Diesel
2. Electric
3. Natural gas
4. Other (please describe): _______________________

37. What was the lint yield in pounds per acre?

_____ Pounds per acre **MAX = 4,000**

ASK IF Q28 = 1

38. Since this field was irrigated, what is your estimate of what the yield would have been if it had been grown without irrigation?

_____ Pounds per acre **MAX = 4,000**
□ Don't know

39. What was the total rainfall, in inches, received during the cotton growing season (in-season rainfall)?

_____ Inches

□ Don’t know

40. What is the acreage of the field?

____ Acres **MAX = 1,000**

41. What type of winter cover was used?

RANDOMIZE 1-5
1. The soil had residue from the previous crop most of the winter
2. The soil was bare most of the winter
3. Native vegetation
4. Planted cover crop
5. The field was double cropped
6. Other (please describe): ______________________
7. No winter cover was used

42. How often is cotton planted on this field?

1. Every year
2. 2 of 3 years
3. Every other year
4. 1 of 3 years
5. Other (please describe): ______________________

43. What is the primary tillage method used on this field?

1. **No-till/strip-till** - The soil is left undisturbed from harvest to planting except for strips up to 1/3 of the row width (surface residue and soil are disturbed only in the strip).
2. **Conservation tillage** including ridge-till, mulch-till, stale seedbed, or reduced till (approximately 15% to 30% or more crop residue is left on the soil surface after planting).
3. **Conventional tillage** - Full width tillage which disturbs all the soil surface and is performed prior to and/or during planting. Weeds are controlled by herbicides and/or mechanical cultivation.
4. **Other** (please describe): ______________________

ASK IF Q43=2

44. For each of the following **conservation tillage** methods, please enter the number of trips (for example, 1, 2, 3…) for fall and spring tillage operations.

	Row Cleaners	Chisel	In-row Chisel	Disk	Field Cult.	Bed/ Hip/List	Other
Fall	__	__	__	__	__	__	__
Spring	__	__	__	__	__	__	__

ASK IF Q43=3

45. For each of the following **conventional tillage** methods, please enter the number of trips (for example, 1, 2, 3…) for fall and spring tillage operations.

	Mold-board	Rip	Chisel	Disk	Field Cult.	Bed/ Hip/List	Other
Fall	__	__	__	__	__	__	__
Spring	__	__	__	__	__	__	__

~~SHOW Q46 AND Q47 ON THE SAME SCREEN~~

46. Considering the use of herbicides, insecticides, plant growth regulators, fungicides, nematicides, defoliants, desiccants, and boll-openers applied by ground or air including all burndown and post-harvest applications;

    About how many separate application trips were made on this field?

    ____ Applications ***(IF ZERO, SKIP TO Q48)***
    □ Don't know

ASK IF Q46>0 OR DON'T KNOW

47. On average about how many different products were used **in each application**? *(For example, if a tank mix of two insecticides and one herbicide were applied, that would be 3 chemicals for that application.)*

    1. 1
    2. 1.5
    3. 2
    4. 2.5
    5. 3 or more

48. What are your target pests? *Please check all that apply.*

    1. Aphids
    2. Banded Winged Whitefly
    3. Beet Armyworm
    4. Boll Weevil
    5. Bollworm/Budworm
    6. Cotton Fleahopper
    7. Cotton Leaf Perforator
    8. Cutworms
    9. European Cornborer
    10. Fall Armyworm
    11. Grasshoppers
    12. Loopers
    13. Lygus
    14. Pink Bollworm
    15. Plant Bugs
    16. Saltmarsh Caterpillars
    17. Silverleaf Whitefly (Bemesia)
    18. Southern Armyworms
    19. Spider Mites
    20. Stink Bugs
    21. Thrips
    22. Other insects (please describe): ______________________

49. Are fertilizer application rates based on soil test recommendations?

1. Yes
2. No

Please provide the pounds (lbs) of applied Nitrogen, Phosphate and Potash as well as details related to their application. (This includes all applications on this field including pre-plant, at-planting and side-dress fertilizers.)

