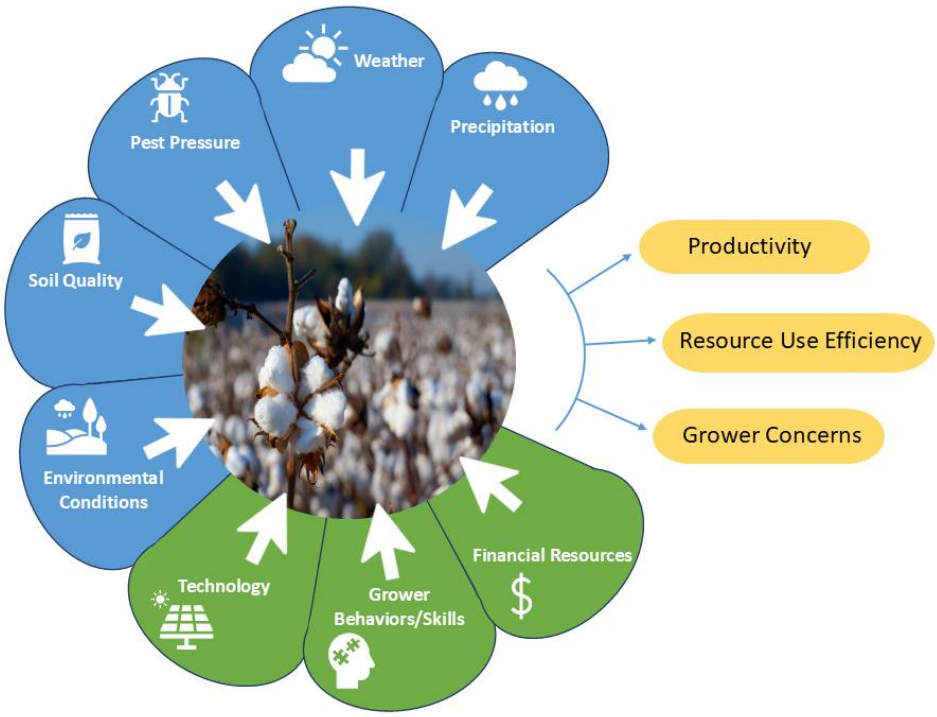
Sustainable Cotton Farming Trends: Leveraging Natural Resource Survey Insights for U.S. Cotton Production

Jeyran Bayramova,[a] Steven Pires,[a,b] Ed Barnes,[a] Gaylon Morgan,[a] Ryan Kurtz,[a] and Jesse Daystar [a]

*Corresponding author: JDaystar@cottoninc.com

DOI: 10.15376.biores.19.4.7279-7319

GRAPHICAL ABSTRACT



Sustainable Cotton Farming Trends: Leveraging Natural Resource Survey Insights for U.S. Cotton Production

Jeyran Bayramova,[a] Steven Pires,[a,b] Ed Barnes,[a] Gaylon Morgan,[a] Ryan Kurtz,[a] and Jesse Daystar [a]

Cotton cultivation in the United States is relevant globally, with the nation ranking among the top producers and exporters. This study examines conservation practice adoption trends and technological advancements in U.S. cotton production, focusing on sustainability and productivity. Efforts to improve cotton farming practices have reduced its environmental impacts, including decreased soil loss, water usage, and greenhouse gas emissions. Precision agriculture technologies have been instrumental in enhancing efficiency and reducing input costs, albeit with varying degrees of success. To gain deeper insights into cotton grower challenges and needs, a Natural Resource Survey was conducted in 2023 with 753 respondents. As a follow-up to the 2008 and 2015 surveys, the insights from this survey provide valuable data on grower practices and priorities, highlighting the increasing influence of climate change on cotton production. The findings underscore the importance of conservation agriculture and ongoing research to address grower concerns while improving production efficiency. Particularly noteworthy are the outcomes indicating an increase in cover crop adoption and a decrease in tillage practices, reflecting the industry's commitment to sustainability. This study contributes to understanding the dynamics shaping the U.S. cotton industry and offers insights into the challenges and opportunities for continual improvement in U.S. cotton cultivation.

DOI: 10.15376.biores.19.4.7279-7319

Keywords: Cotton; Survey; Sustainable agriculture; Precision technologies; Cover crops; Pest management and pesticides; Water use; Conservation practices; Biodiversity

Contact information: a: Cotton Incorporated, 6399 Weston Pkwy, Cary, NC 27513;
*b: North Carolina State University, Department of Forest Biomaterials, 2820 Faucette Dr., Raleigh, NC 27607, USA; *Corresponding author: JDaystar@cottoninc.com*

INTRODUCTION

Sustainability Trends in Cotton Production

Cotton represents a significant global commodity, characterized by active trade in both its raw and processed forms. The United States is the third among global cotton producers and holds a dominant role in international exports, supplying over 35% of the world's raw cotton (Cotton Sector at a Glance 2022). Cotton cultivation in the U.S. is centered in the 17 southern-tiered states known as the "Cotton Belt," with Texas leading as the largest producer, accounting for approximately 40% of the nation's cotton output in recent years. Cotton is predominantly cultivated for its lint, which serves as fiber, while its seeds are a valuable byproduct utilized in various ways, including cottonseed oil and animal feed. Notably, the inclusion of whole cottonseed in the diet of lactating dairy cows

has been shown to consistently reduce methane (CH_4) emissions, which are among the most potent greenhouse gas emissions contributing to climate change (Grainger *et al.* 2010). Other parts of cotton plants, such as cotton stalks, have potential uses as renewable sources of cellulose (Prakash *et al.* 2024).

Among fiber types, cotton is perceived by consumers (LifestyleMonitor, 2023) as more environmentally friendly; however, all fiber production has an environmental impact. Continuous improvement is a key tenant of U.S. cotton production. Over the past four decades, U.S. cotton growers have decreased soil loss by 45%, improved irrigation water use efficiency by 58%, and reduced greenhouse gas emissions by 25%, all while improving land use efficiency by 30% (Field to Market 2021). These achievements are primarily the result of improvements in irrigation management and precision technologies, cotton variety development, and Integrated Pest Management (IPM) strategies. Notably, the U.S. has seen a reduction of over 50% in insecticide applications in the past 30 years (Mississippi State University 2022), thanks to boll weevil eradication efforts, biotechnology, new cotton varieties, and IPM.

Recognizing the advantages of digitalization in U.S. agriculture, current initiatives are directed towards enhancing farming efficiency, decreasing inputs, boosting yields, and ultimately sustaining the livelihoods of cotton farmers while also addressing environmental concerns. Precision technologies are increasingly spotlighted, with Autosteer/GPS applications integrated into the management of 40% of all U.S. farm and ranchland acreage for on-farm production by 2019, and adoption rates nearing 65% for cotton-planted acreage (McFadden *et al.* 2023). These technologies have resulted in a reduction of both overall inputs and costs for fertilizers, pesticides, and fuels among adopters, although the extent of reductions has been modest and varies depending on the type of technology utilized.

Through the adoption of sustainable agriculture practices, such as cover crops and no-till, cotton growers help to restore soil health, mitigate climate change, and continually improve the industry. Thus, for the last decade, planted cover crop acreage increased by nearly 50%, while cotton farmers using reduced/no-till practices reached 45% (Wallander *et al.* 2021; ICAC 2022). Including cotton yields, the adoption of regenerative practices by U.S. farmers has resulted in an annual increase of over 8.8 million tons of carbon stored in cultivated cropland soils (USDA 2022). Informed consumers and industry stakeholders can contribute by opting for sustainable apparel choices and supporting initiatives like the Regenerative Cotton Fund and Climate Smart Cotton Program, both of which prioritize soil health, continual improvement, and the adoption of other conservation practices.

Understanding the economic, social, and sustainability aspects of cotton production is essential in addressing its profitability and environmental concerns. Developed by Cotton Incorporated, the global cotton life cycle assessment (LCA), first introduced in 2010 and last updated in 2016, provides comprehensive data on cotton fiber production, textile manufacturing, and consumer use impacts. A key discovery from this LCA revealed that textile manufacturing and consumer usage were dominant categories across the entire cotton supply chain due to their substantial energy consumption—such as fiber processing during manufacturing and laundering in consumer use. Although the agricultural phase generally exhibited lower impacts in most categories, blue water consumption was highest for cotton cultivation (Cotton Incorporated 2016).

Considering agriculture's unique opportunity to mitigate climate change impacts, more research is needed to better understand how the adoption of conservation practices and precision agriculture technologies is enhancing crop productivity and increasing the

resiliency of agricultural landscapes globally. In general, conservation practices, such as cover cropping and reduced/no tillage, can lower the environmental impacts of cotton production and improve soil health (Soil Health Institute 2023). There remains a limited understanding of how beneficial these practices are across regions with different topography, climatic conditions, and water availability. The latter, water availability, has posed challenges to all agricultural sectors, including cotton production, potentially affecting yields due to changes in precipitation patterns, increased weather extremes, and shifts in pest pressure. As examples, Hurricane Harvey resulted in a $100 million loss to Texas cotton in 2017 (Fannin 2017), while drought conditions caused a record 46% crop loss in the U.S. when considering all-cotton production in 2022 (Meyer *et al.* 2023). To address water supply challenges, further research is needed to understand and cope with excessive and limited water for cultivating cotton into the future. This includes exploring adaptations such as stress-resistant crop varieties, sustainable agricultural practices such as cover crop and no-tillage, modifying IPM and nutrient management recommendations, improving irrigation methods, *etc*. Climate change may also lead to water scarcity in some regions, forcing a shift in acreage to non-irrigated production due to limited water availability and declining profitability. However, amidst these challenges, there are also emerging opportunities. For instance, rising temperatures have enabled regions such as Kansas to expand cotton cultivation notably compared to a decade prior, with statewide cotton acreage witnessing a twelvefold increase between 2015 and 2020 (Kansas AGGROWTH 2021, 2019).

Along with climate change and extreme weather events, biodiversity loss is another challenge and was highlighted as a top three risks in the World Economic Forum's 2022 Global Risks Report (Foro Económico Mundial *et al.* 2022). Cotton growers recognize the importance of biodiversity, which is why the lands becoming unsuitable for cotton cultivation are often repurposed into habitats for various wildlife species, including birds like quail, as well as pollinators (CottonToday). These initiatives not only contribute to wildlife conservation but also enhance the efficiency of neighboring cotton fields. However, there is still a deficiency in understanding the factors correlated between cotton cultivation and preserving biodiversity.

Access to updated agricultural data and insights into grower concerns and their research needs are critical for guiding research and development efforts aimed at supporting grower profitability while mitigating environmental footprints. In this context, insights from the Natural Resource Survey results hold particular significance.

Natural Resource Survey

In the summer of 2023, Cotton Incorporated launched a Natural Resource Survey (NRS) targeting U.S. cotton producers, seeking to evaluate the environmental footprint of cotton, contribute to the U.S. LCA project, and gain a better understanding of grower practices and challenges. These survey results were collected digitally, and invitations were sent to growers *via* emails and postcards. A third-party market research company assisted in the digital survey administration. A copy of the survey questionnaire is provided in Appendix 1. The survey data produced aimed to:

1. Assess changes in grower practices and priorities between 2008 and 2023.
2. Identify grower challenges.
3. Provide U.S. cotton production data for the U.S. life cycle assessment.
4. Gather growers' insights regarding practices and agricultural technologies that

positively impact resource efficiency and productivity.
5. Maintain an accurate understanding of growers' research needs.

EXPERIMENTAL

The Natural Resource Survey covered a wide range of topics with 62 core questions, including demographics, grower practices and concerns, and field-level data in the 2021 or 2022 crop years. Similar surveys were conducted in 2008 and 2015, enabling comparisons where production data in those surveys also were representative of conditions from the previous crop year. However, questions related to grower attitudes are reflective of the year the survey was conducted. For simplicity, in presenting the results, the year the survey was conducted, namely 2023, is used in this report. Consistent with prior methodologies, the 2023 survey reached growers across 17 cotton-growing states. The results were summarized by assigning data from all these states to four regions – Far West (CA, AZ, NM), Southwest (TX, OK, KS), Midsouth (MO, AR, LA, MS, TN), and Southeast (AL, FL, GA, SC, NC, VA) to provide a representative response about each area's production as illustrated in Fig. 1. The data have been analyzed using different tools, including Microsoft Excel and Power BI.

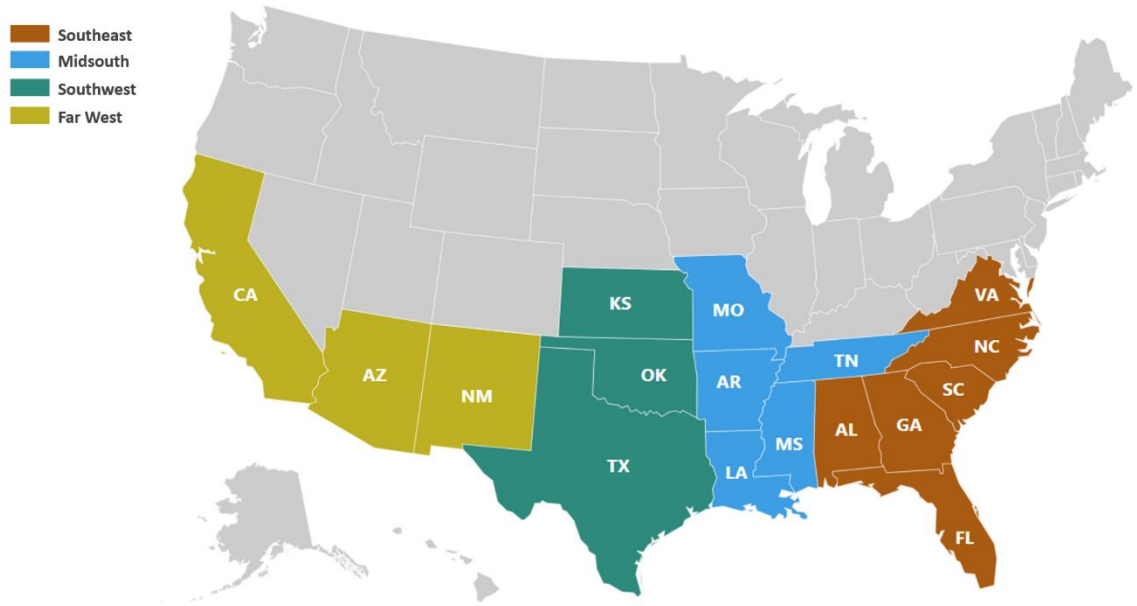


Fig. 1. Cotton growing states in four regions

The survey focused on filling the knowledge gap about how farming practices are connected and their broader impacts at a national level across all U.S. cotton-growing regions. Additionally, the survey aimed to offer direction for future research efforts. The examination of independent variables, such as cultivation methods and technology adoption, facilitated the establishment of correlations with dependent variables including field productivity (yield), resource efficiency (nitrogen and water use), and grower concerns (Fig. 2). However, it is important to approach these connections with caution, since each grower faces unique variables and circumstances that can influence how their

fields perform. It should be noted that the growers in each survey are not the same producers, and such trends between years may not reflect changes in reality. Rather, it may be a different sample group. However, the results do provide some insights into shifts in the industry that are useful to the goals of this study.

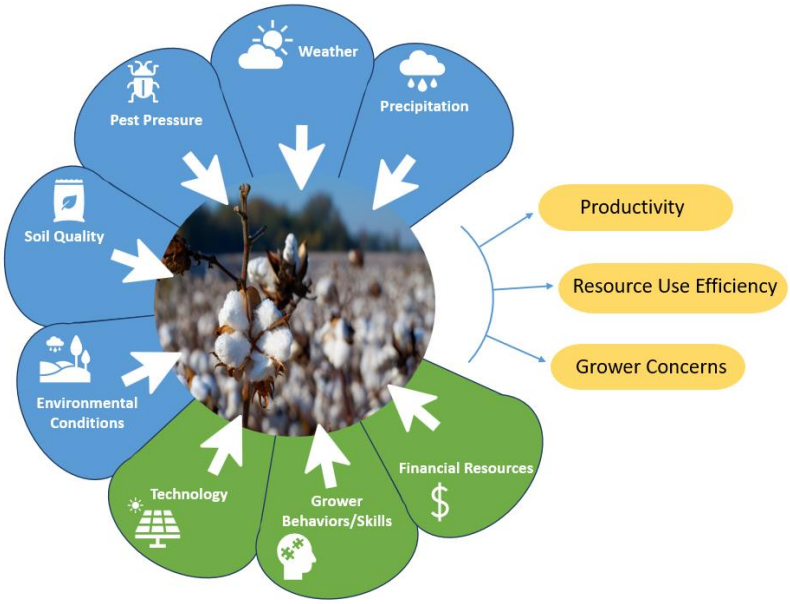


Fig. 2. Cotton growing production-system simplified model with independent variables labeled in green (more grower control) and blue (less grower control) and the corresponding dependent variables represented in the yellow labels.

Survey Method

The survey was conducted during May, June, and July of 2023. Cotton Incorporated facilitated outreach by sending eleven thousand postcards to farmers who had produced cotton in 2021. These postcards were dispatched three times between the end of May and the end of July 2023. Additionally, a total of 4,300 emails were sent to request survey participation during this period. The survey encompassed all U.S. cotton-growing regions, yielding 753 responses, as illustrated in Fig. 3. Texas provided the most responses, at 37% of the total, followed by Georgia, the second-largest cotton-producing state, at 13%. In general, the percentage of responses per state corresponded to state-level cotton production volumes.

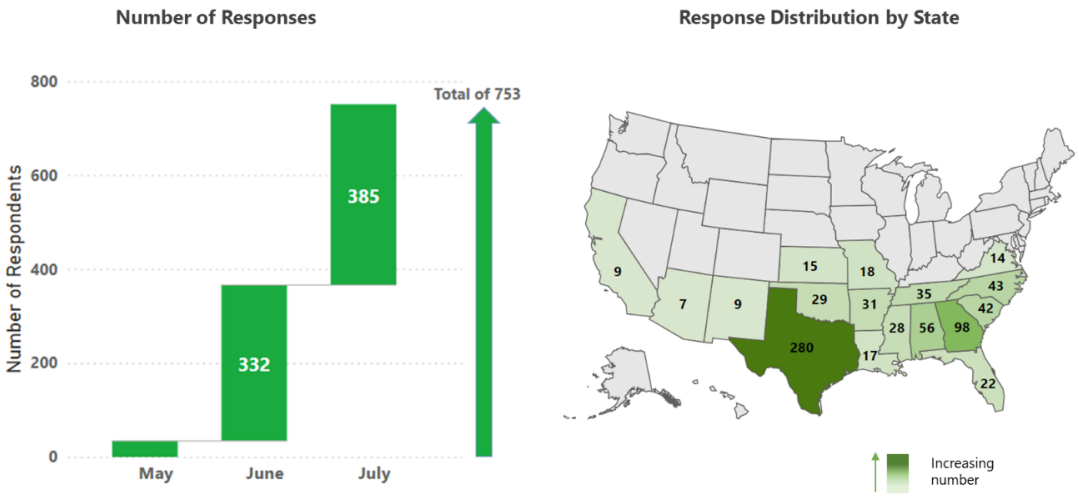


Fig. 3. Cumulative number of responses by date and state

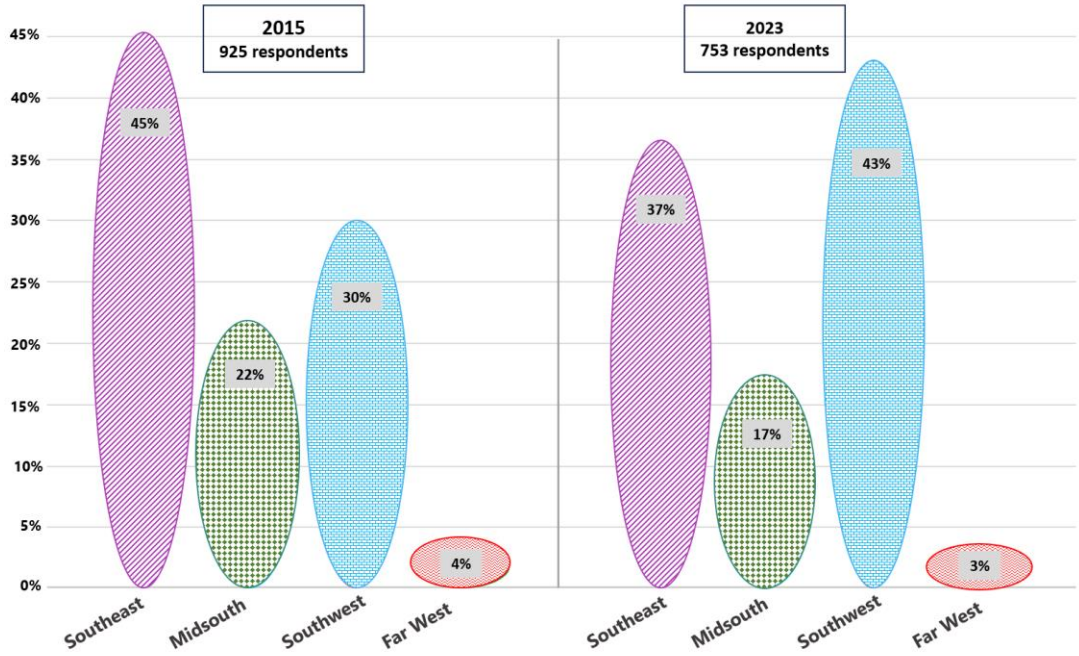


Fig. 4. Percent of respondents by region in the 2015 and 2023 surveys

For comparison, in the previous 2015 survey data, there were a total of 925 respondents, with the majority of responses originating from the Southeast region (45%). The Southwest region then accounted for 30% of responses, while in 2023, it constituted the majority with 43% of responses. Conversely, the Far West region witnessed a slight decrease from 4% in 2015 to 3% in 2023. In general, cotton output in the Far West has been consistently decreasing due to declining water resources and competition from higher value crops, such as almonds and processing tomatoes in California (Geisseler and Horwath 2016). The percentage of responses by regions through 2015 and 2023 is shown in Fig. 4.

Key factors, such as weather conditions and production costs, can significantly influence cotton farming trends and may contribute to the observed differences in eligibility and interest in participating in the survey. According to USDA-NASS data, in

2022, 16% of planted acres in the Far West went unharvested due to water shortages, while the Southwest experienced a severe drought resulting in the loss of 52% of planted acres (Fig. 5). Additionally, cotton acreage remained at a record low from 2021 to 2023 due to a prolonged drought reducing water allocations in the region (USDA Quick Stats 2024). Consequently, it's important to note that data from the Far West may not accurately reflect typical production conditions, given the prevailing challenges posed by the long-term drought. Although irrigation scheduling technologies have contributed to improved water productivity in cotton farming, their adoption by farmers remains limited, indicating significant room for improvement (Barnes *et al.* 2020). Matching irrigation schedules with the crop's water use is important, especially during the flowering stage when cotton is most sensitive to water shortages. Optimizing the timing of irrigation termination (IT) for each geographical area is also essential, as early IT can save water but may not maximize yields, while late IT can lead to increased pest damage and reduced yield quality (Koudahe *et al.*, 2021). Continued advancements in sensor and water delivery technologies, enhanced crop simulation models, and the development of drought-tolerant cotton varieties are just a few examples of strategies to address challenges posed by reduced water allocations and droughts (Barnes *et al.* 2020). Additionally, as irrigation water supplies become depleted, it will be important to consider rotation with high residue crops or cover crops to increase infiltration and soil water holding capacity when possible.

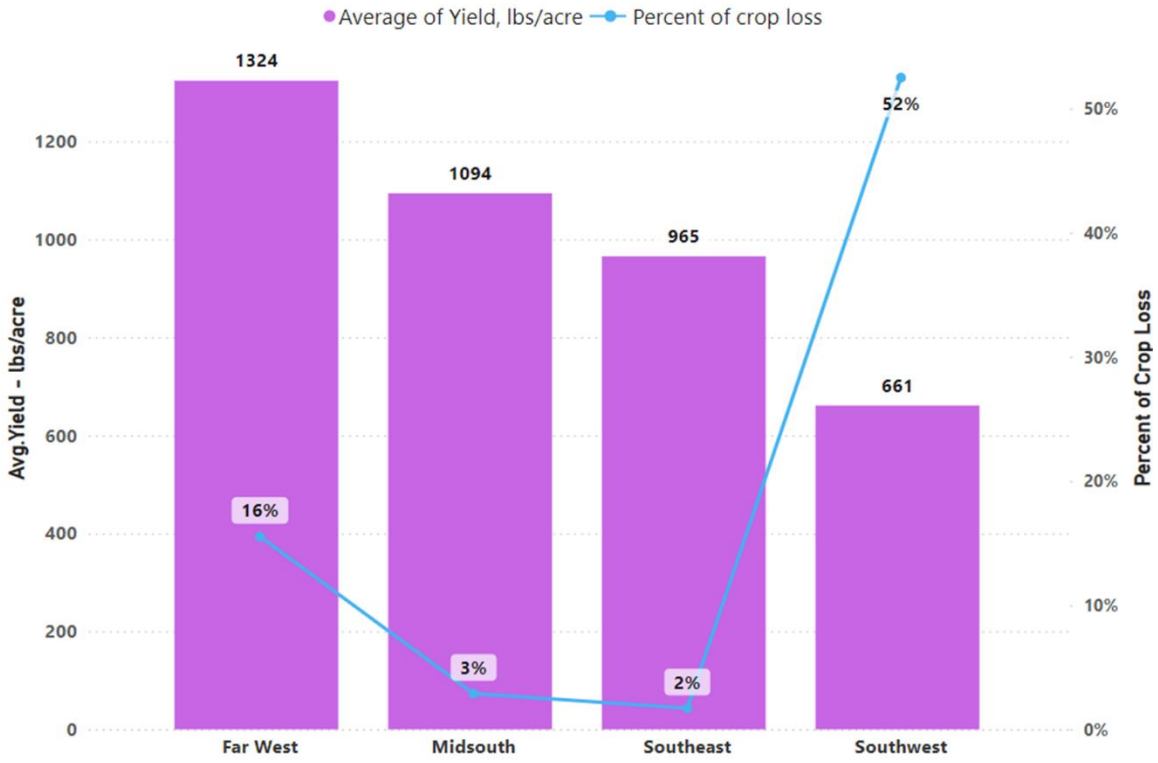


Fig. 5. Crop loss data by regions in 2022 (USDA Quick Stats 2022)

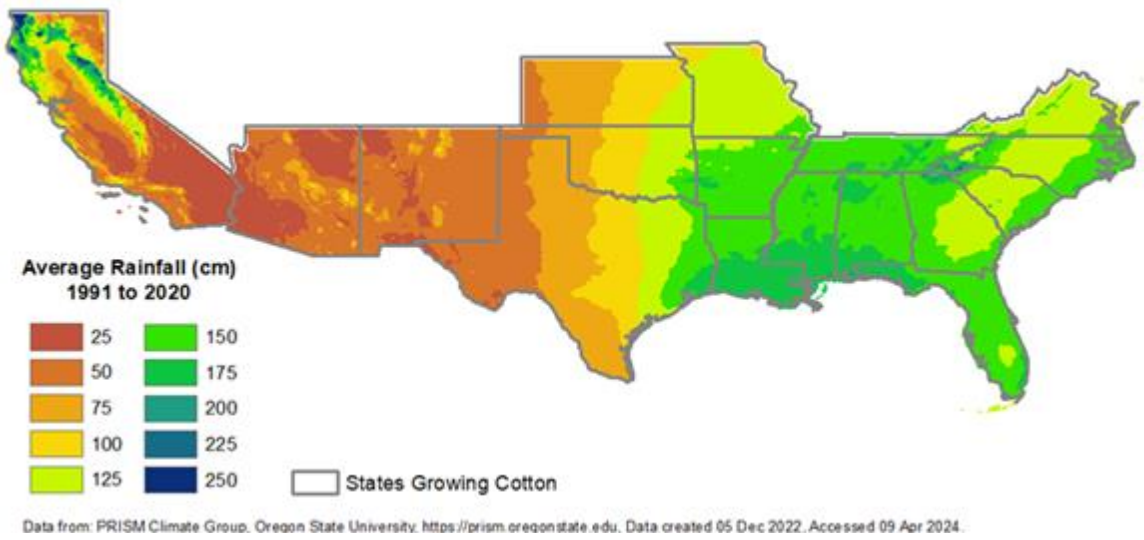


Fig. 6. A 30-year average rainfall from 1991 to 2020 in cotton-producing states (rainfall data from Prism Climate Group)

To underscore the environmental differences among cotton-growing regions, Fig. 6 depicts precipitation patterns, which show adequate precipitation to grow a cotton crop in the Southeast and Mid-South, while a dramatic precipitation gradient occurs within the Southwest region. In the West region, cotton cannot be grown without irrigation due to the very low annual precipitation. Figure 7 illustrates the diverse soil types across the U.S. and farming practices are significantly influenced by the predominant soil type characteristics across and within each region: Ultisols in the Southeast, Alfisols in the Midsouth, Mollisols in the Southwest, and Aridisols in the Far West.

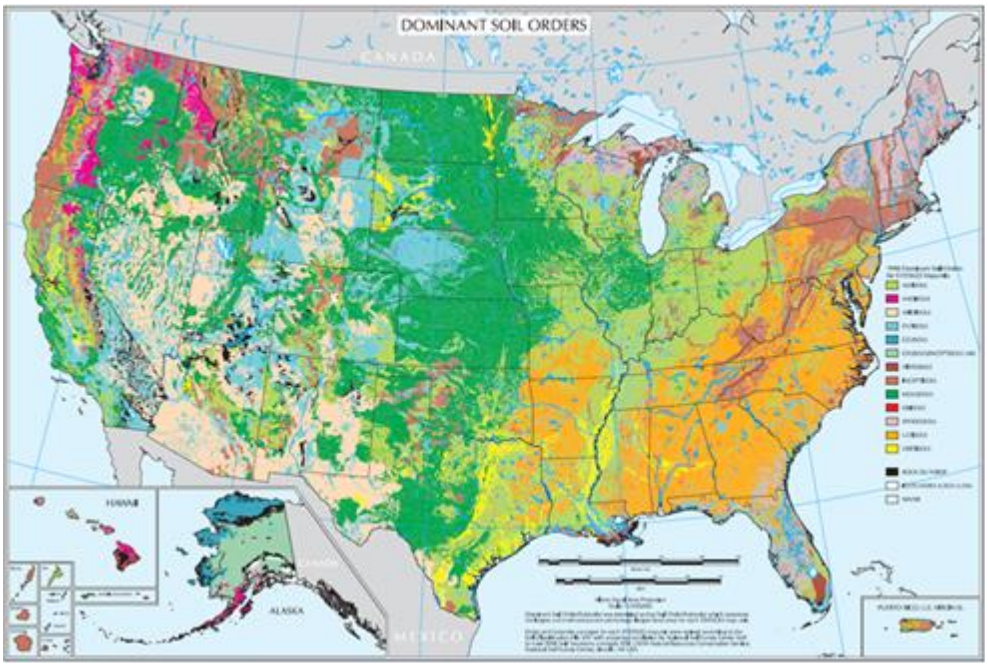


Fig. 7. Dominant soil orders for the U.S. (USDA Natural Resources Conservation Service, 1998)

Respondent Demographics and Data Representativeness

The 2023 survey revealed that nearly half of respondents were 51 or older in age and had over 20 years of experience in cotton farming (Fig. 8). Overall demographic makeup of respondents was similar to the 2015 survey with the exception of increased participation of the younger generation (18 to 30) in the Far West increasing from 3% to 20% in 2023. The group of farmers growing cotton during the last 5 years constituted 16% compared to an average of 7 to 8% of the same group observed in other regions (Fig.8). However, it should be noted that the Far West also had the lowest cotton acres and response rate of all regions surveyed, with only 3% of the total responses.

In general, responses from the cotton-growing states were reflective of the distribution of cotton-growing acreage, with Texas and Georgia having the highest number of respondents. According to USDA-NASS data, cotton-planted acreage across all 17 states totaled 10.2 million acres in 2023, whereas the surveyed acreage amounted to approximately 0.94 million acres (Fig. 9). The surveyed cotton acreage accounted for 9.2% of the total U.S. cotton cultivated acres. In comparison, the previous 2015 survey reported 818,804 cotton acres, which represented 10% of the cotton planted in the US in 2015.

Years of Growing Cotton

Region	0-5 years	6-10 years	11-20 years	21-30 years	31+ years
Southeast	6%	13%	24%	25%	32%
Midsouth	9%	9%	19%	31%	33%
Southwest	9%	11%	24%	13%	43%
Far West	16%	8%	16%	4%	56%
U.S. Total	**8%**	**11%**	**23%**	**20%**	**38%**

Farmers' Age

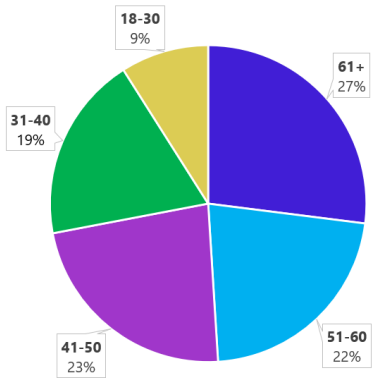


Fig. 8. Distribution of respondents categorized by age and years of growing experience (Refer to Q59 and Q60 in Appendix 1)

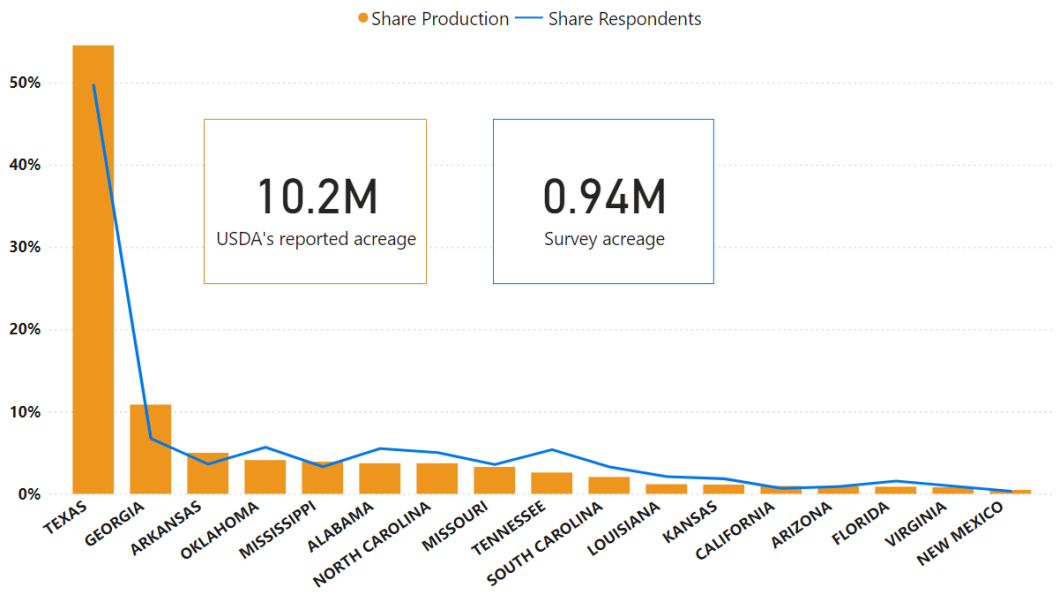


Fig. 9. Percent of U.S. cotton acres planted in each state in the 2023 growing season (orange) and the percentage of cotton acres by state from survey participants (blue)

RESULTS AND DISCUSSION

Cotton Grower Concerns

Within the Natural Resource Survey, respondents were prompted to assess 29 randomly presented concerns or challenges linked to cotton production, scoring each as a Major, Moderate, or Not an Issue on their farm. Noteworthy concerns included cotton production input costs, weed resistance to herbicides, weed control, and cottonseed value, which have consistently ranked as the top four major concerns since the previous survey, comprising 78%, 65%, 55%, and 50% of responses, respectively (Fig. 10).

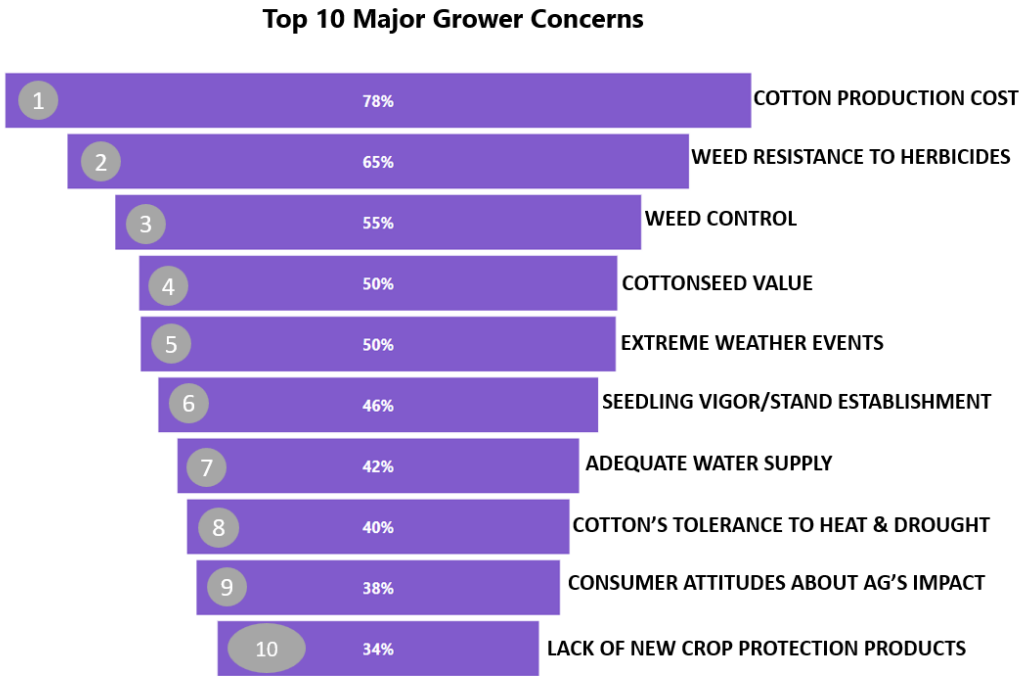


Fig. 10. A summary ranking of the top 10 cotton growers' concerns

In contrast, the spread of plant disease and weeds declined from the 5th to the 11th ranking in the latest survey. New concerns introduced in the 2023 survey, such as nematodes, now rank 9th, with a higher percentage of responses from the southeast and midsouth regions. Cotton grower's concerns about water conservation are evidenced in overall water productivity increases through the adoption of better irrigation delivery systems (Barnes *et al.* 2020), and adequate water supply remains in their top 10 concerns, rising from 10th place in 2015 to 7th in 2023. Additionally, concerns were raised regarding the lack of new crop protection products and insect resistance to insecticides and Bt cotton, resulting in a 4-point difference. Table 1 displays a shift in concern rankings, with increased concern towards the increasing occurrence of extreme weather events, rising from 13th to 5th place. This shift underscores the escalating impact of climate change effects on these concerns. For grower concerns by region, see ST 1 in Appendix 2.

Grower Communication Methods

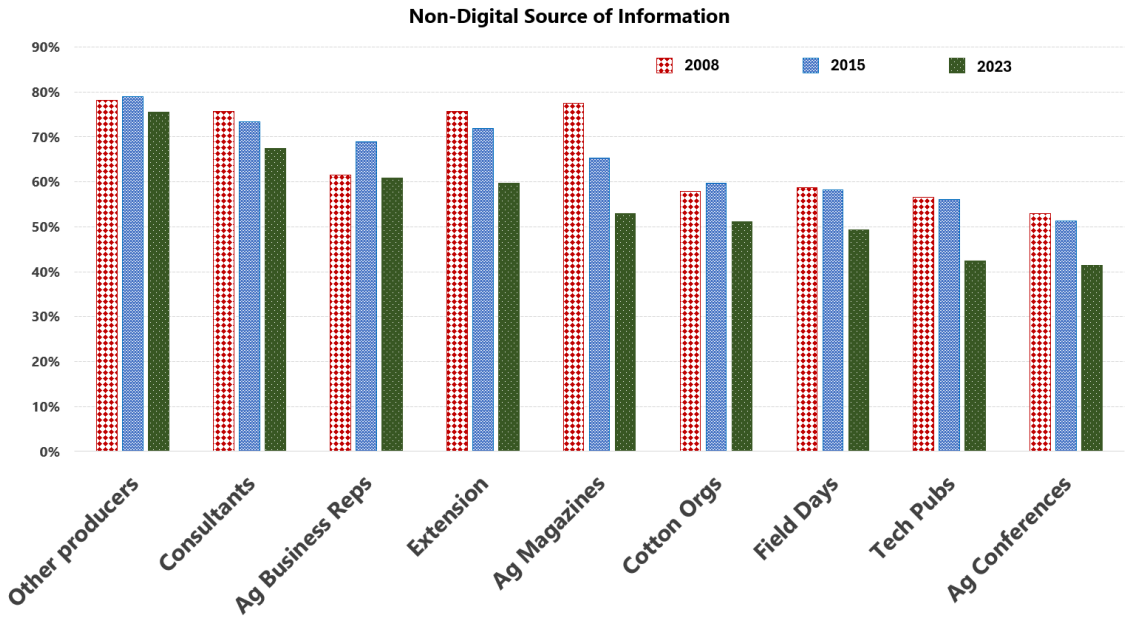
In order to consistently provide producers with updated information to enhance their production efficiency, it is critical to understand the sources from which they acquire information about new technology and practices. Thus, the 2023 survey respondents evaluated 17 information sources based on their reliance, ranging from none to slight, moderate, or great dependence. The survey findings emphasize that cotton producers heavily rely on face-to-face interactions, consultants, and extension agents for information on new technologies (Fig. 11-A). However, there has been a decline in magazine interest since 2008, while apps are more widely utilized. Additionally, social media platforms, particularly YouTube and Facebook, are among the most used social media platforms viewed by producers, as illustrated in Fig. 11-B.

Table 1. A Summary Ranking of Cotton Growers' Concerns through 2015 and 2023 with Light Blue Highlighting Total Ranking <5, and Dark Blue >5 (Refer to Q26 in Appendix 1)

Cotton Production Concerns	Major Issue		Rank		total
	2023	2015	2023	2015	Δ
Cotton production input costs	78%	81%	1	1	0
Weed resistance to herbicides	65%	69%	2	2	0
Weed control	55%	64%	3	3	0
Cottonseed value	50%	51%	4	4	0
Increased frequency of drought and extreme weather events (climate change)	50%	30%	5	13	8
Seedling vigor and stand establishment	46%	42%	6	6	0
Adequate water supply	42%	37%	7	10	3
Cotton's tolerance to heat and drought	40%	39%	8	8	0
Consumer attitudes about agriculture's impact on the environment	38%	40%	9	7	-2
Lack of new crop protection products (insecticides, herbicides, etc.)	34%	29%	10	14	4
Spread of plant diseases and weeds	30%	42%	11	5	-6
Insect resistance to insecticides and Bt cotton	30%	28%	12	16	4
Efficient use of fertilizer	28%	37%	13	9	-4
Herbicides drift	27%	28%	14	15	1
Disease concerns related to nematodes, target spots, viruses, etc.	24%	N/A	15	New	
Variety selection	24%	34%	16	11	-5
Plant bug control	23%	32%	17	12	-5
Soil erosion	19%	19%	18	21	3
Harvest aid materials and application timing	19%	24%	19	19	0
Stinkbug control	19%	23%	19	20	1
Monitoring cotton's plant growth	17%	25%	21	18	-3
Soil sampling and analysis for fertilization	17%	27%	22	17	-5
Soil compaction	16%	17%	23	22	-1
Insecticides drift	11%	28%	24	15	-9
Water salinity of irrigation wells	11%	7%	25	26	1
Effects of agriculture on wildlife	10%	10%	26	24	-2
Soil salinity	9%	8%	27	25	-2
Water quality protection from agricultural runoff	8%	12%	28	23	-5
Dust from harvesting, farming, gins	4%	4%	29	27	-2

Selected Farm Characteristics

The 2023 survey explored land and management practices as well as their associated characteristics through a series of multiple questions. Respondents were asked to provide information related to their land and management practices within a selected representative cotton field. One of the questions was about the field size, as this parameter may impact the feasibility of adopting certain practices for producers. In the 2021/2022 growing season, the average size of the representative cotton field varied across regions, with the Southwest reporting the largest size at 187 acres, while the Far West reported the smallest at 73 acres. The average representative field size by region across all surveyed years has been compared and analyzed, see Fig. 12. In the 2023 survey data, larger average field sizes were reported for the Southwest and Midsouth regions compared to the previous two surveys, while sizes remained consistent for the Far West and Southeast regions. In the Far West, the design of irrigation systems often limits field size to ensure efficient water distribution, necessitating restricted field lengths. On the other hand, in the Southeast, field size limitations often stem from topographical features, such as established tree lines.