	Nitrogen - (N)	Phosphate - (P_2O_5)	Potash - (K_2O)
50. **Total lbs Per Acre Per Year** Examples: • 100 lbs Urea = 46 lbs of N; • 28.2 gal UAN 32 = 100 lbs of N; • 100 lbs 0-0-60 = 60 lbs of (K_2O)	____ **MAX = 300**	____ **MAX = 300**	____ **MAX = 300**
51. **Number of Applications Per Year**	____	____	____
52. **Application Rate Below, At, or Above Soil Test or University Recommendation** **DO NOT FORCE RESPONSE IF Q50 =0 AND Q51 = 0**	1. Below 2. At 3. Above	1. Below 2. At 3. Above	1. Below 2. At 3. Above
53. **Dominant Source of Nitrogen** • Examples: Dry Blend, Liquid Blend, Anhydrous Ammonia, Urea, and UAN 32 **DO NOT FORCE RESPONSE IF Q50 =0 AND Q51 = 0 FOR NITROGEN**			
54. **Dominant Application Method of Nitrogen** **DO NOT FORCE RESPONSE IF Q50 =0 AND Q51 = 0 FOR NITROGEN**	1. Injected 2. Surface banded 3. Broadcasted (ground, air, or fertigation) 4. Broadcasted and incorporated		

55. Not including fertilizer applications through an irrigation system, how many trips (ground or air) were necessary to apply all fertilizer products?

_____ Trips
□ Don't know

56. Please indicate if you use Micro nutrients, Lime, or Gypsum.

	1.Yes	2. No
1. Micro nutrients		
2. Lime		
3. Gypsum		

57. What were moisture conditions at picking?

FLIP ORDER 1-3 AND 3-1
1. Cotton was dryer than normal
2. Normal
3. Cotton was wetter than normal

58. What conservation practices are associated with this field? *Please check all that apply.*

RANDOMIZE
1. Sediment basin
2. Grass waterway
3. Tailwater recovery system
4. Riparian forest buffer
5. Water and sediment control basin
6. Contour strip cropping
7. Filter strip
8. Contour buffer strip
9. Field borders
10. Field strip cropping
11. Conservation cover
12. Riparian herbaceous cover
13. Vegetative border
14. Stream habitat improvement
15. Drop pipes for erosion control
16. Precision leveled (0.1 to 0.3 % grade)
17. Recycle farm plastic (pesticide containers, poly pipe…) and/or paper and cardboard
18. None of the above

59. How many miles is this field from the gin?

_____ Miles
□ Don't know

Demographics

The last few questions are for classification purposes only.

60. In what state is **MOST** of your farm located?

1. Alabama
2. Arizona
3. Arkansas
4. California
5. Florida
6. Georgia
7. Kansas
8. Louisiana
9. Mississippi

10. Missouri
11. New Mexico
12. North Carolina
13. Oklahoma
14. South Carolina
15. Tennessee
16. Texas
17. Virginia

61. In what county or parish is **MOST** of your farm located?

____

62. What is the latitude and longitude of the approximate center of the “typical” field you provided data on?

Latitude: __ __ __ __ __ __ __

Longitude: __ __ __ __ __ __ __

□ Prefer not to answer

63. Please indicate your age.

1. 20-30
2. 31-40
3. 41-50
4. 51-60
5. 61+

64. How many total years have you been growing cotton?

1. 0-5
2. 6-10
3. 11-20
4. 21-30
5. 31+

65. What is your highest level of education?

1. High school
2. Some college
3. Associate degree
4. Bachelor degree
5. Masters or higher degree

66. To help Cotton Incorporated and the Cotton Board improve your access to results from its cotton production research program, please rate how much you depend on the sources of information below.

RANDOMIZE; REPEAT HEADER	1. None	2. Slightly	3. Moderately	4. Greatly

EVERY 6 ROWS				
1. Ag. Magazines (ex: Cotton Grower, Cotton Farming, Progressive Farmer, Farm Press, etc)				
2. University/Extension Specialists or Agents				
3. Crop consultants				
4. Other cotton producers				
5. Agribusiness sales representatives				
6. Cotton industry organizations (ex: National Cotton Council, Cotton Incorporated, local and regional grower associations)				
7. Internet web sites				
8. Smart Phone Apps				
9. Email newsletters				
10. Field Days/Demonstrations				
11. Technical Publications/Journals/Fact Sheets				
12. Agricultural conferences				

Close

That completes the survey. Thank you very much for your time!

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To sign up for the custom report, please provide your name and email address below. Your information and choices will be shared with Cotton Incorporated.

First name: ______________________

Last name: ______________________

Email: ______________________

□ I am not interested in a custom report.

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