(A)

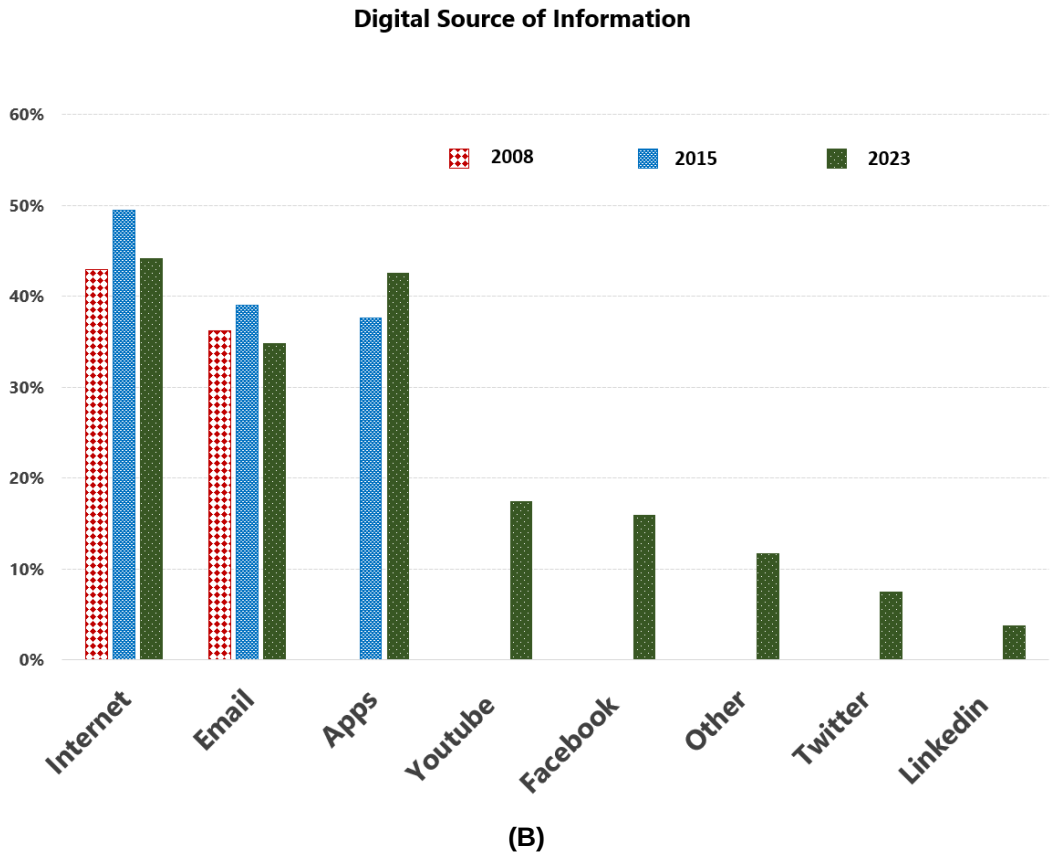


Fig. 11. Preferred information sources: moderate to high ranking (Refer to Q61 in Appendix 1). (A) Non-digital source of information by respondents through 2008, 2015 and 2023 survey years. (B) Digital source of information by respondents through 2008, 2015, and 2023 survey years

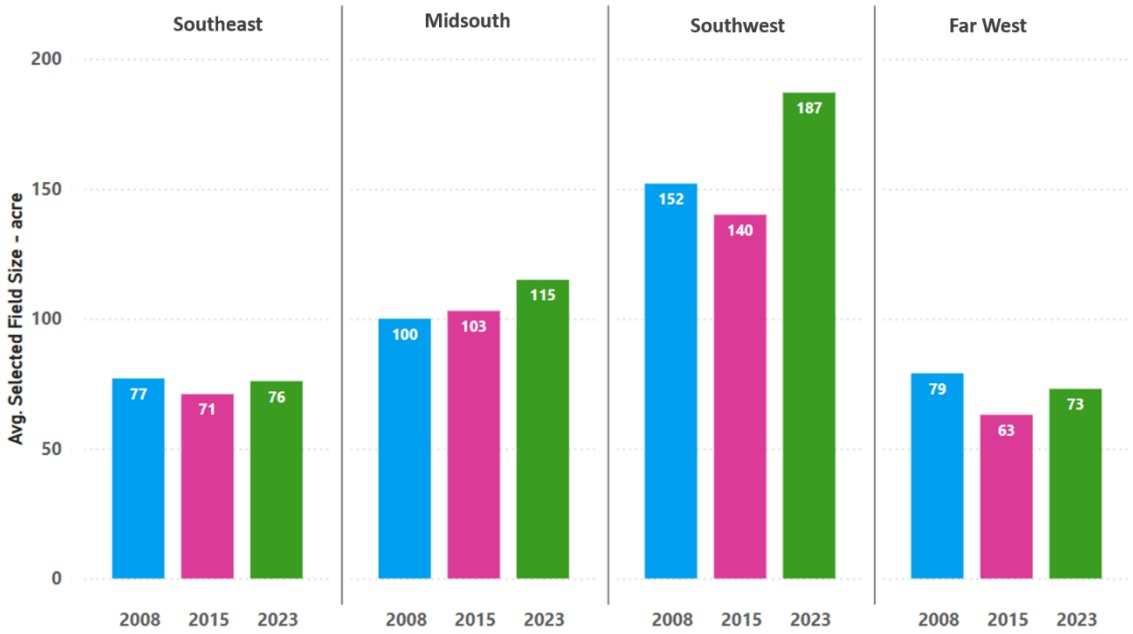


Fig. 12. Average field size by region for 2008, 2015, and 2023 survey data (Refer to Q28 in Appendix 1)

Land Use

In addition to reporting the acreage of selected cotton fields, the 2023 survey respondents were asked to share details about their entire land holdings. In total, the farmers managed 1,963,111 crop acres (+17% from 2015), with 48% (-1% from 2015) planted to cotton. This allocation translates to 9.2% (-1% from 2015) of the total cotton planted in the United States in 2023.

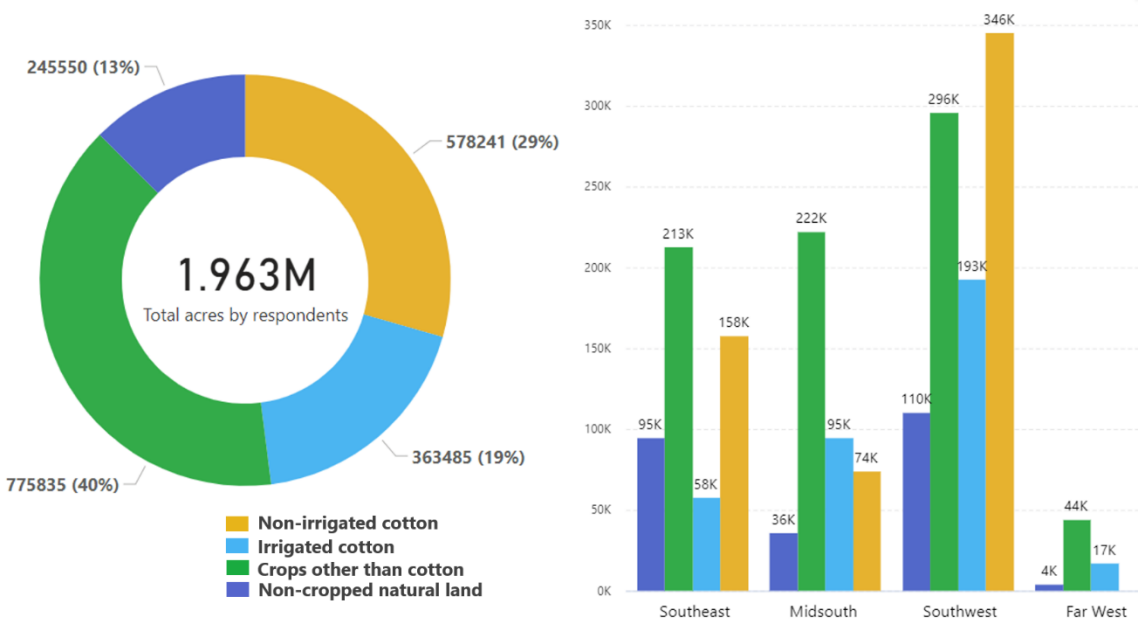


Fig. 13. Acres of irrigated and non-irrigated cotton, non-cotton crops, and natural land from the 2023 survey. (Refer to Q1 in Appendix 1)

Notably, only 39% (-6% from 2015) of the surveyed cotton acres received irrigation, which closely aligns with the 36% of irrigated acres reported by the USDA 2018 Farm and Ranch Irrigation Survey (USDA Quick Stats 2022). In comparison to the 2015 survey data, where 49% of the crop acres were planted to cotton, and 45% of the cotton acres were irrigated, the current survey reflects a downward shift.

In the 2023 survey, the Far West region had 99% of irrigated cotton fields (and high yields), whereas the Southwest, Southeast, and Midsouth regions reported 36%, 27%, and 56%, respectively. Expanding beyond cropland, respondents also reported a combined 245,550 acres of natural land within their farming enterprises, constituting around 13% of total land ownership. This percentage aligns with the proportion of natural land reported in the 2015 survey data. Figure 13 illustrates all acres by 2023 survey respondents and Fig. 14 shows the percentage of non-irrigated and irrigated cotton acres through the survey years.

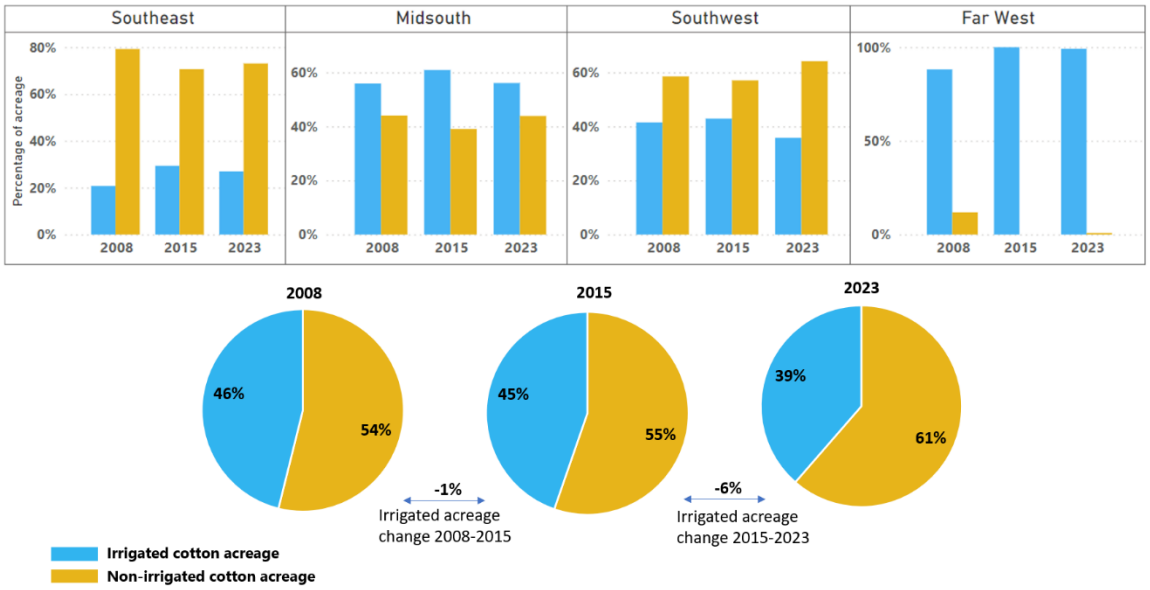


Fig. 14. Irrigated and non-irrigated cotton through years and regions

Around 40% (775,835 acres) were reported as land for crops other than cotton. Table 2 displays the additional crops cultivated by respondents and the percentage of respondents growing them, showcasing slight variations from the 2008 and 2015 results. The fluctuations in the utilization of other crops over the years can be attributed to the fluctuating commodity prices observed during 2020 to 2021. Consequently, wheat experienced a decrease, whereas peanuts and pasture saw marked increases (USDA NASS 2021).

Nevertheless, the primary alternative cash crops in the U.S. during the 2021 growing season included corn, soybean, and wheat, with corn dominating across most regions. Notably, in the Midsouth, soybean took a significant lead, comprising 84% of the crops. The Far West region had a diverse set of crops that include various vegetables and orchards suited to its unique climate (Table 3).

Table 2. The Percentage of Respondents Who Indicated They Commercially Produced the Crops Listed

Crop	% Grown 2008	% Grown 2015	% Grown 2023
Corn	48%	46%	46%
Wheat	47%	40%	31%
Soybeans	37%	39%	32%
Sorghum	25%	19%	21%
Natural Vegetation	22%	17%	18%
Pasture	21%	16%	26%
Hay	19%	15%	26%
Peanuts	18%	27%	26%
Alfalfa	7%	4%	5%
Vegetables	6%	5%	5%
Orchards	6%	3%	3%
Rice	4%	3%	3%
Vines	1%	1%	<1%
None of the above	0%	3%	12%

Table 3. Alternative Cash Crops by Respondents by Regions (Refer to Q3 in Appendix 1)

Commercial crop/Livestock	Region				
	Southeast	Midsouth	Southwest	Far West	U.S.
Corn	54.6%	73.6%	29.0%	44.0%	**46.5%**
Soybeans	40.4%	83.7%	6.5%	0.0%	**31.9%**
Wheat	21.8%	11.6%	44.4%	44.0%	**30.5%**
Cattle	29.1%	18.6%	34.9%	24.0%	**29.6%**
Peanuts	65.5%	7.0%	2.8%	0.0%	**26.3%**
Hay	24.4%	17.1%	31.2%	24.0%	**26.0%**
Pasture	25.1%	13.2%	31.2%	24.0%	**25.6%**
Sorghum	5.8%	3.1%	41.1%	12.0%	**20.7%**
Natural Vegetation	26.6%	13.2%	12.0%	12.0%	**17.5%**
None of the above	6.6%	8.5%	17.6%	20.0%	**12.1%**
Other	4.7%	2.3%	9.0%	12.0%	**6.4%**
Vegetables	7.6%	1.6%	1.9%	28.0%	**4.8%**
Alfalfa	0.4%	0.0%	6.5%	52.0%	**4.6%**
Rice	0.4%	14.0%	1.5%	4.0%	**3.3%**
Orchards	4.4%	0.0%	1.2%	36.0%	**3.3%**
Poultry	6.2%	0.0%	0.6%	0.0%	**2.5%**
Dairy	0.4%	0.8%	1.2%	4.0%	**0.9%**
Swine	1.5%	0.0%	0.3%	4.0%	**0.8%**
Vines	0.0%	0.0%	0.6%	4.0%	**0.4%**

Crop Rotation and Cover Crops

The 2023 survey sought to understand how farmers utilized land during the offseason, recognizing its potential for various crops, which can enhance revenue and benefit the land. Data from the survey indicates an increase in cover crop utilization among cotton farmers, with 48% of respondents planting cover crops, compared to 20% in the 2015 survey. Respondents reported an increase from 9% to 14% in 2015 to 2023 in native

vegetation practice, respectively. Noteworthy is the positive trajectory witnessed in the Far West region, with 0% of native vegetation usage in 2015 to 7% in 2023 (Fig. 16). The evolving trends in cover crop adoption across time and regions emphasize the increasing preference for cover crops such as wheat (64%), cereal rye (30%), and mixed crops (13%) — a blend of diverse plant species promoting soil vitality and biodiversity. By 2023 survey respondents, cotton was planted annually (23%), every other year (22%), 2 of 3 years (25%), and 1 of 3 years (12%).

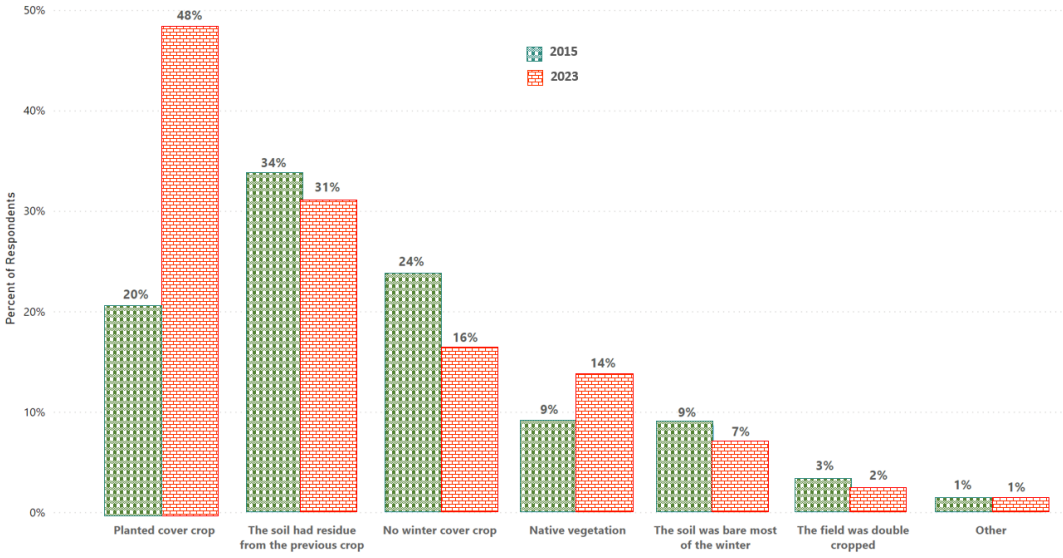


Fig. 15. Cover crop and residue management practices by 2015 and 2023 survey respondents

The survey also explored how growers utilized their land during the offseason, with a focus on regional differences.

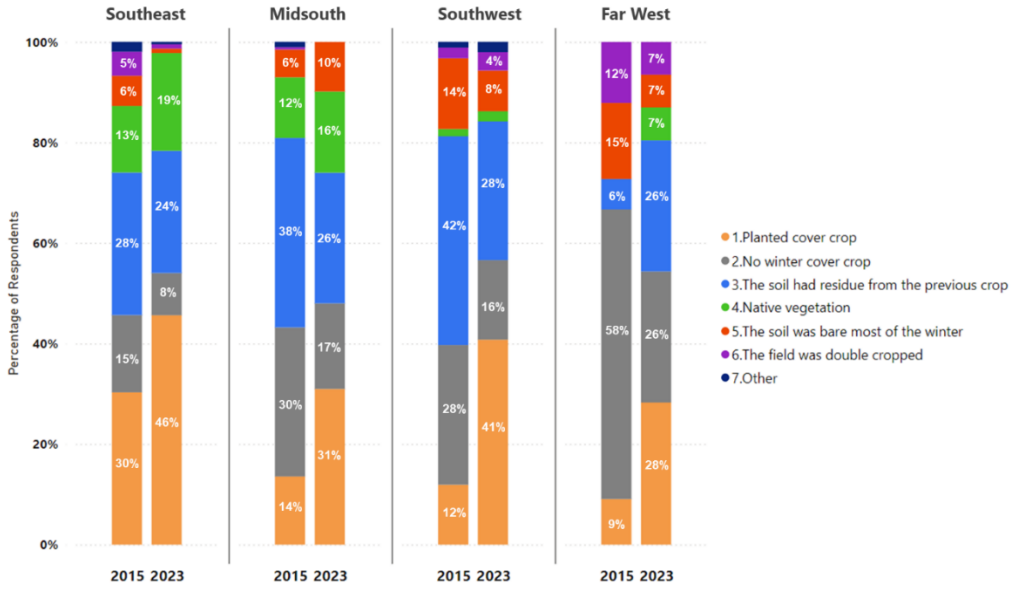


Fig. 16. Cover crop practices across regions over time (For the 2023 Survey, refer to Q40 in Appendix 1)

Farmers adopting cover crops reported an increase in cotton yields, especially in the Southwest, where planted cover crops resulted in a 14% increase in cotton yields compared to practices without cover. In the Southeast and Midsouth, a similar practice reported a 5% and an 8% increase in yield, respectively. However, in the Far West region, with its unique environment, the reported yields using planted cover crops were lower compared to those not utilizing these practices. Cotton serves as the main crop in a rotation with other crops every 3 to 4 years. As these fields may include low-residue crops, introducing cover crops becomes an opportunity for cotton farmers to elevate residue levels. This strategy aligns with the common practice of planting cotton following a winter cover crop, which helps safeguard the cotton seedlings from early spring wind damage.

Tillage Practices

For almost three decades, Cotton Incorporated has been underscoring the benefits of conservation and no-till practices (Daystar *et al.* 2017). For clarity, each tillage practice can be explained as follows:

1. No-till/strip-till: Soil undisturbed except for narrow strips, preserving surface residue.
2. Conservation tillage: Leaves approximately 15% to 30% or more crop residue on the soil surface after planting.
3. Conventional tillage: Full-width soil disturbance, with weed control via herbicides or cultivation.

Over the span of 2008 to 2023, there has been a shift in tillage practices: conventional tillage has declined by approximately 10%, whereas no-till/strip-till methods have increased by 20% (Fig. 17). Regionally, the Southeast region utilizes more no-till/strip-till practices (68%), whereas conventional tillage accounts for 15% (For regional breakdown, refer to ST2, Appendix 2). This shift in tillage approaches may reflect the influence of educational efforts, along with other factors, such as weed pressure which may also drive changes in tillage practices. Additionally, growers may be motivated by broader agronomic benefits, a decrease in input costs, and additional cotton marketing opportunities. The transition from conventional tillage to no-till/strip-tilling holds the promise of cost savings for growers by reducing time and energy requirements ("Soil Health Institute," 2023).

However, concerns loom among many conventional tillage growers about potential reductions in cotton yields. To probe the relationship between tillage practices and cotton yield, a detailed analysis was conducted, plotting the yield for each tillage practice across U.S. regions (Fig. 18). The Far West was the only region where conventional tillage resulted in higher yields, averaging 1672 lbs/acre, while in other regions, conventional tillage practices reported lower average yields. In the Midsouth and Southwest, conservation tillage emerged with the highest reported cotton yields, registering 1200 lbs/acre and 981 lbs/acre, respectively. The Southeast had a high adoption of no-till/strip-till and the highest reported yield for this practice, averaging 1086 lbs/acre. Research shows increased yields on cotton cultivation in no-till fields with cover crops, including (Soil Health Institute 2023) and (University of Arkansas System 2016); however, results are variable and may not correlate to improved yields in all situations. It should also be noted that no-till and cover cropping provide other benefits aside from yield, such as increased soil carbon and soil water holding capacity, among others.

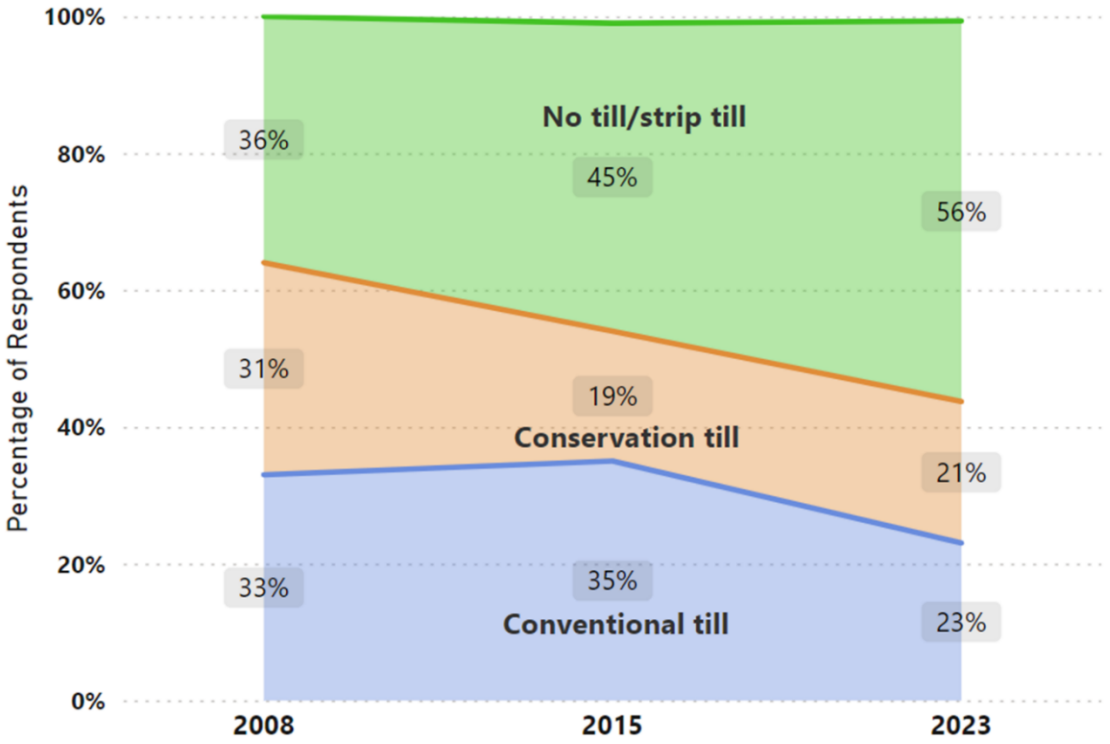


Fig. 17. Tillage systems use identified in the 2008, 2015, and 2023 surveys. (For the 2023 Survey, refer to Q43 in Appendix 1)

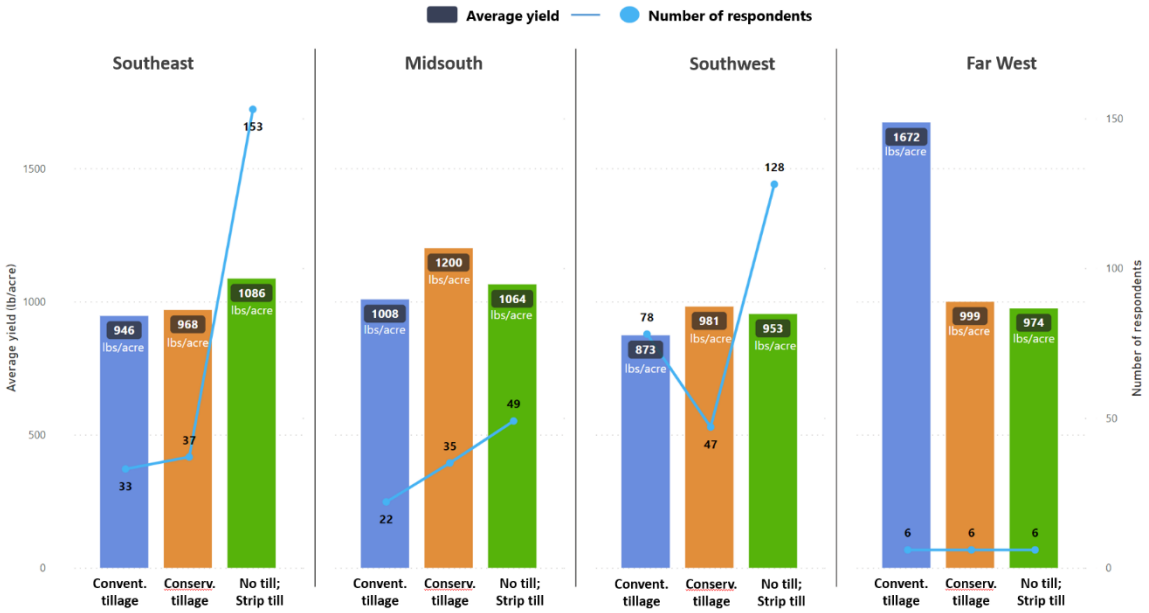


Fig. 18. U.S. cotton yields based on tillage method and region (Refer to Q43 and Q38 in Appendix 1)

Soil Management

In the 2023 survey, 97% of respondents adopted at least one of the listed practices to mitigate soil erosion. Strip-till/no-till remained prevalent, and the usage of other specific practices remained relatively stable between 2008 and 2023. Additionally, in 2008, 39% of respondents reported using winter cover crops, from 48% in 2015 to 65% in 2023. Irrigation management has increased by 5% since 2015, reaching 45%, while the prevalence of precisely leveled fields has nearly halved during the same period. Fig. 19 illustrates a full list of practices to mitigate soil erosion by 2023 survey respondents. For regional breakdown, refer to ST3, Appendix 2).

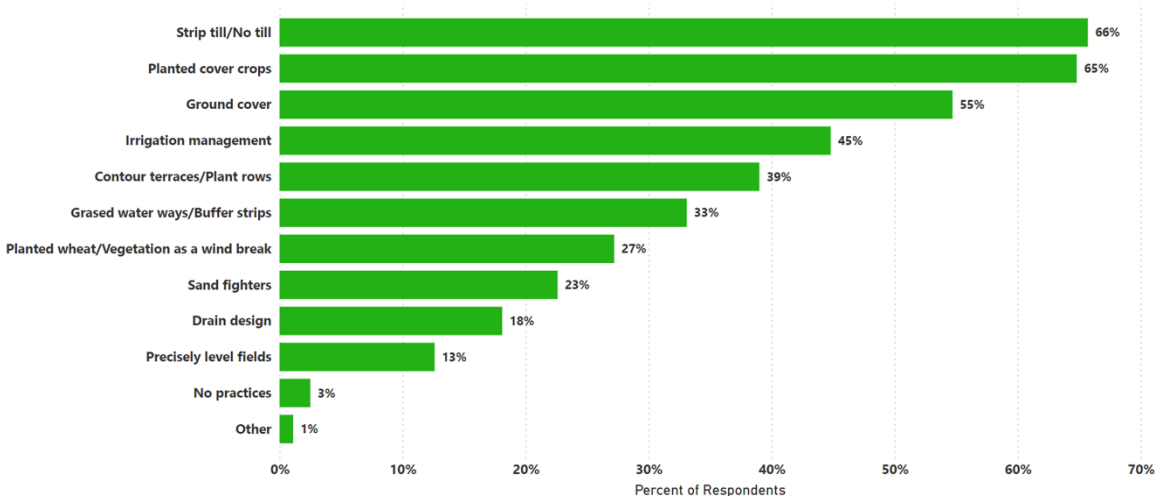


Fig. 19. Practices to minimize soil erosion among 2023 survey respondents (Refer to Q8 in Appendix 1)

Since 2008, soil testing to determine fertilizer application rates has remained a predominant practice among producers, with 77% in 2023 (Fig. 20). Most respondents (56%) indicated soil sampling annually, while 6% reported never using soil fertility testing, primarily in the Far West and Southwest regions.

Fig. 20. Fertilizer factors rated by 2023 survey respondents (Refer to Q10 in Appendix 1)

Table 4 indicates that more than 50% of growers did soil sampling once or more a year, while 20% – once every 2 years and 13% – once every 3 years. Other factors utilized in the fertilizer evaluation process showed changes as follows: yield goals rose to 67% from 61% in 2015, consultant recommendations increased to 56% from 49% in 2015, and petiole or leaf testing grew to 34% from 23% in 2015.

Table 4. Frequency of Soil Fertility Testing in Cotton Fields by 2023 Survey (Refer to Q9 in Appendix 1)

Region	Once or more a year	Once every 2 years	Once every 3 years	Once every 4 or more years	Never
Far West	38%	8%	N/A	31%	23%
Midsouth	31%	35%	33%	1%	N/A
Southeast	85%	11%	3%	N/A	1%
Southwest	40%	21%	15%	12%	11%
U.S.	**56%**	**20%**	**13%**	**6%**	**6%**

Source of Organic Matter

In the 2023 survey, respondents used various sources of organic matter such as manure, gin trash, or cover crops to enhance soil health. In the Far West region, the respondents' total acreage where manure and gin trash (gin waste) were applied was notably larger compared to other regions where various cover crops were the dominant source of organic cover. When comparing these practices with the 2015 survey results, the average total acreage where gin trash/cotton compost was applied remained unchanged (Fig. 21). However, the use of manure decreased to 8.5%, down from 14.3% in 2015. On the other hand, the application of multispecies cover crops increased to 6.3%, up from 2.5% in 2015, as a percentage of respondents' total acreage.

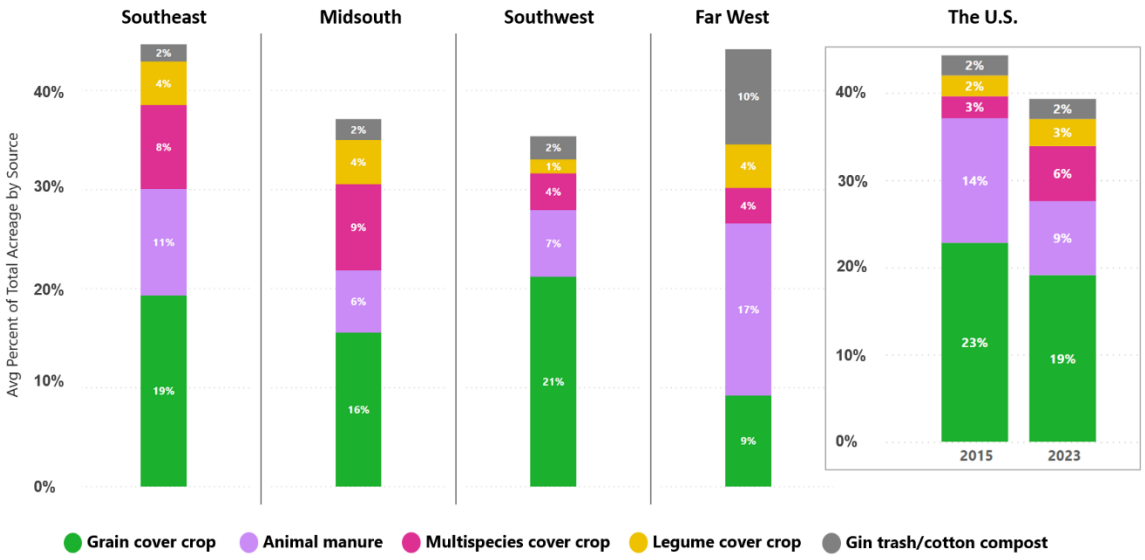


Fig. 21. The average percentage of respondents' total acreage attributed to the source of organic matter across regions in the 2023 survey. The average U.S. data is presented by years (Refer to Q11 in Appendix 1).

Fertilizer Management

The precision in fertilizer management is presented in Fig. 22, which illustrates nutrient use efficiencies for nitrogen, phosphate, and potassium (N, P, K, respectively) by region (mass of cotton fiber produced per mass of nutrient applied), where higher nutrient use efficiency values equate to higher cotton yield per unit of fertilizer applied. Like all crops, N, P, and K are primary nutrients critical to the growth of the plant, and nitrogen is most susceptible to loss due to its high mobility (Wyatt *et al.* 2019). Maintaining a consistent replacement of nitrogen is crucial in cotton farming, given that nitrogen is extracted from the field in cottonseed. While soils can contain ample phosphate and/or potassium naturally, the availability of these nutrients varies by region and soil type. For example, around 15 to 30 lbs/acre of potassium is removed when cotton is harvested, depending on yield. Additionally, managing nitrogen supplied by soil mineralization is complex, as it is influenced by factors such as soil organic matter content and previous crops. For instance, cotton cultivated on soils containing higher clay contents after peanuts may require lower nitrogen application (Frame *et al.* 2016).

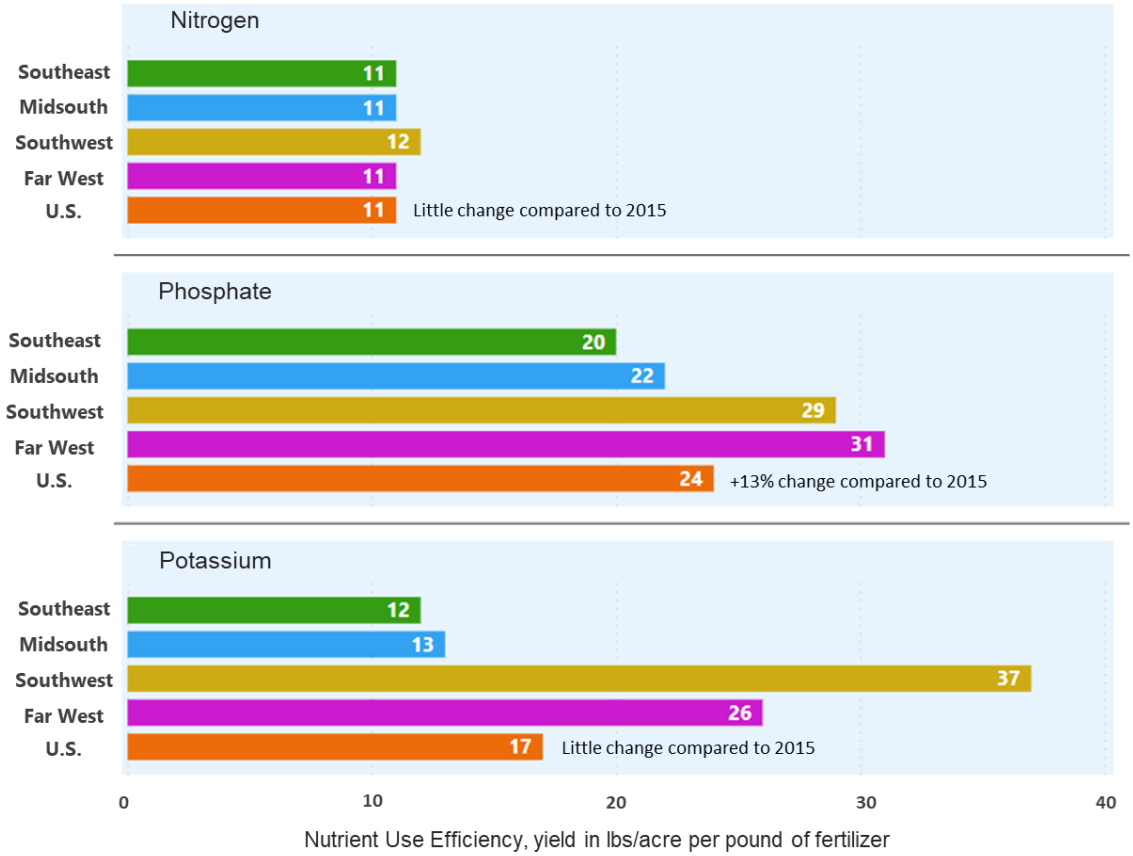


Fig. 22. Nutrient use efficiencies for nitrogen, phosphate, and potassium (N, P, K, respectively) by region (mass of cotton fiber produced per mass of nutrient applied, where higher nutrient use efficiency values equate to higher cotton yield per unit of fertilizer applied). Refer to Q48 in Appendix 1

In general, soils with high infiltration rates and low nutrient retention capacities, such as sandy soils or well-aggregated soils with low organic matter, are prone to nutrient leaching compared to soils with higher clay and organic matter content (Wyatt *et al.* 2019). The classification of soil textures into three main types – light, medium, and heavy – reflects their respective sandy, loamy, and clayey characteristics, determined by the proportions of sand, silt, and clay they contain. Fig. 23 illustrates the mapping of these soil textures through USA regions.

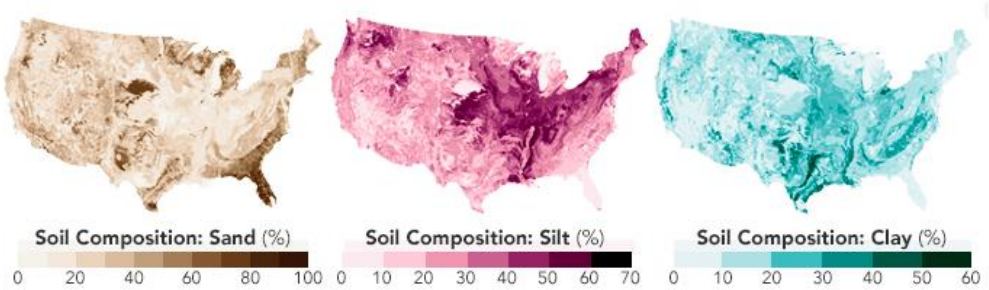


Fig. 23. Soil composition across the U.S. by NASA Earth Observatory (Miller and White 1998)

Nitrogen application levels vary across states depending on whether the field was irrigated or non-irrigated, largely due to the increased yield potential in irrigated fields. For instance, the average nitrogen application for irrigated fields across all regions ranged between 99 and 109 lbs/acre, with the lowest observed in the Midsouth region and the highest in the Far West. Conversely, non-irrigated fields in the Midsouth and Southeast regions exhibited relatively higher nitrogen application levels, at 106 lbs/acre and 97 lbs/acre respectively, in contrast to the Far West and Southwest regions, where the applied levels were notably lower, at 80 and 62 lbs/acre, respectively. Due to the low number of respondents from the Far West, the fertilizer rates in this region, however, may not accurately reflect actual application practices. Potassium application levels also reveal regional disparities, influenced by the irrigation factor and soil type. In the Southwest region, both non-irrigated and irrigated fields exhibited the lowest fertilizer applications, with 18 and 35 lbs/acre respectively. These regional differences, which are illustrated in Fig. 24, highlight the nuanced fertilizer application practices tailored to specific soil, climate conditions, and yield potential. Recommended fertilizer levels also vary by state. In Missouri, for instance, a total range of 80 to 120 lbs/acre of nitrogen is considered adequate, with split applications recommended for both sandy and silt soils (University of Missouri). In Mississippi, for medium-textured soils with a yield potential of two bales per acre, it is recommended to apply 120 to 140 pounds of nitrogen per acre (Mississippi State University 2017). The respondents reported the following as their main sources of nitrogen: during pre-planting, dry blend (42%), liquid blend (23%), urea (9%), and ammonia (2%); while in-season, these practices accounted for 25%, 34%, 15%, and 1%, respectively.

Most respondents (77%) indicated that fertilizer application levels were determined based on soil test recommendations, a practice supported by the high nutrient use efficiency values mentioned earlier. Nitrogen (N) application methods varied, with 32% injecting N into the soil profile, 12% applying a band to the surface, 35% broadcasting, and 6% broadcasting followed by incorporation. On average, two trips were made during the season to apply fertilizer, increasing the probability of its availability to the crop when needed. One-third of respondents (34%) reported using nitrification inhibitors with most responses coming from the Midsouth region. Cotton grows optimally within a soil pH range of 5.8 to 6.5, targeting 6.2. Low pH can lead to toxic element concentrations, while pH over 7.0 affects nutrient availability (Frame *et al.* 2016). Various products are employed to raise pH levels. According to a 2023 survey, 33% of respondents, mainly from the Southeast, favor dolomitic lime, while 21%—predominantly from the Midsouth region—use lime.

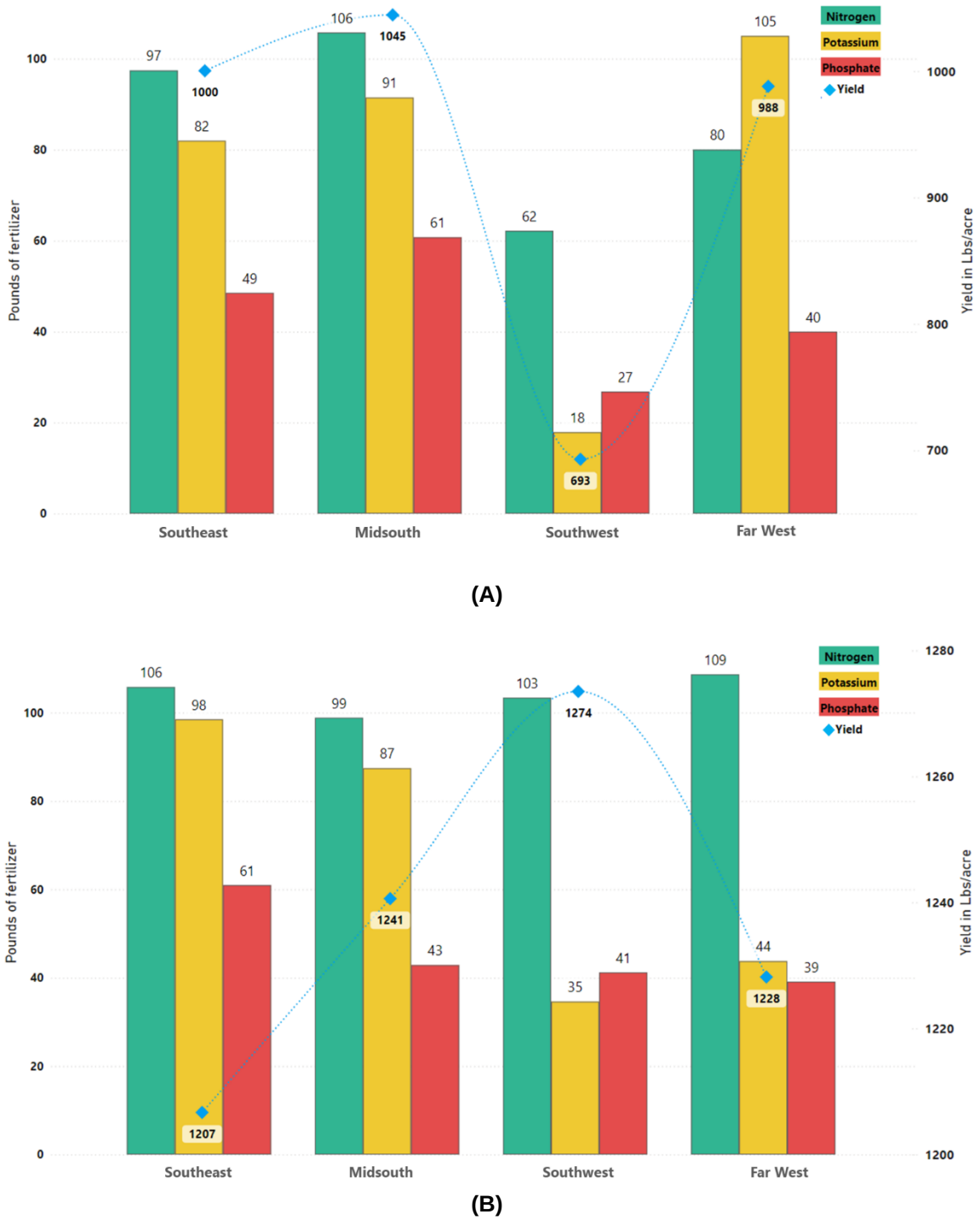


Fig. 24. State-wise average fertilizer application (in pounds) vs. yield (in lbs/acre) by 2023 survey. (A) Non-irrigated and (B) irrigated cotton fields

Irrigation Management

Survey respondents reported that approximately 39% (363,000 acres) of their cotton croplands were irrigated. The primary water source for cotton irrigation is well water, accounting for 85%. Additionally, 8% of respondents reported using on-farm surface water, and 4% reported using off-farm surface water in addition to well water. The

highest average inches of irrigation water was observed in the Far West region, amounting to 36 inches, while the Midsouth region reported the lowest at 9 inches. This disparity can be attributed to the specific climate of each region and variability in average annual precipitation. The primary energy sources for irrigation reported by respondents are electric (73%), diesel (20%), and natural gas (6%). Figure 25 depicts all the mentioned irrigation aspects, while Table 5 provides the regional percentage of irrigation sources, where on-farm sources are predominant in the Southeast region, and off-farm sources are prevalent in the Far West.

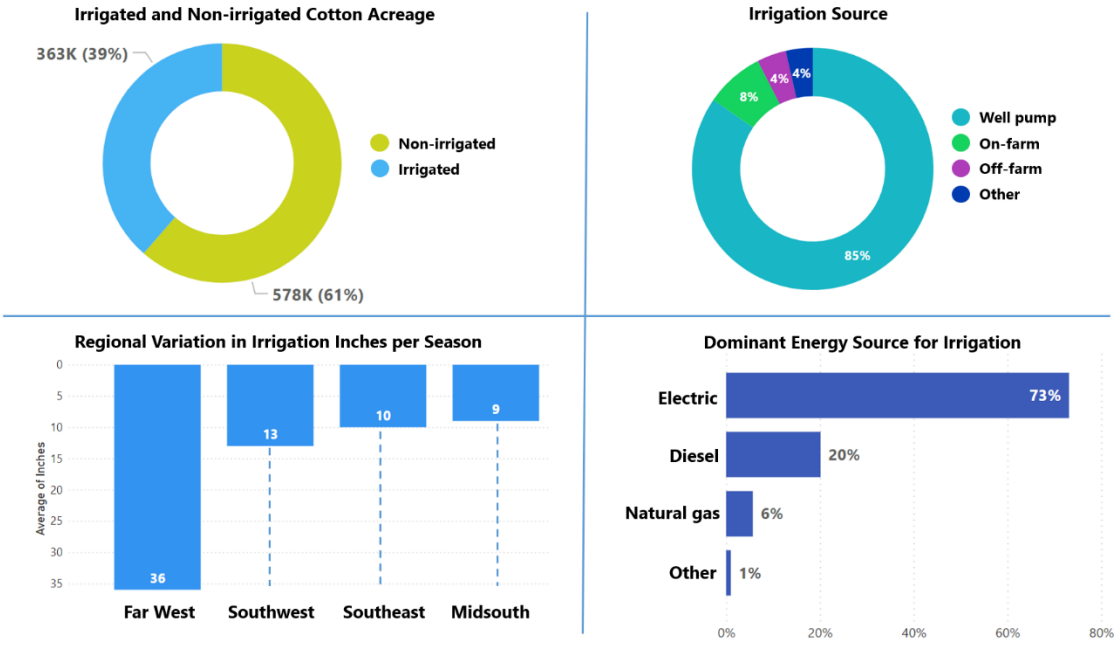


Fig. 25. Irrigated and non-irrigated cotton acreage, irrigation inches, water source, and energy source for irrigation by 2023 survey (Refer to Q1, Q30, Q33, and Q37 in Appendix 1)

Table 5. Irrigation Source by Region (Refer to Q33 in Appendix 1)

Region	Well pump	On-farm	Off-farm	Other
Southeast	74%	22%	0%	4%
Midsouth	93%	6%	0%	2%
Southwest	91%	0%	6%	3%
Far West	65%	0%	24%	12%
U.S.	**85%**	**8%**	**4%**	**4%**

When comparing survey results for producers using irrigation from 2008 and 2015 to 2023, a consistent trend is evident toward reduced use of surface irrigation, as depicted in Fig. 26. Specifically, the utilization of furrow systems has decreased from 44% in 2008 to 26% in 2023, while the adoption of pivot/sprinkler systems has increased from 49% in 2008 to 59% in 2023. In general, the shift to pressurized systems, such as pivot systems, is associated with higher water use efficiencies, given their enhanced precision and

operational control. Additionally, there is an observable trend towards an increased adoption of drip (surface or subsurface) irrigation systems at approximately 15%. The adoption was observed mainly in the Southwest region (Refer to ST 4 in Appendix 2), where the return on investment is better and irrigation water capacity is limited.

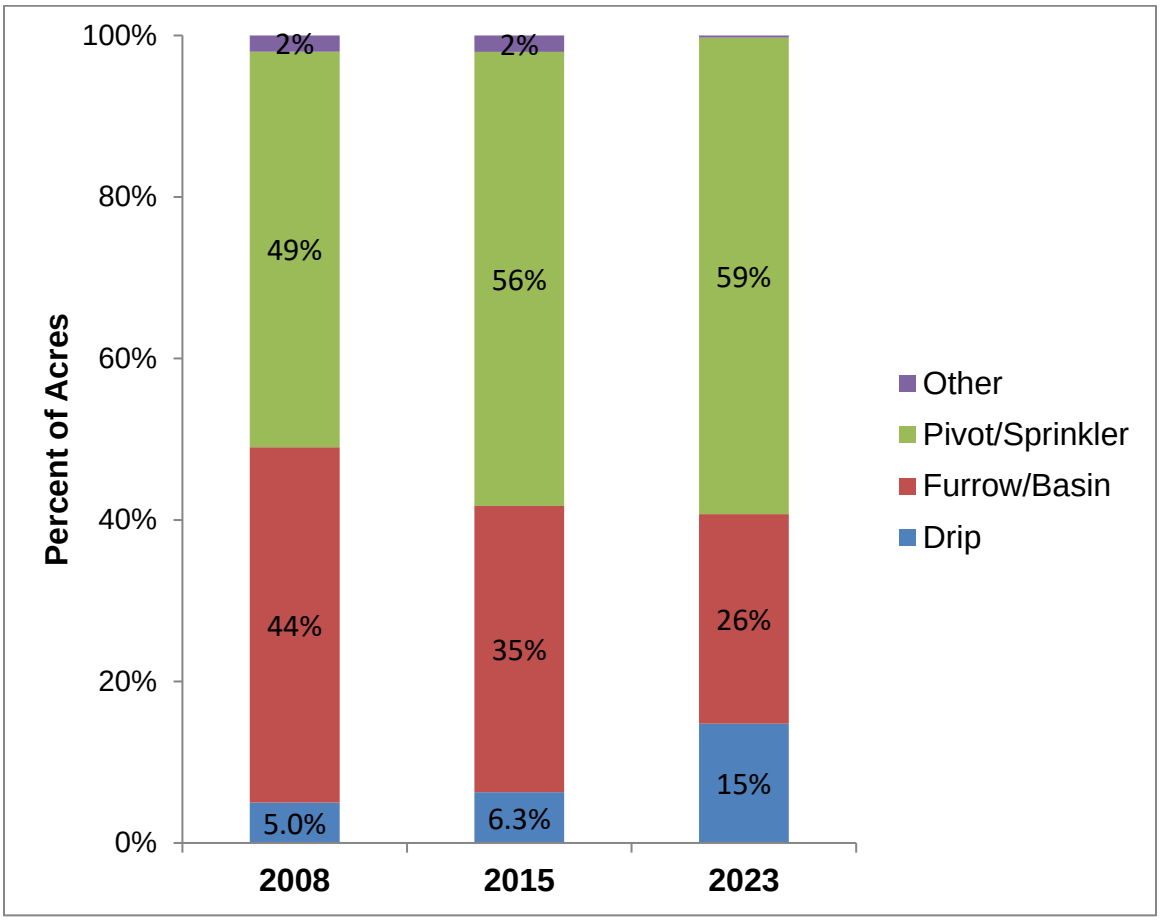


Fig. 26. Irrigation systems used in 2008, 2015, and 2023**.** Less than 1% of respondents selected "Other" in 2023. (For the 2023 Survey, refer to Q32 in Appendix 1)

In the management of irrigation tailwater from furrow/basin irrigation, a majority of respondents (68%) reported implementing adjustments to field slope and length to minimize runoff. Additionally, 14% utilize holding ponds, and 10% specifically address tailwater runoff (Refer to ST 5 in Appendix 2). Notably, around 16% of farmers expressed concerns about water salinity in their farm wells, a slight increase from the previous 2015 survey at 11%. Efforts to enhance the efficiency of irrigation water usage can be advanced by promoting greater adoption of flow measuring devices. These devices serve as an effective means to ensure the smooth functioning of an irrigation system. Notably, the utilization of flow meters and irrigation scheduling has increased to 52% for both practices in the 2023 survey year, up from 38% and 34% in 2015, respectively. Additionally, there has been an increase in the adoption of moisture monitoring, climbing from 21% to 44%. Figure 27 illustrates irrigation efficiency improvement practices over the years on regional and national levels.

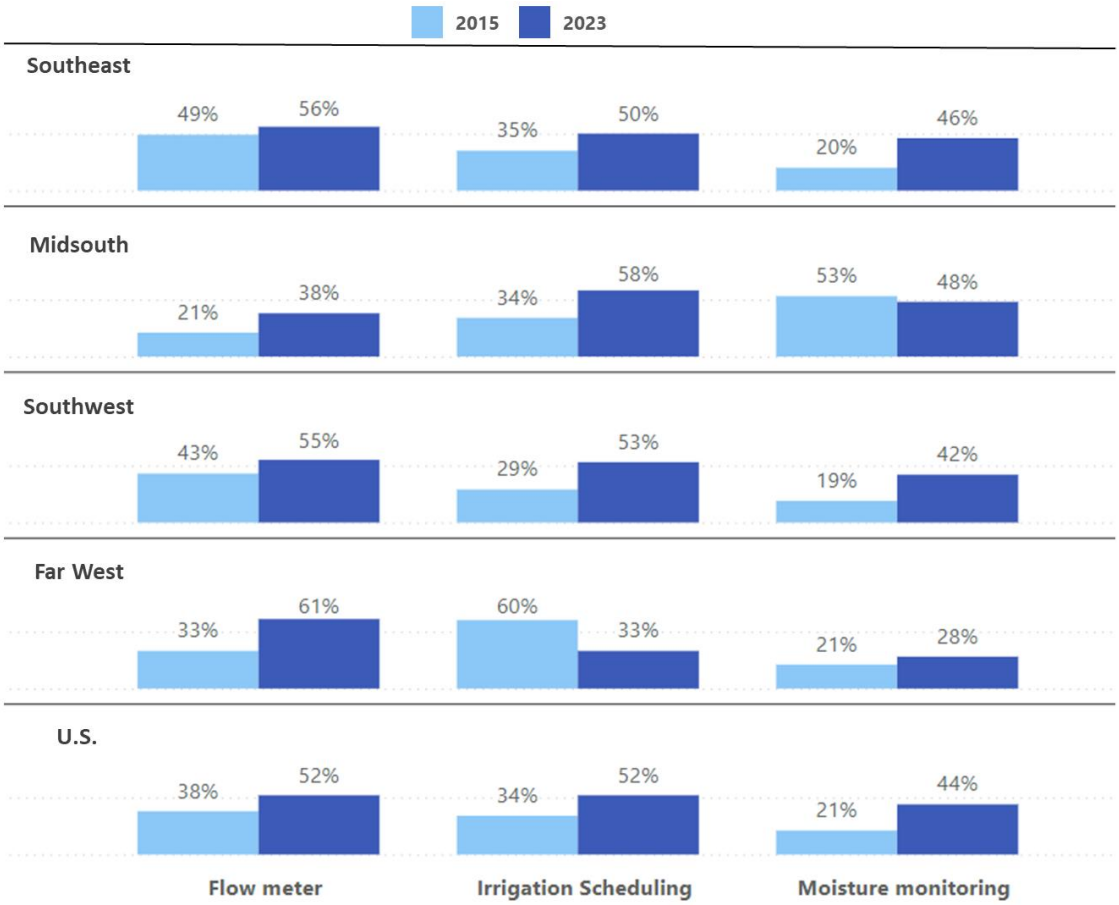


Fig. 27. Irrigation efficiency improvement practices adopted by region through 2015 and 2023 (For the 2023 Survey, refer to Q31 in Appendix 1)

Precision Farming Technologies

The survey data indicate a noticeable upward trend in the adoption of various technologies, except for soil sampling, which has remained steady at 46% (Fig. 28). Autosteer/GPS technology, in particular, has experienced a significant increase, surging from 46% in 2008 to 69% in 2015 and further to 86% in 2023. The rapid rise in autosteer technology adoption, surpassing other options, signifies its emergence as a standard feature on new equipment which may require minimal preparation to use compared to alternatives that involve downloading, interpreting, and re-uploading maps. A new report on precision technologies (McFadden *et al.* 2023) suggests that these benefits, along with potential savings from reduced skips and overlaps in input costs (like fuel, seed, nutrients, and pesticides), are likely driving the increase in adoption rates.

The survey further revealed a significant increase in yield monitor adoption (from 20% in 2015 to 35% in 2023) across all regions, reflecting a growing inclination towards integrating data-collecting technologies into agricultural equipment. According to the same USDA report, yield monitors are predominantly employed to assist in determining crop input usage in cotton farming. As shown in Fig. 29, the Midsouth and Southwest regions experienced the most significant increase, with an average rise of 20% from 2015 to 2023. As new technologies evolved, there were new additions to the question of precision technologies.

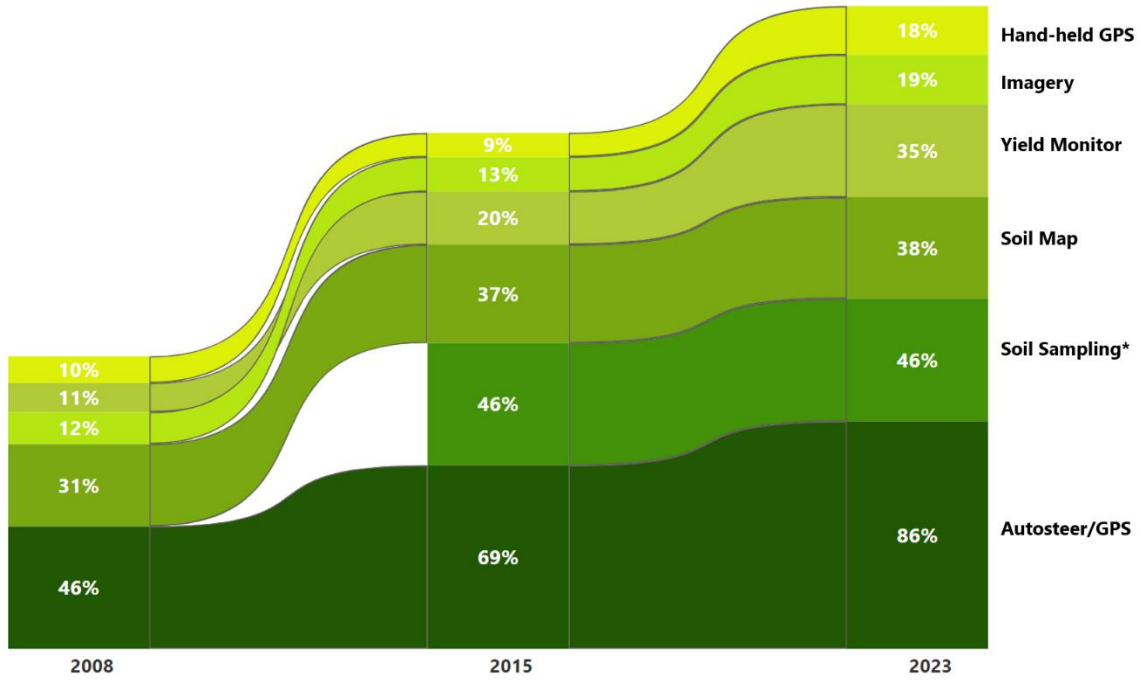


Fig. 28. Precision technologies used in 2008, 2015, and 2023. (*: Soil Sampling question wasn't asked in the 2008 survey; it was only introduced in 2015). (For the 2023 Survey, refer to Q19 in Appendix 1).

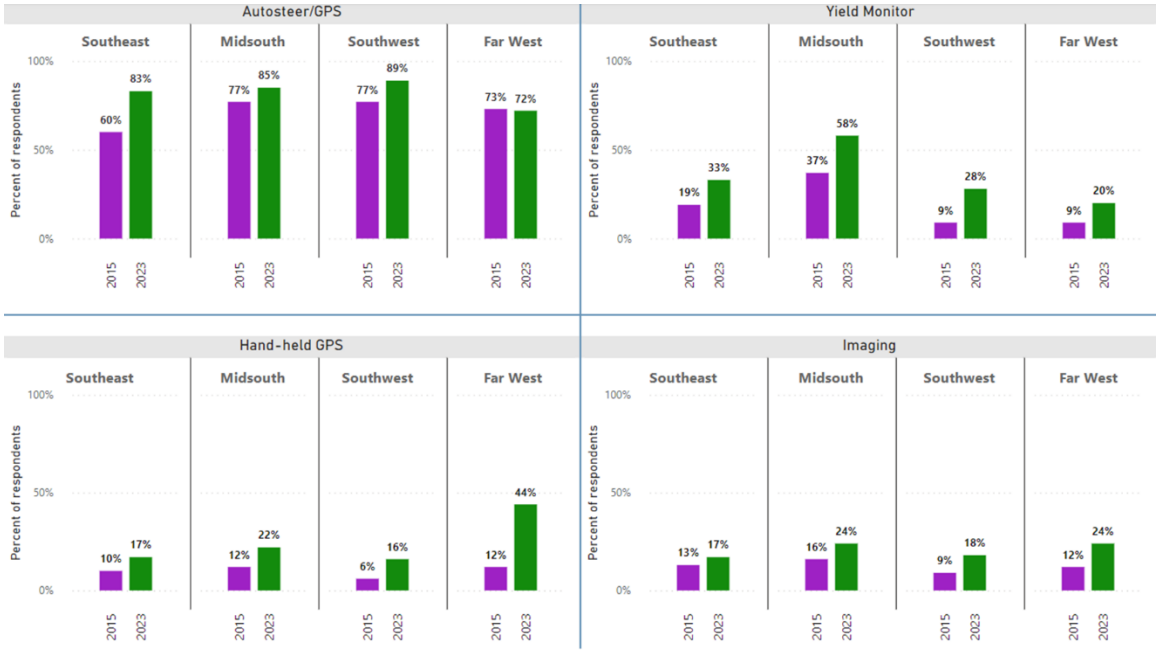


Fig. 29. Precision technologies by regions and over time by 2023 survey (For the 2023 Survey, refer to Q19 in Appendix 1)

These additions included the use of see and spray systems (such as Weed IT, WeedSeeker, John Deere, *etc*.), swath control, and unpiloted aerial vehicles (UAVs). The

survey found that most respondents (71%) reported using swath control on their spray boom, and 40% reported using swath control on their planter. Additionally, nearly 6% of respondents reported operating UAVs, while 5% reported deploying see and spray systems (Refer to ST6 in Appendix 2). In general, only 4% of all respondents reported not using precision technologies. Growers utilizing precision technologies have reported higher average cotton yields across all growing regions, except for the Far West region. However, due to the small sample size in the Far West, the differences shown may not be significant.

Automation

Automation, including the integration of driverless tractor technology, may significantly enhance operational efficiency and precision in agricultural practices by streamlining tasks such as planting, spraying, and harvesting. The 2023 survey introduced some new questions to cotton farmers regarding the benefits and impediments of using driverless tractors on their farms, the machines that are capable of operating without human intervention. More than 50% of respondents reported labor savings as one of the perceived future benefits of driverless tractors, 41% cited improved efficiency, 28% highlighted decreased worker exposure, and 34% considered the technology to have no benefits (Fig. 30).

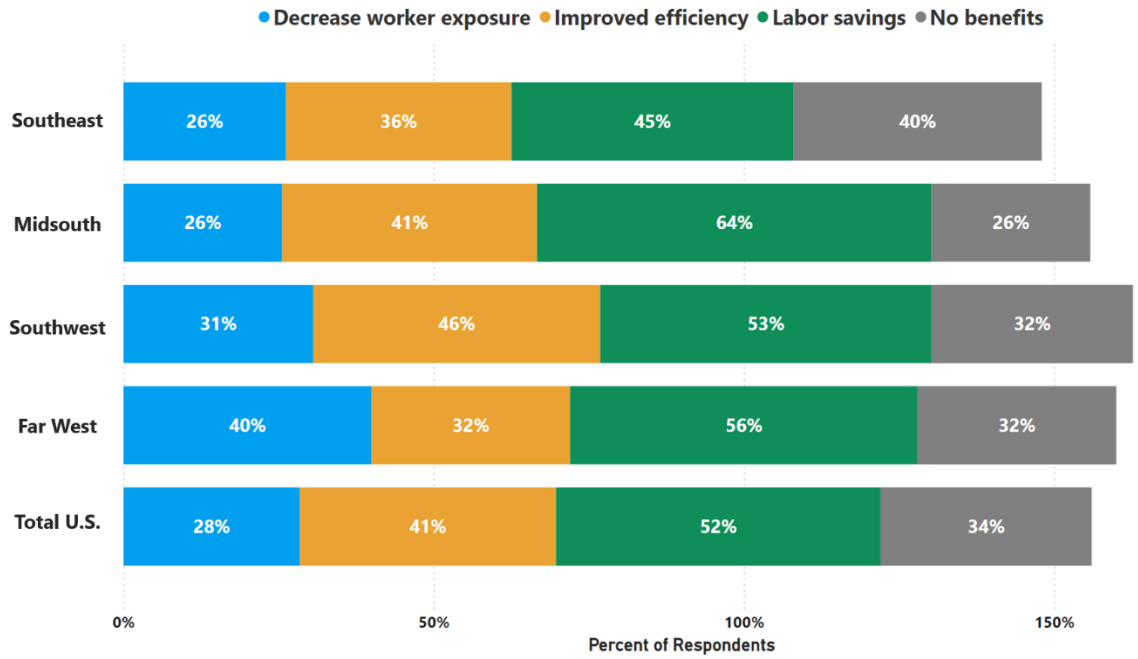


Fig. 30. Perceived benefits of using driverless tractors on farms by 2023 survey respondents (Refer to Q22 in Appendix 1)

Another question focused on potential obstacles to the adoption of driverless tractors, as outlined in Table 6. In general, responses exhibited a common trend across regions, except for increased concerns regarding field obstacles and inter-field transportation in the Southeast and Midsouth. This disparity is likely influenced by the increased presence of water features and topographical variations, which may pose challenges to field operations compared to the terrains of the Southwest and Far West.

However, regardless of geographical location, approximately 80% of respondents highlighted costs as the primary barrier to integrating driverless tractors into their farms. Furthermore, among the practices where respondents favored utilizing this technology, planting (40%), spray applications (40%), harvest (35%), and pre-plant weed control (35%) emerged as the most preferred high-priority activities.

Table 6. Impediments to Using Driverless Tractors on Farms by 2023 Survey Respondents (Refer to Q21 in Appendix 1)

Impediments to using driverless tractors	Region				
	Southeast	Midsouth	Southwest	Far West	U.S.
Costs	80%	80%	76%	80%	**78%**
Risk of accidents resulting in litigation	61%	60%	60%	68%	**61%**
Too many obstacles in field	62%	63%	59%	48%	**60%**
Field-to-field transportation	63%	64%	54%	52%	**59%**
Dependability	52%	45%	52%	44%	**50%**
Skilled labor to supervise	44%	45%	42%	36%	**43%**
No Impediments	5%	5%	6%	4%	**6%**
Other	4%	4%	2%	8%	**3%**

Pesticide Management

Cotton growers are embracing new technologies to enhance the precision of their pesticide applications, as previously mentioned regarding the use of swath and other spray technologies. Some of these technologies (like Weed-IT, Weed seeker, John Deere See and Spray) may see increased adoption in the future. Ground rigs remain the predominant method for pesticide applications, with 85% of respondents opting for this approach, mirroring trends observed in 2008 and 2015 (For the 2023 Survey, refer to ST 7, Appendix 2). Additionally, 66% of respondents indicated their reliance on professional consultants to advise on foliar insecticide treatments, marking a slight decline from the 71% reported in 2015. Notably, less than 8% of respondents reported using a calendar-based spray schedule, consistent with the 6% figure recorded in 2015. Also, 37% of respondents reported fields that did not receive foliar insecticides during the season, compared to 33% in 2015 and 29% in 2008. Additionally, an estimated 16% of reported cotton acres went untreated with insecticide, a decrease from 21% in 2015 (For the 2023 Survey, refer to ST 8, Appendix 2).

The distribution of target pests has shown a consistent pattern from 2015 to 2023 (Fig. 31). According to respondents' percentages, there were slight increases in the populations of aphids (+4%), cotton flea hoppers (+10%), and grasshoppers (+8%). Notably, the top three targeted insects reported by respondents have remained unchanged since 2008. Thrips have seen a significant increase of 34%, stink bugs increased by 15%, and aphids by 19% over this period. The trend indicates a persistent focus on these three pests among survey participants; however, it's important to take regional variations. For instance, stink bugs and plant bugs are predominantly found in the Southeast (87%, 62%) and Midsouth (50%, 86%), whereas their prevalence in the Southwest and Far West is less than 30%. Conversely, cotton fleahoppers are most prevalent in the Southwest (59%),

while their occurrence in other regions ranges from 4% to 12% (Refer to ST 9, Appendix 2). The primary target pathogens are boll rots in the Southeast (61%) and Midsouth (58%), and verticillium wilt in the Southwest (40%) and Farwest (68%). For a more detailed regional breakdown, refer to ST 10, Appendix 2.

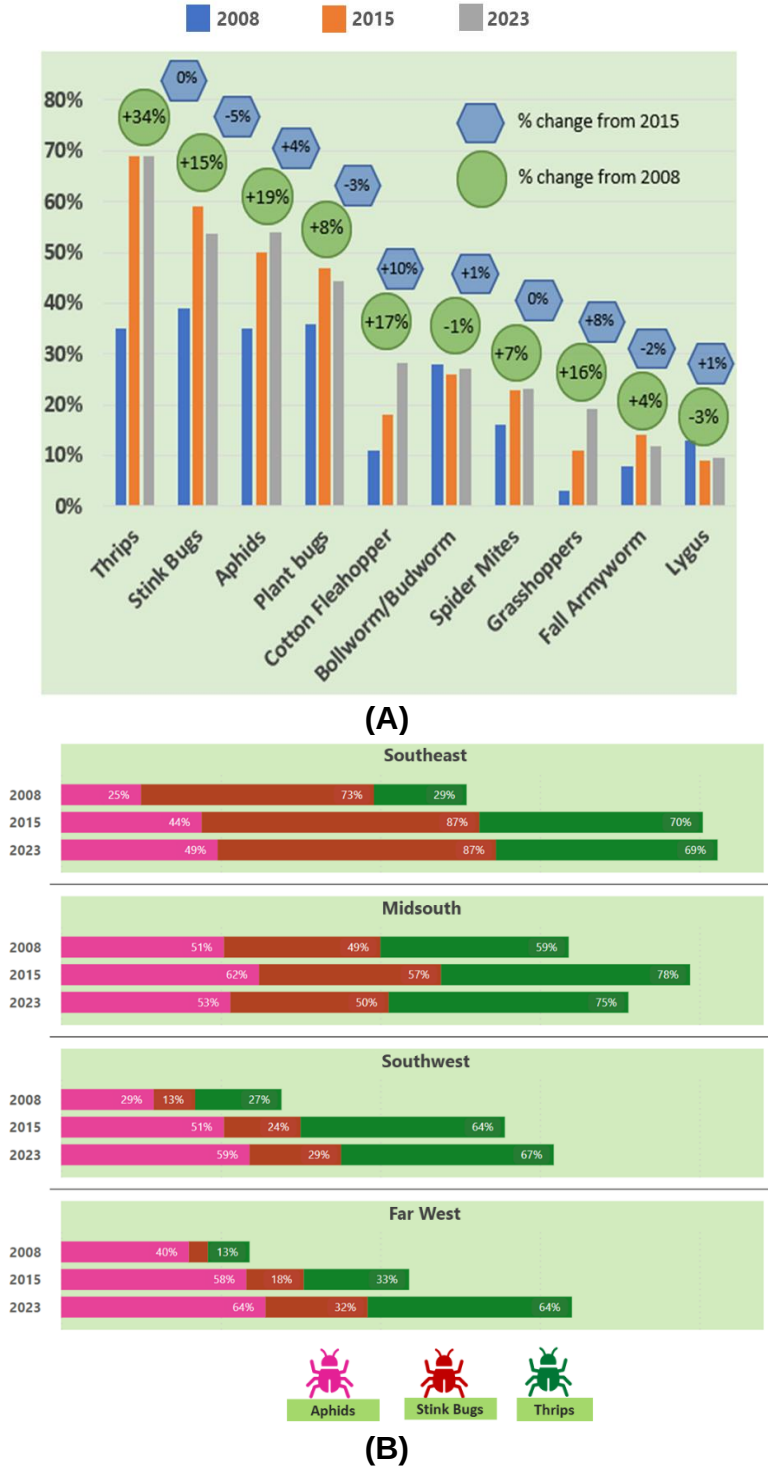


Fig. 31. Target pests across U.S. cotton production among respondents (A) in 2008, 2015 and 2023 and (B) through regions

Integrated pest management (IPM) strategies play a critical role in addressing challenges posed by resilient pests like thrips, emphasizing the importance of a multifaceted approach. For instance, conservation and reduced tillage methods, particularly when integrated with high-residue cover crops, exhibit significant potential in mitigating thrips populations on cotton seedlings by up to 50% (Virginia Cooperative Extension).

Cotton growers reported an increased concern regarding herbicide-resistant weeds, as evidenced by the fact that 95% of them expressed worry about the costs associated with herbicides. Moreover, only 1% of growers opt not to cultivate herbicide-tolerant cotton varieties. The major concern about weed resistance to herbicides, indicated by 65% of respondents, is reflected in various practices:

- 71% checked for weed escapes (76% in 2008, 72% in 2015).
- 81% used a pre-emergent herbicide (70% in 2008, 82% in 2015).
- 79% alternated herbicide modes of action (62% in 2008, 79% in 2015).
- 49% reported hand hoeing (not asked in 2008, 66% in 2015).
- 55% planted cover crops, a significant increase from 33% in 2015.

To conveniently observe the main trends and their changes from 2015 to 2023, the data were scaled to 100%, as shown in Fig. 32.

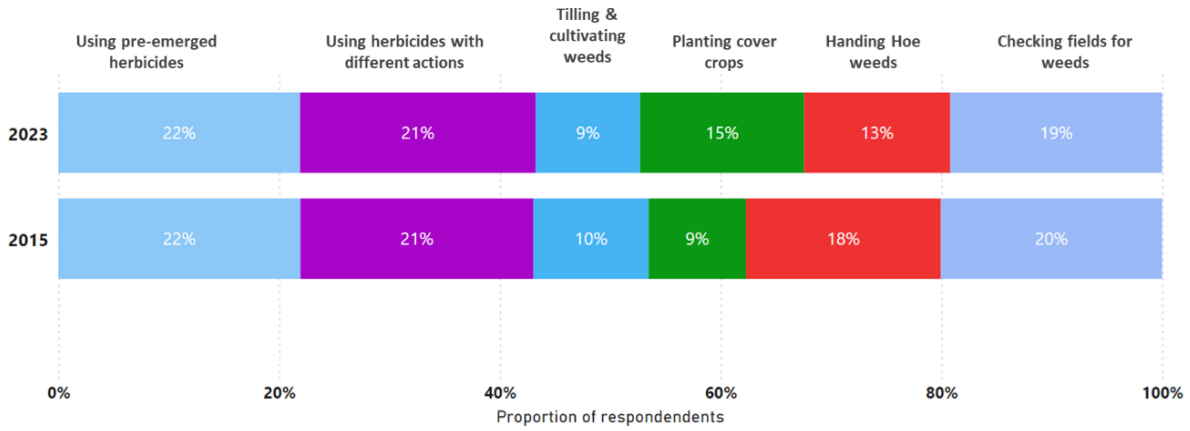


Fig. 32. Adopting herbicide control practices among cotton producers over time. The data for both survey years was adjusted to a 100% scale (For the 2023 Survey, refer to Q12 in Appendix 1).

When analyzing herbicide control practices across regions, a consistent trend emerges across the majority of practices, except for tilling and cultivating weeds that have escaped herbicide control. In this regard, the Southwest (60%) and Far West (69%) regions exhibit a notably higher preference compared to the Southeast (15%) and Midsouth (24%), as illustrated in Table 7. In general, over 70% of respondents decided to apply foliar herbicide after scouting their crop, while only 14% set a calendar spray schedule. Additionally, 10% of respondents reported that their fields don't require a foliar herbicide, representing 3% of all reported cotton acreage (Refer to ST 7, Appendix 2).

Conservation Practices and Natural Habitat Management

Conservation practices are pivotal in mitigating the environmental footprint of cotton cultivation and safeguarding the ecosystem, which is essential for the sustained production of cotton. To grasp the extent of the adoption of these practices, the survey asked growers about the conservation methods employed on their farms.

Table 7. Herbicide Control Practices by Regions in the 2023 Survey (Refer to Q12 in Appendix 1)

Practices to manage Roundup Ready, Liberty Link, and other herbicide-tolerant cotton varieties	% of Respondents by Region				
	Southeast	Midsouth	Southwest	Far West	U.S.
Using pre-emerged herbicide	78.7%	80.2%	83.9%	69.2%	**80.9%**
Using herbicides with different modes of action	82.8%	69.8%	79.6%	76.9%	**79.1%**
Checking fields for weeds that escaped herbicide control	77.6%	65.1%	69.2%	38.5%	**70.9%**
Planting cover crops to reduce weed pressure	60.8%	48.7%	53.6%	44.4%	**55.1%**
Handing hoe weeds that escaped control	52.1%	46.5%	48.8%	38.5%	**49.4%**
Tilling and cultivating weeds that escaped herbicide control	14.6%	24.4%	55.9%	69.2%	**35.1%**
Not growing herbicide tolerant cotton varieties	0.0%	1.2%	1.9%	0.0%	**1.0%**
Other	0.5%	0.0%	1.4%	0.0%	**0.8%**

Table 8. Percent of Respondents Using Listed Conservation Practices by Regions through 2015 and 2023 (For the 2023 Survey, refer to Q55 in Appendix 1)

Conservation Practices	2015					2023				
	SE	MS	SW	FW	U.S.	SE	MS	SW	FW	U.S.
Conservation cover	26.4%	14.6%	18.1%	6.1%	**20.7%**	46.4%	25.3%	42.7%	15.4%	**40.4%**
Field borders	31.0%	29.7%	16.3%	36.4%	**26.5%**	32.3%	27.9%	14.7%	53.9%	**24.7%**
Grass waterway	25.5%	15.1%	16.3%	0.0%	**19.6%**	29.2%	20.9%	10.0%	0.0%	**18.9%**
Recycle farm plastic/paper	9.1%	32.7%	6.1%	15.2%	**13.5%**	4.7%	23.3%	6.2%	7.7%	**8.6%**
Efforts to improve wildlife habitat	N/A					8.9%	10.5%	6.2%	7.7%	**8.0%**
Vegetative border	16.6%	15.6%	10.8%	3.0%	**14.2%**	10.9%	15.1%	2.4%	0.0%	**7.8%**
Precision leveled	0.2%	26.1%	8.3%	54.6%	**10.2%**	2.1%	22.1%	5.2%	23.1%	**7.4%**
Drop pipes for erosion control	4.1%	26.6%	6.5%	0.0%	**9.5%**	5.2%	16.3%	3.3%	0.0%	**6.2%**
Livestock integration	N/A					2.6%	2.3%	10.0%	23.1%	**6.2%**
Contour strip cropping	7.0%	2.5%	5.4%	0.0%	**5.3%**	4.2%	0.0%	8.5%	0.0%	**5.2%**
Leave riparian	N/A					6.8%	8.1%	1.4%	0.0%	**4.6%**
Field strip cropping	9.4%	1.0%	4.3%	0.0%	**5.7%**	5.2%	0.0%	3.3%	0.0%	**3.4%**
Riparian forest buffer	7.0%	2.5%	1.4%	0.0%	**4.1%**	4.7%	7.0%	1.0%	0.0%	**3.4%**
Water and sediment control basin	2.2%	11.6%	11.8%	0.0%	**4.0%**	1.6%	9.3%	1.4%	0.0%	**2.8%**
Filter strip	5.3%	3.5%	0.7%	3.0%	**3.5%**	2.1%	5.8%	1.0%	0.0%	**2.2%**
Riparian herbaceous cover	0.7%	1.5%	0.4%	0.0%	**0.8%**	1.6%	4.7%	1.0%	0.0%	**1.8%**
Contour buffer strip	3.1%	1.5%	2.2%	0.0%	**2.4%**	1.6%	4.7%	0.5%	0.0%	**1.6%**
Tailwater recovery system	0.2%	1.5%	1.4%	24.2%	**1.7%**	0.5%	2.3%	1.4%	15.4%	**1.6%**
Sediment basin	0.5%	8.0%	1.4%	0.0%	**2.4%**	1.0%	5.8%	0.0%	0.0%	**1.4%**
Stream habitat improvement	1.2%	1.0%	0.4%	0.0%	**0.8%**	0.0%	2.3%	0.0%	0.0%	**0.4%**
None of the above	28.4%	20.1%	44.8%	15.2%	**31.0%**	16.2%	18.6%	28.4%	23.1%	**21.9%**

Out of the practices listed in Table 8, about 78% of growers indicated using at least one (compared to 69% in 2015). The preferred practices included adopting conservation cover crops (+21% from 2015), establishing field borders (-1% from 2015), and implementing grass waterways (-1% from 2015).

In terms of efforts made on farms to enhance wildlife habitat, 47% (+6% from 2015) of respondents reported maintaining field borders conducive to wildlife habitat. Overall, 76% of respondents indicated their efforts to improve wildlife habitat, reflecting an increase of 8% from 2015. When considering barriers to enhancing wildlife habitat, 37% of respondents cited a lack of funding, while 26% highlighted increased pest pressure from conservation areas. Interestingly, nearly 29% indicated they didn't perceive any significant barriers. Furthermore, there has been an increase in participation in wildlife conservation programs. For instance, 33% joined conservation reserve programs, up from 22% in 2015. Similarly, participation in wildlife habitat incentive programs increased to 19%, compared to 8% in 2015. Evidence concerning wildlife habitat improvement practices is presented in Table 9, derived from survey questions.

Table 9. Percent of Respondents Adopting Practices on Wildlife Habitat Improvement in the 2023 Survey Year (Refer to Q24 and Q25 in Appendix 1)

Efforts to enhance wildlife habitat	% of Respondents by Region				
	Southeast	Midsouth	Southwest	Far West	U.S.
Some portion of the farm is left unharvested for wildlife feed	33.8%	38.3%	28.4%	33.3%	**32.3%**
Field borders are conducive to wildlife habitat	52.4%	52.3%	40.9%	44.4%	**47.4%**
Manage some field areas during the winter to provide wildlife habitat	28.1%	33.7%	22.3%	7.7%	**26.1%**
Forested areas are preserved	50.0%	39.5%	12.8%	0.0%	**31.3%**
Conservation Reserve Program	27.6%	36.9%	37.6%	27.8%	**33.5%**
Wildlife Habitat Incentive Program	19.8%	22.5%	17.9%	11.1%	**19.2%**
Wetlands Reserve Program	7.3%	16.3%	3.3%	0.0%	**7.0%**
No efforts	16.7%	16.3%	33.7%	46.2%	**24.5%**
Barriers to enhance wildlife habitat	**Southeast**	**Midsouth**	**Southwest**	**Far West**	**U.S.**
Lack of funding to incentivize wildlife enhancement practices	42.2%	37.2%	33.0%	40.0%	**37.3%**
Lack of precision agriculture data to support the decision	5.8%	10.1%	10.8%	4.0%	**8.6%**
Increased pest pressure from conservation areas	26.2%	32.6%	23.8%	24.0%	**26.2%**
Lack of guidance on how to enroll in a program that supports wildlife habitat enhancement	19.3%	17.1%	17.9%	24.0%	**18.5%**
Not interested in enhancing wildlife habitat	18.6%	11.6%	16.7%	16.0%	**16.5%**
No barriers	23.3%	31.0%	32.7%	24.0%	**28.7%**

Yield and Other Specific Data

In the 2021/2022 growing season, the average U.S. cotton yield covering all 4 regions, based on USDA data, was approximately 1038 pounds per acre, nearly aligning with the surveyed average of 1073 pounds per acre. When compared to the average yields from the previous surveys, the average didn't change much (a 3% increase from 2008 and a 1% decrease from 2015). Numerous factors, including precipitation and climate conditions, impact average yields, making it challenging to pinpoint the causes of year-to-year fluctuations. Notably, the limited number of respondents from the Far West region could be a contributing factor in an observed decrease in average field yield with 1625 lbs/acre in 2008 to 1215 lbs/acre in 2023, representing a 25% decrease (Fig. 33).

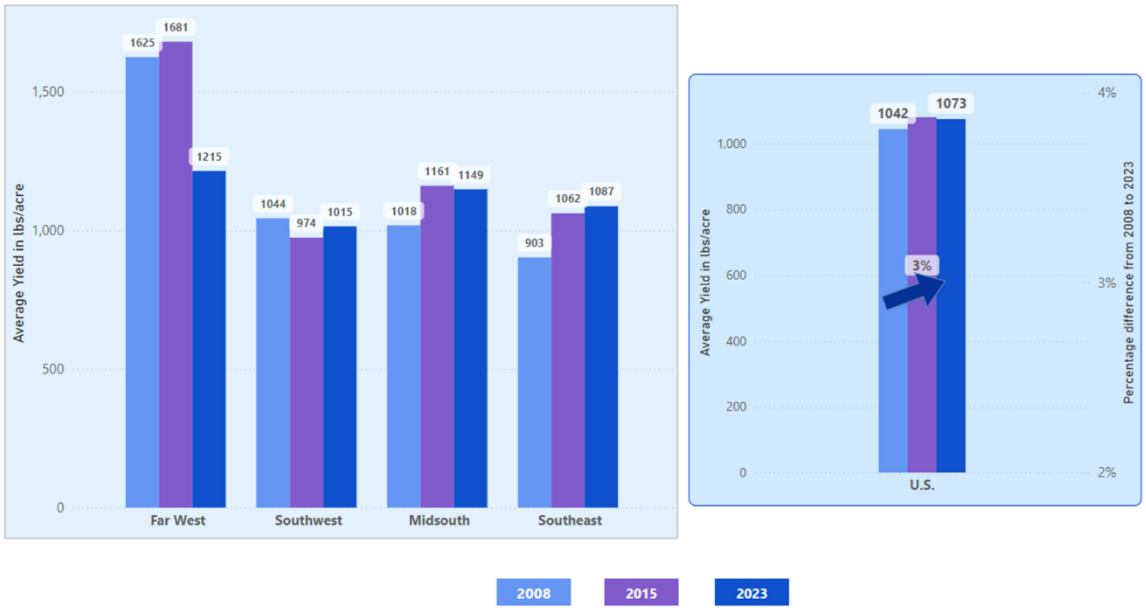


Fig. 33. Average yield difference by 2008, 2015, and 2023 survey respondents (For the 2023 Survey, refer to Q38 in Appendix 1)

On average, farmers spent between $80 and $120 per acre on cotton harvesting, with distinct regional variations (Fig. 34). One factor impacting harvest costs by region is yield, where regions with higher yields will have higher costs for packaging and generally harvest at a slower rate. The Far West region reported the highest costs, exceeding $150 on average (reported by 40% of respondents) due to higher fuel and labor costs than the other regions coupled with high yields, while the Southwest region recorded comparatively lower expenses, ranging from $50 to $100 on average (Table 10). The lower cotton harvesting costs in the Southwest can be explained by the types of harvesting machines used, specifically pickers versus strippers. Historically, most of the cotton grown on the in the Southwest region has been harvested using strippers (Faulkner *et al.* 2008). The operational and other associated costs of using strippers usually are lower compared to pickers, which likely accounts for the reduced harvesting costs in this region (Yates *et al.* 2007).

Since the harvesting cost typically includes expenses such as transporting cotton from the field to the gin, among others, the distance to the gin may affect the overall expenses for growers. However, according to the surveyed data, the distance between the

fields and gins has increased in all regions, except for the Southeast. This change is likely attributed to the improved cost-effectiveness of transporting larger cylindrical modules over longer distances and some consolidation of gins over the past decade.

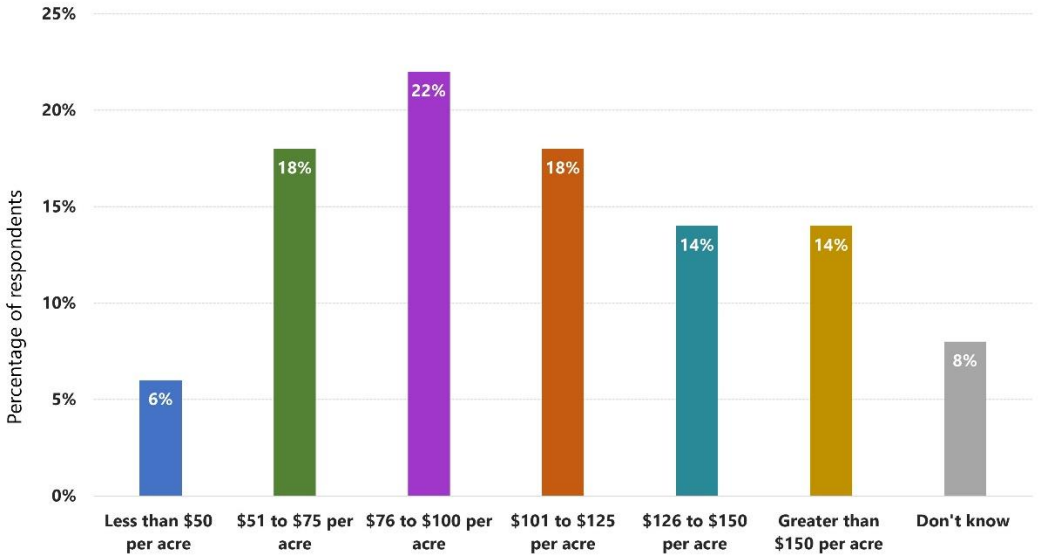


Fig. 34. Average cost to harvest cotton among 2023 survey respondents (Refer to Q20 in Appendix 1).

Table 10. Regional Averages for Yield and Harvesting Cost, and Distance from Farm to Gin: 2023 Survey Data with Gin Comparison to 2015

Region	Yield (lbs/acre)	Harvesting Cost ($)	Tillage Passes (Avrg)	Distance from Farm to Gin in 2023 (miles)	Distance from Farm to Gin in 2015 (miles)
Southeast	1087	$80-$100	1.3	23	23
Midsouth	1149	$120-$150	1.5	24	15
Southwest	1015	$50-$80	1.9	18	15
Far West	1215	>$150	2	20	12
U.S.	**1073**	**$80-$100**	**1.6**	**21**	**18**

CONCLUSIONS

1. The 2023 survey provided a comprehensive dataset of U.S. cotton growers, offering valuable insights into demographics, practices, and challenges regionally and nationwide.
2. Utilizing the 2023 survey results can inform current agricultural systems, track the impact of outreach and technology adoption, and guide decisions for more profitable and sustainable cotton production.
3. Grower concerns over extreme weather events indicate the increasing impact of climate change on cotton production challenges and the need to increase cotton's climate resilience.

4. While face-to-face interactions remain common and most useful, cotton growers are increasingly turning to digital tools like apps and social media to disseminate information.
5. From 2008 to 2023, a notable shift in tillage practices towards no-till/strip-till methods suggests potential cost savings and reduced energy requirements.
6. A consistent trend is observed among producers using irrigation, with a shift away from surface irrigation methods, such as furrow systems, towards pressurized systems like pivot/sprinkler systems, indicating increased water use efficiencies attributed to enhanced precision and operational control.
7. Autosteer/GPS technology has seen a significant increase in adoption rates, becoming a standard feature on new equipment, driven by simplified setup processes and potential cost savings from reduced skips and overlaps in input costs.
8. The increasing adoption of conservation practices, particularly increased adoption of winter cover crops among U.S. cotton growers highlights their dedication to continual improvement, climate resiliency, and creating positive environmental outcomes.

ACKNOWLEDGMENTS

The completion of this work was made possible by the funding provided by Cotton Incorporated and the invaluable contributions of cotton farmers who participated in the natural resource survey.

REFERENCES CITED

Barnes, E. M., Campbell, B. T., Vellidis, G., Porter, W. M., Payero, J. O., Leib, B. G., Sui, R., Fisher, D. K., Anapalli, S., Colaizzi, P. D., Bordovsky, J. P., Porter, D. O., Ale, S., Mahan, J., Taghvaeian, S., and Thorp, K. R. (2020). "Forty years of increasing cotton's water productivity and why the trend will continue," *Applied Computational Electromagnetics Society Journal* 36(4), 457-478. DOI: 10.13031/aea.13911

Cotton Incorporated. (2016). *Life Cycle Assessment*.

CottonToday. *Biodiversity and Wildlife Habitat.* https://cottontoday.cottoninc.com/our-sustainability-story/land/habitat-preservation/

Daystar, J. S., Barnes, E., Hake, K., and Kurtz, R. (2017). "Sustainability trends and natural resource use in U.S. cotton production," *BioResources* 12(1) 362-392. DOI: 10.15376/biores.12.1.362-392

Fannin, B. (2017). "Texas agricultural losses from Hurricane Harvey estimated at more than $200 million," (https://agrilifetoday.tamu.edu/2017/10/27/texas-agricultural-losses-from-hurricane-harvey-estimated-at-more-than-200-million/), Accessed June 26, 2024.

Faulkner, W. B., Wanjura, J. D., Shaw, B. W., and Hequet, E. F. (2008). "Effect of harvesting methods on fiber and yarn quality from irrigated cotton on the High Plains," *2009 Beltwide Cotton Conferences*, San Antonio, TX, USA, pp. 449-461.

Field to Market. (2021). *Environmental Outcomes from On-Farm Agricultural Production in the United States (Fourth Edition)*. ISBN: 978-0-578-33372-4

Foro Económico Mundial., Marsh and McLennan., SK Group., and Zurich Insurance Group. (2022). *The Global Risks Report 2022*. World Economic Forum.

Frame, W. H., Herbert, D. A., Mehl, H., Cahoon, C., Reiter, M., and Flessner, M. (2016). *Virginia Cotton Production Guide* (https://www.sites.ext.vt.edu/newsletter-archive/cotton-production-guide/2016.pdf), Virginia Cooperative Extension, Virginia Tech, Blacksburg, VA, USA.

Geisseler, D., and Horwath, W. R. (2016). *Economically Optimal Nitrogen Availability for Cotton*, (https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Cotton_EONR.pdf), UC Davis, CA, USA.

Grainger, C., Williams, R., Clarke, T., Wright, A. D. G., and Eckard, R. J. (2010). "Supplementation with whole cottonseed causes long-term reduction of methane emissions from lactating dairy cows offered a forage and cereal grain diet," *Journal of Dairy Science* 93(6), 2612–2619. DOI: 10.3168/jds.2009-2888

ICAC. (2022). *ICAC Cotton Data Book*, Technical Information Section of the International Cotton Advisory Committee, Washington DC.

Kansas AGGROWTH. (2021).

LifestyleMonitor. (2023). *Sustainability in Consumers' Lives and Wardrobes* .

McFadden, J., Njuki, E., and Griffin, T. (2023). *Precision Agriculture in the Digital Era: Recent Adoption on U.S. Farms*," Economic Information Bulletin No. (EIB-248) 52 pp, https://www.ers.usda.gov/publications/pub-details/?pubid=105893.

Meyer, L., Dew, T., Grace, M., Lanclos, K., MacDonald, S., and Soley, G. (2023). *Cotton Outlook THE WORLD AND UNITED STATES COTTON OUTLOOK*. https://www.usda.gov/oce/ag-outlook-forum/commodity-outlooks

Miller, D. A., and White, R. A. (1998). Soil Composition Across the U.S., *NASA Earth Observatory*.

Mississippi State University Extension. (2017). *Inorganic Nutrient Management for Cotton Production in Mississippi*, Publication Number: P1622.

Mississippi State University. (2022). *Cotton Crop Losses*. https://www.biochemistry.msstate.edu/resources/cottoncrop.php

Prakash, S., Radha, Sharma, K., Dhumal, S., Senapathy, M., Deshmukh, V. P., Kumar, S., Madhu, Anitha, T., Balamurugan, V., Pandiselvam, R., and Kumar, M. (2024). "Unlocking the potential of cotton stalk as a renewable source of cellulose: A review on advancements and emerging applications," *International Journal of Biological Macromolecules* 261, article 129456. DOI: 10.1016/J.IJBIOMAC.2024.129456

PRISM Climate Group. (2020). Prism Climate Data, Oregon State University.

Soil Health Institute. (2023). *Economics of Soil Health Management Systems on Eight Cotton Farms in the Texas Southern Great Plains*, (https://soilhealthinstitute.org/economics/).

University of Arkansas System. (2016). *Summaries of Arkansas Cotton Research*, (https://arkansasagnews.uark.edu/1356.htm).

University of Missouri. *Cotton Extension*.

USDA (2022). "Cotton sector at a glance," (https://www.ers.usda.gov/topics/crops/cotton-and-wool/cotton-sector-at-a-glance/), Accessed June 26, 2024.

USDA NASS. (2021). *Agricultural Prices*.

USDA Natural Resources Conservation Service. (1998). *Dominant Soil Orders for STATSGO Mapunits* .
USDA Quick Stats. (2022). *USDA NASS*.
USDA Quick Stats. (2024). *USDA NASS*. https://quickstats.nass.usda.gov/results/A775E607-A201-33CA-AF2C-1DE7C7473328
USDA. (2022). *Conservation Practices on Cultivated Cropland: A Comparison of CEAP I and CEAP II Survey Data and Modeling - Summary of Findings*.
Virginia Cooperative Extension. *Managing Thrips in Cotton*.
Wallander, S., Smith, D., Bowman, M., and Claassen, R. (2021). *Cover Crop Trends, Programs, and Practices in the United States*, (www.ers.usda.gov).
Wyatt, B. M., Arnall, D. B., and Ochsner, T. E. (2019). *Nutrient Loss and Water Quality*, (https://extension.okstate.edu/fact-sheets/print-publications/pss/nutrient-loss-and-water-quality-pss-2286.pdf), Oklahoma Cooperative Extension Service, Oklahoma State University, Stillwater, OK, USA.
Yates, J., Gueck, N., Boman, R., Kelley, M., Brown, M., and Klose, S. (2007). *Comparison of Costs and Returns for Alternative Cotton Harvest Methods in the Texas High Plains*, (https://farmassistance.tamu.edu/files/2013/08/2008-2.pdf), Texas AgriLife Extension Service, Texas A&M University System.

Article submitted: June 20, 2024; Peer review completed: July 31, 2024; Revised version received: August 2, 2024; Accepted: August 8, 2024; Published: August 19, 2024.
DOI: 10.15376.biores.19.4.7279-7319

APPENDIX 1

COTTON GROWERS NATURAL RESOURCE SURVEY

INTRODUCTION

DISPLAYONLY

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

The following survey by Cotton Incorporated is critical to shaping our research program and telling your sustainability story. Only aggregated data from this survey will be used and no individual grower data will be shared. This reoccurring survey helps to shape research direction and to complete cotton life cycle assessments. A similar version of this survey was previously administered in 2008 and 2014. Having a representative dataset of U.S. cotton production is critical to help tell our sustainability story and document continuous improvement in the industry.

Please note that to keep this survey completely anonymous, it is not possible to save responses to an incomplete session. Therefore, please be sure that you have at least 25 -35 minutes to devote this survey once you begin. The session will time out if you close your browser, so only close the browser when the survey is complete. Also, please note that once an answer is entered and the next button is pressed, answers cannot be changed. Therefore, be sure of your answers before moving on to the next screen.

The first 1000 respondents who grew cotton in 2021 and fully complete the survey will receive a Cotton branded 30 oz. Yeti Rambler as a token of appreciation for your time and participation. A link is provided at the end of the survey to provide your shipping information to receive your Cotton Yeti Rambler. We thank you for your time and participation. Link to legal information

SCREENER

S1 RADIOBUTTON

TERM IF S1=2

Did you grow cotton in 2021? Select one.

1 Yes

2 No

S2 RADIOBUTTON

If you were a member of the U.S. Cotton Trust Protocol in 2022 and would like to give the Trust Protocol permission to share an anonymized copy of your self-assessment questionnaire results and anonymized Fieldprint Calculator data with Cotton Incorporated to conduct an aggregated U.S.-focused cotton production life cycle assessment, please indicate so below. The Trust Protocol will not release your anonymized information – self-assessment questionnaire or Fieldprint Calculator data – without your express consent. To anonymize the data, all personally identifiable information will be removed from the data prior to sharing it with Cotton Incorporated.

Sharing data here will save you time in completing the survey. Select one. Selecting yes will serve as your consent to share your anonymized self-assessment questionnaire results and anonymized Fieldprint Calculator data from the Trust Protocol with Cotton Incorporated.

1 Yes

2 No / I was not a U.S. Cotton Trust Protocol Member in 2022

S3 SLINETEXT

CASE: ASK IF S2=1

REQUIRE RESPONSE TO HAVE @ CHARACTER

ERROR MESSAGE "Please provide a valid email address"

If you agree to sharing your aggregated and anonymized self-assessment questionnaire or

aggregated and anonymized Fieldprint Calculator information from the U.S. Cotton Trust Protocol, please provide the email used in your 2022 U.S. Cotton Trust Protocol enrollment.

ON MOBILE, HIDE KEYPAD FOR INTEGER QUESTIONS

QUESTIONNAIRE

Q1 INTEGER_STACKED
MIN = 0
MAX = 9999
RANDOMIZE STUBS
How many acres did your farming business cover in 2021? Please enter the appropriate crop acreage.
Enter a number
ROWS
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.)

INSERT PUNCH: Q1_COTTON_TOTAL=Q1_1 Q1_2

Q2 SLIDER
VALUES 0-100 IN INTERVALS OF 5
PLACE A "% owned" label to the right of the number box
LABEL 0 AS "All leased" and 100 AS "All owned" underneath the slider
What percent of your total farm acreage is owned versus leased?
Drag the slider to a point on the scale to indicate your farm ownership.

Q3 CHECKBOX
In addition to cotton, did you grow any of the following crops or raise livestock commercially in 2021 or 2022?
Select all that apply
1 Alfalfa
2 Corn
3 Cotton STUBCASE: DO NOT SHOW, AUTOPUNCH Y IF S1=1
4 Hay
5 Pasture
6 Peanuts
7 Rice
8 Sorghum
9 Soybeans
10 Orchards
11 Vegetables
12 Vines
13 Wheat
17 Cattle
18 Dairy
19 Poultry
20 Swine
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.

97 Other, specify ANNOTATE, FIXED
98 None of the above EXCLUSIVE, FIXED

Q4 CHECKBOX
RANDOMIZE STUBS
Do you have any of the following renewable energy sources on your farming operation?
Select all that apply
1 Wind
2 Solar
97 Other (please describe): ANNOTATE, FIXED
98 Do not have renewable energy sources EXCLUSIVE, FIXED

Q5 CHECKBOX
RANDOMIZE STUBS
What management practices are used to handle tailwater or surface run-off?
Select all that apply
1 I have a holding pond to capture run-off.
2 I have an irrigation tailwater return system in place.
3 My field and distribution system are designed and operated to minimize run-off (field slope, length, and flow rate designed to minimize runoff).
4 Tailwater run-off is routed to other fields.
5 Surge system is used to get even distribution across the field.
97 Other method (please describe): ANNOTATE, FIXED

Q6 RADIOBUTTON
Do you use a flow meter or other device to manage irrigation water volume?
Select one
1 Yes
2 No
3 Not Applicable

Q7 RADIOBUTTON
Do you have wells on your farm where water salinity is a concern?
Select one
1 Yes
2 No
3 Not Applicable

Q8 CHECKBOX
RANDOMIZE STUBS
What practices are used to minimize soil erosion on your farm?
Select all that apply
1 I maintain **ground cover and surface residue**.
2 I manage **irrigation to minimize runoff**.
3 I use **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, buffer strips, or silt traps**.
6 I **precisely (e.g., laser) level** fields.
7 I design **drains to minimize water velocities**.
8 I plant **cover crops**.
9 I plant wheat or other **vegetation to serve as a wind break**.
10 I use **sand-fighters** to minimize wind erosion.
97 Other (please describe): ANNOTATE, FIXED

12 I do not use any of the practices listed above because erosion is not a problem on my farm.
EXCLUSIVE, FIXED

Q9 RADIOBUTTON
CASE: ASK IF S2=2
How often do you conduct soil fertility tests on your cotton fields?
Select one
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

Q10 CHECKBOX
CASE: ASK IF S2=2
RANDOMIZE STUBS
Please identify the factors that you use in determining your fertilizer rate.
Select all that apply
1 Fertilizer costs
2 Soil test recommendations (including state recommendation)
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
97 Other (please describe): ANNOTATE, FIXED

Q11 CONSTANT_SUM_GRID
DOES NOT HAVE TO SUM TO 100
MAX SUM PER STUB=100
Q10_3. Please identify the factors that you use in determining your fertilizer rate. Select all that apply. ... Consultant recommendations
PLACE "%" TO THE RIGHT OF EACH STUBS NUMBER BOX
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.
RANDOMIZEROWS
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, please specify: ANNOTATE, FIXED

Q12 CHECKBOX
CASE: ASK IF S2=2
RANDOMIZE STUBS
What are you doing to manage Roundup Ready, Liberty Link, and other herbicide tolerant cotton varieties on your farm?
Select all that apply
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. EXCLUSIVE, FIXED
97 Other, specify ANNOTATE, FIXED

Q13 CHECKBOX
CASE: ASK IF S2=2
How do you decide you need to apply a foliar **insecticide** to cotton fields?
Select all that apply
RANDOMIZE STUBS 1-3
1 I decide after scouting 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.
98 None of the above EXCLUSIVE, FIXED

Q14 RADIOBUTTON
CASE: ASK IF S2=2
Were there any cotton fields that did NOT require foliar **insecticides** in the most recent year you grew cotton?
Select one
1 Yes
2 No

Q15 INTEGER
CASE: ASK IF S2 =2 AND Q14=1
MIN = 1
MAX <= Q1_COTTON_TOTAL
ADD "(In other words, no more than the total acreage of cotton fields you reported growing)"
TO THE ERROR STATEMENT
Approximately how many cotton acres did NOT require foliar **insecticides** in the most recent year you grew cotton?
Enter a number

Q13a CHECKBOX
CASE: ASK IF S2=2
RANDOMIZE STUBS
How do you decide you need to apply a foliar **herbicide** to cotton fields?
Select all that apply
1 I decide after scouting 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.
98 None of the above EXCLUSIVE, FIXED

Q14a RADIOBUTTON
CASE: ASK IF S2=2
Were there any cotton fields that did NOT require foliar **herbicides** in the most recent year you grew cotton?
Select one
1 Yes

2 No

Q15a INTEGER
CASE: ASK IF Q14a=1
MIN = 0
MAX <= Q1_COTTON_TOTAL
ADD "(In other words, no more than the total acreage of cotton fields you reported growing)" TO THE ERROR STATEMENT
Approximately how many cotton acres did NOT require foliar **herbicides** in the most recent year you grew cotton?
Enter a number

Q16 CHECKBOX
CASE: ASK IF S2=2
RANDOMIZE STUBS
How do you decide you need to apply a foliar **fungicide**?
Select all that apply
1 I decide after scouting my crop.
2 My scout or consultant makes recommendations.
3 I have a set program or calendar spray schedule.
4 Based on cultivar selected
98 None of the above EXCLUSIVE, FIXED

Q17 RADIOBUTTON
CASE: ASK IF S2=2
Were there any cotton fields that did NOT require foliar **fungicides** in the most recent year you grew cotton?
Select one
1 Yes
2 No

Q18 INTEGER
CASE: ASK IF Q17=1
MIN = 1
MAX <= Q1_COTTON_TOTAL
ADD "(In other words, no more than the total acreage of cotton fields you reported growing)" TO THE ERROR STATEMENT
Approximately how many cotton acres did NOT require foliar **fungicides** in the most recent year you grew cotton?
Enter a number

Q19 CHECKBOX
RANDOMIZE STUBS
Which of the following precision agriculture technologies do you use in your cotton operation?
Select all that apply
1 I use a cotton yield monitor to identify yield variability.
9 See and spray system (e.g., Weed-IT, Weed seeker, John Deere see and spray…)
10 Swath control on spray boom
11 Swath control on planter
2 I use an auto steer/guidance system.
3 I use a handheld GPS unit or smartphone 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.
12 Unpiloted Aerial Vehicles (UAVS)
97 Other (please describe): ANNOTATE, FIXED
98 None of the above EXCLUSIVE, FIXED

Q20 RADIOBUTTON
What is your average cost to harvest cotton (including defoliation) per acre?
Select one
1 Less than $50 per acre
2 $51 to $75 per acre
3 $76 to $100 per acre
4 $101 to $125 per acre
5 $126 to $150 per acre
6 Greater than $150 per acre
99 Don't know

Q21 CHECKBOX
RANDOMIZE STUBS
What impediments do you see to using driverless tractors on your farm?
Select all that apply
1 Dependability
2 Skilled labor to supervise
3 Too many obstacles in field
4 Costs
5 Risk of accidents resulting in litigation
6 Field to field transportation
7 Other (please describe): ANNOTATE, FIXED
8 No impediments EXCLUSIVE, FIXED

Q22 CHECKBOX
RANDOMIZE STUBS
What benefits do you see to driverless tractors on your farm?
Select all that apply
1 Labor savings
2 Improved efficiency
3 Decrease worker exposure
4 Other (please describe) ANNOTATE, FIXED
5 No benefits EXCLUSIVE, FIXED

Q23 RATING_GRID
RANDOMIZE ROWS
REPEAT HEADERS EVERY 5 ROWS
Please rate the following operations as priorities for automation:
Please select rating for each operation.

COLUMNS
A High priority
B Medium priority
C Low priority
D Does not need to be automated

ROWS

1 Tillage (including strip till)
2 Pre-plant weed control
3 Planting
4 Cultivation (including sand fighting)
5 In-season weed control
6 Spray applications (all products such as insecticides, PGRs...)
7 Field scouting
8 Staging modules in the field
9 Harvest
10 Ginning
11 Warehouse bale logistics

Q24 CHECKBOX
CASE: ASK IF S2=2
RANDOMIZE STUBS
What efforts are being made on the farm to enhance wildlife habitat?
Select all that apply

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): ANNOTATE, FIXED
9 No special efforts EXCLUSIVE, FIXED

Q25 CHECKBOX
RANDOMIZE STUBS
What are the barriers, if any, to enhancing wildlife habitat on your farm?
Select all that apply

2 Lack of funding to incentivize the wildlife enhancement practices
3 Lack of precision agriculture data to support the decision
4 Increased pest pressure from conservation areas
5 Lack of guidance on how to enroll in a program that supports wildlife habitat enhancement
6 Lack of interest/ I am not interested in enhancing wildlife habitat
97 Other (please describe) ANNOTATE, FIXED
98 No barriers FIXED, EXCLUSIVE

Q26 RATING_GRID
RANDOMIZE ROWS
REPEAT HEADERS EVERY 5 ROWS
How would you rate the following cotton production concerns or challenges on your farm?
Please select a rating for each concern or challenge.

COLUMNS
1 Not an issue
2 Moderate issue
3 Major issue

ROWS

1 Water quality protection from agricultural runoff
2 Adequate water supply
3 Water salinity of irrigation wells
4 Soil salinity
5 Herbicide drift
29 Insecticide drift
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 Increased frequency of drought and extreme weather events
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, seed quality, 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
28 Disease concerns related to nematodes, target spot, fusarium wilt, virus or seedling diseases, or another disease not listed

Q27 RATING_GRID
RANDOMIZE ROWS
REPEAT HEADERS EVERY 5 ROWS
Are the following production cost concerns a major concern, a minor concern, or not a concern at all?
Please select a rating for each concern.

COLUMNS
1 Not a concern
2 Minor concern
3 Major concern

ROWS
1 Seed
2 Fertilizer
3 Herbicide
4 Insecticide
5 Fungicide
6 Harvest aids
7 Harvest costs (harvester and/or custom harvest cost)
8 Labor cost
9 Labor availability

10 Ginning
11 Land
12 Irrigation
13 Fuel
14 Other equipment (excluding harvester)

INTRO2 DISPLAYONLY
For the next series of questions, please think about **one SPECIFIC cotton field** with a harvestable crop that represents typical conditions on your farm **in 2021**. 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)

Q28 INTEGER
MIN = 1
MAX = Q1_COTTON_TOTAL
What is the acreage of the field selected?
Enter a number

Q29 RADIOBUTTON
CASE: ASK IF S2=2
Was the field irrigated?
Select one
1 Yes
2 No

Q30 INTEGER
CASE: ASK IF S2=2 AND Q29=1
MIN = 1
MAX = 99
SHOW_REFUSAL_OPTION=YES
REFUSAL_LABEL = Don't know
How many inches of irrigation were applied during the season?
Enter a number.

Q31 CHECKBOX
CASE: ASK IF S2=2 AND Q29=1
RANDOMIZE STUBS
Do you utilize any of the following to improve irrigation efficiency?
Select all that apply
6 Make a visual assessment of plant vigor
1Irrigation scheduling programs (e.g., use local real time crop water use)
7 I make applications in response to local weather forecasts
2 Moisture monitoring equipment
3 Flow meter
4 Other tools (please describe) ANNOTATE, FIXED
5 None of the above EXCLUSIVE, FIXED

Q32 RADIOBUTTON
CASE: ASK IF S2=2 AND Q29=1
RANDOMIZE STUBS
What type of irrigation system was used?
Select one

1 Surface (furrow or basin)
2 Sprinkler with high pressure nozzles
3 Sprinkler with low pressure drop nozzles
4 Drip (surface or subsurface)
97 Other systems (please describe): ANNOTATE, FIXED

Q33 RADIOBUTTON
CASE: ASK IF S2=2 AND Q29=1
RANDOMIZE STUBS
What was the source of water?
Select one
1 Pumping from a well
2 On-farm surface water (e.g., farm ponds)
3 Off-farm surface water (e.g., irrigation district water)
97 Other (please describe) ANNOTATE, FIXED

Q34 RADIOBUTTON
CASE: ASK IF S2=2 AND Q29=1
What was the static water level (e.g., depth to water table)?
Select one
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

Q35 RADIOBUTTON
CASE: ASK IF S2=2 AND Q29=1
How has the static water level changed over the last 10 years?
Select one
1 Decreased
2 Stayed the same
3 Increased

Q36 RADIOBUTTON
CASE: ASK IF S2=2 AND Q29=1 AND Q33=1
What is the pressure of the well pump?
Select one
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
11 Don't have a gauge
10 Don't know

Q37 RADIOBUTTON
CASE: ASK IF S2=2 AND Q29=1
RANDOMIZE STUBS
What is the dominant energy source for your pumps?
Select one
1 Diesel
2 Electric
3 Natural gas
5 Solar
6 Wind
4 Other (please describe): ANNOTATE, FIXED

Q38 INTEGER
MIN=1

MAX=5,000

CASE: ASK IF S2=2

What was the field average lint yield in pounds per acre?
Enter a number

Q39 INTEGER
CASE: ASK IF S2=2 AND Q29=1
MIN=1
MAX=5,000
SHOW_REFUSAL_OPTION=YES
REFUSAL_LABEL = Don't know
Since this field was irrigated, what is your estimate of what the yield would have been if it had been grown without irrigation (e.g., compared to pivot corner yield or base on a nearby non-irrigated field)?
Enter a number.

Q40 CHECKBOX
CASE: ASK IF S2=2
RANDOMIZESTUBS
What type of winter cover was used during the (2021-22) season?

Select all that apply.

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) ANNOTATE, FIXED
7 No winter cover was used EXCLUSIVE, FIXED

Q41 CHECKBOX
CASE: ASK IF S2=2 AND Q40=4
Which type of cover crop(s) did you plant?
Select all that apply.

2 Cereal rye
5 Clover

7 Lupine
4 Tillage radish
6 Vetch
1 Winter wheat
8 Perennial cover crop
3 Mixed species cover crop
97 Other, specify ANNOTATE, FIXED

Q42 RADIOBUTTON
CASE: ASK IF S2=2
How often is cotton planted on this field?
Select one.

1 Every year
2 2 of 3 years
3 Every other year
4 1 of 3 years
5 Other (please describe) ANNOTATE

Q43 RADIOBUTTON
CASE: ASK IF S2=2
RANDOMIZESTUBS
What is the primary tillage method used on this field?
Select one

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) ANNOTATE, FIXED

Q43a RADIOBUTTON
Do you conduct a deep tillage operation in this field (e.g., para-tillage, deep ripping)?
Select one.

1 Yes
2 No

Q43b RADIOBUTTON
CASE: ASK IF Q43A=1
How often do you conduct a deep tillage operation in this field?
Select one

1 Every year
2 Every 2 years
3 Every 3 years
4 Every 4 or more years
5 Other (please describe) ANNOTATE

Q43c RADIOBUTTON
Excluding deep tillage and planting, how many times per season do you till this field?
Select one

1 Once per season
2 Twice per season
3 Three times per season
4 Four or more times per season

SHOW Q44 AND Q45 ON SAME PAGE
Q44 INTEGER_STACKED
CASE: ASK IF S2=2
RANDOMIZESTUBS
MIN = 0
MAX = 99
Please list the number of applications of the following used on this field during the (2021-22) season.

ROWS
1 Herbicides
2 Insecticides
3 Fungicides
4 Nematicides
5 Harvest aides
6 Plant growth regulators

Q45 INTEGER_STACKED
SHOW ON SAME PAGE AS Q44

CASE: ASK IF S2=2
RANDOMIZESTUBS
MIN = 0
MAX = 99
Please list the total number of spray events made (either total of above or less than the above if using tank mixes)
ROWS
1 Aerial
2 Ground

Q46 CHECKBOX
What are your target insect pests?
Select 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 specify): ANNOTATE, FIXED

Q47 CHECKBOX
What are your target pathogens?
Select all that apply

1 Alternaria leaf spot
2 Areolate mildew (Grey mold, Ramularia)
3 Ascochyta blight (wet weather blight)
4 Boll rots (Hard lock)
5 Cercospora leaf spot
10 Cotton leaf roll dwarf virus
13 Fusarium (FOV), other than FOV Race 4 (FOV 4)
14 Fusarium Race 4 (FOV 4)
6 Reniform nematode
7 Root knot nematode
8 Stemphyllium leaf spot
9 Target spot
11 Verticillium wilt
15 Seedling disease
97 Other diseases (please specify) ANNOTATE, FIXED

SHOW Q48 AND Q48B ON SAME PAGE
Q48 INTEGER_GRID
CASE: ASK IF S2=2
MIN = 0
MAX = 9999
RANDOMIZESTUBS
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.

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 (K20)
Enter a number

COLUMNS
1 Nitrogen (N)
2 Phosphate (P_2O_5)

3 Potash (K_2O)

ROWS
1 Total lbs per acre per year
2 Number of applications per year

Q48b RATING_GRID
CASE: ASK IF S2=2
SHOW ON SAME PAGE AS Q48

Application Rate **Below**, **At**, or **Above** soil test or university recommendation.
Select one for each.

ROWS
1 Nitrogen (N)
2 Phosphate (P_2O_5)
3 Potash (K_2O)
COLUMNS
1 **Below** soil test or university recommendation application rate
2 **At** soil test or university recommendation application rate
3 **Above** soil test or university recommendation application rate
4 Don't know

Q49 CHECKBOX_GRID
CASE: ASK IF S2=2
What is your dominant source of nitrogen during the following times?
Select all that apply.
COLUMNS
1 Dry blend
2 Liquid blend
3 Anhydrous ammonia
4 Urea
5 UAN (28, 32, etc.)
6 Other
7 Do not apply at this time EXCLUSIVE
ROWS
1 Pre-plant
2 In-season

Q50 CHECKBOX_GRID
CASE: ASK IF S2=2
What is your dominant application method for nitrogen during the following times?
Select all that apply
COLUMNS
5 Dry blend
1 Injected or placed below the surface
2 Surface banded
3 Broadcast (ground, air, or fertigation)
4 Broadcasted and incorporated
97 Other
ROWS
RANDOMIZESTUBS

1 Pre-plant
2 In-season

Q51 INTEGER
CASE: ASK IF S2=2
MIN = 0
MAX = 99
SHOW_REFUSAL_OPTION=YES
REFUSAL_LABEL = Don't know
Not including fertilizer applications through an irrigation system, how many trips (ground or air) were necessary to apply all fertilizer products?
Enter a number.

Q52 RADIOBUTTON
Do you use nitrification inhibitors with your fertilizer applications?
Select one.

1 Yes
2 No
3 I am not familiar with these products
4 Not applicable

Q53 CHECKBOX
CASE: ASK IF S2=2
Which of the following, if any, do you use?
Select all that apply.

2 Dolomitic lime
3 Gypsum
4 Lime (other than dolomitic and gypsum)
5 Manure
1 Micronutrients such as sulfur or boron
97 Other, specifyANNOTATE, FIXED
98 None of the above EXCLUSIVE, FIXED

Q54 INTEGER_STACKED
CASE: ASK IF S2=2 AND Q53<98
MATCH ORDER FROM Q53

How many pounds of each of the following did you use on this field during the 2021 growing season?
Enter a number.

1 Micronutrients such as sulfur or boron
MAX=999999
STUBCASE: DISPLAY IF Q53_001 = Y
SHOW_REFUSAL_OPTION=Y
REFUSAL_LABEL = Don't know
2 Dolomitic Lime
MAX=999999
STUBCASE: DISPLAY IF Q53_002 = Y
SHOW_REFUSAL_OPTION=Y
REFUSAL_LABEL = Don't know

3 Gypsum
MAX=999999
STUBCASE: DISPLAY IF Q53_003 = Y
SHOW_REFUSAL_OPTION=Y
REFUSAL_LABEL = Don't know
4 Lime (other than dolomitic and gypsum)
MAX=999999
STUBCASE:DISPLAY IF Q53_004=Y
SHOW_REFUSAL_OPTION=Y
REFUSAL_LABEL = Don't know
5 Manure
MAX=999999
STUBCASE: DISPLAY IF Q53_005 = Y
SHOW_REFUSAL_OPTION=Y
REFUSAL_LABEL = Don't know
97 PIPE IN Q53_097_ANNOTATE
MAX=999999
STUBCASE DISPLAY IF Q53_097 = Y
SHOW_REFUSAL_OPTION=Y
REFUSAL_LABEL = Don't know

Q55 CHECKBOX
CASE: ASK IF S2=2
What conservation practices are associated with this field?
Select all that apply.

11 Conservation cover
8 Contour buffer strip
6 Contour strip cropping
15 Drop pipes for erosion control
9 Field borders
10 Field strip cropping
7 Filter strip
2 Grass waterway
19 Leave riparian (i.e., vegetated areas bordering streams) areas undisturbed
21 Livestock integration
20 Make efforts to improve wildlife habitat
16 Precision leveled (0.1 to 0.3 % grade)
17 Recycle farm plastic (pesticide containers, poly pipe…) and/or paper and cardboard
4 Riparian (i.e., vegetated areas bordering streams) forest buffer
12 Riparian (i.e., vegetated areas bordering streams) herbaceous cover
1 Sediment basin
14 Stream habitat improvement
3 Tailwater recovery system
13 Vegetative borders
5 Water and sediment control basin
97 Other, specify ANNOTATE, FIXED
98 None of the above EXCLUSIVE, FIXED

Q56 INTEGER
CASE: ASK IF S2=2
MIN = 0
MAX = 99

SHOW_REFUSAL_OPTION=YES
REFUSAL_LABEL = Don't know
How many miles is this field from the gin?
Enter a number.

DEMOGRAPHICS

DISPLAYONLY The last few questions are for classification purposes only.

Q57 DROPDOWN
In what state is MOST of your farm located?
Select one.
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

Q58_AL DROPDOWN
CASE: ASK IF Q57=1
In what county is MOST of your farm located?
Select one.
1 Autauga
2 Baldwin
3 Barbour
4 Bibb
5 Blount
6 Bullock
7 Butler
8 Calhoun
9 Chambers
10 Cherokee
11 Chilton
12 Choctaw
13 Clarke
14 Clay
15 Cleburne
16 Coffee
17 Colbert
18 Conecuh
19 Coosa

20 Covington
21 Crenshaw
22 Cullman
23 Dale
24 Dallas
25 DeKalb
26 Elmore
27 Escambia
28 Etowah
29 Fayette
30 Franklin
31 Geneva
32 Greene
33 Hale
34 Henry
35 Houston
36 Jackson
37 Jefferson
38 Lamar
39 Lauderdale
40 Lawrence
41 Lee
42 Limestone
43 Lowndes
44 Macon
45 Madison
46 Marengo
47 Marion
48 Marshall
49 Mobile
50 Monroe
51 Montgomery
52 Morgan
53 Perry
54 Pickens
55 Pike
56 Randolph
57 Russell
58 St. Clair
59 Shelby
60 Sumter
61 Talladega
62 Tallapoosa
63 Tuscaloosa
64 Walker
65 Washington
66 Wilcox
67 Winston

Q58_AZ DROPDOWN
CASE: ASK IF Q57=2
In what county is MOST of your farm located?
Select one.
1 Apache
2 Cochise
3 Coconino
4 Gila
5 Graham
6 Greenlee
7 La Paz
8 Maricopa
9 Mohave
10 Navajo
11 Pima
12 Pinal
13 Santa Cruz
14 Yavapai
15 Yuma

Q58_AR DROPDOWN
CASE: ASK IF Q57=3
In what county is MOST of your farm located?
Select one.
1 Arkansas
2 Ashley
3 Baxter
4 Benton
5 Boone
6 Bradley
7 Calhoun
8 Carroll
9 Chicot
10 Clark
11 Clay
12 Cleburne
13 Cleveland
14 Columbia
15 Conway
16 Craighead
17 Crawford
18 Crittenden
19 Cross
20 Dallas
21 Desha
22 Drew
23 Faulkner
24 Franklin
25 Fulton
26 Garland
27 Grant
28 Greene

29 Hempstead
30 Hot Spring
31 Howard
32 Independence
33 Izard
34 Jackson
35 Jefferson
36 Johnson
37 Lafayette
38 Lawrence
39 Lee
40 Lincoln
41 Little River
42 Logan
43 Lonoke
44 Madison
45 Marion
46 Miller
47 Mississippi
48 Monroe
49 Montgomery
50 Nevada
51 Newton
52 Ouachita
53 Perry
54 Phillips
55 Pike
56 Poinsett
57 Polk
58 Pope
59 Prairie
60 Pulaski
61 Randolph
62 St. Francis
63 Saline
64 Scott
65 Searcy
66 Sebastian
67 Sevier
68 Sharp
69 Stone
70 Union
71 Van Buren
72 Washington
73 White
74 Woodruff
75 Yell

Q58_CA DROPDOWN
CASE: ASK IF Q57=4
In what county is MOST of your farm located?
Select one.
1 Alameda

2 Alpine
3 Amador
4 Butte
5 Calaveras
6 Colusa
7 Contra Costa
8 Del Norte
9 El Dorado
10 Fresno
11 Glenn
12 Humboldt
13 Imperial
14 Inyo
15 Kern
16 Kings
17 Lake
18 Lassen
19 Los Angeles
20 Madera
21 Marin
22 Mariposa
23 Mendocino
24 Merced
25 Modoc
26 Mono
27 Monterey
28 Napa
29 Nevada
30 Orange
31 Placer
32 Plumas
33 Riverside
34 Sacramento
35 San Benito
36 San Bernardino
37 San Diego
38 San Francisco
39 San Joaquin
40 San Luis Obispo
41 San Mateo
42 Santa Barbara
43 Santa Clara
44 Santa Cruz
45 Shasta
46 Sierra
47 Siskiyou
48 Solano
49 Sonoma
50 Stanislaus
51 Sutter
52 Tehama
53 Trinity
54 Tulare

55 Tuolumne
56 Ventura
57 Yolo
58 Yuba

Q58_FL DROPDOWN
CASE: ASK IF Q57=5
In what county is MOST of your farm located? DROPDOWN
Select one.
1 Alachua
2 Baker
3 Bay
4 Bradford
5 Brevard
6 Broward
7 Calhoun
8 Charlotte
9 Citrus
10 Clay
11 Collier
12 Columbia
13 DeSoto
14 Dixie
15 Duval
16 Escambia
17 Flagler
18 Franklin
19 Gadsen
20 Gilchrist
21 Glades
22 Gulf
23 Hamilton
24 Hardee
25 Hendry
26 Hernando
27 Highlands
28 Hillsborough
29 Homes
30 Indian River
31 Jackson
32 Jefferson
33 Lafayette
34 Lake
35 Lee
36 Leon
37 Levy
38 Liberty
39 Madison
40 Manatee
41 Marion
42 Martin
43 Miami-Dade

44 Monroe
45 Nassau
46 Okaloosa
47 Okeechobee
48 Orange
49 Osceola
50 Palm Beach
51 Pasco
52 Pinellas
53 Polk
54 Putnam
55 St. Johns
56 St. Lucie
57 Santa Rosa
58 Sarasota
59 Seminole
60 Sumter
61 Suwannee
62 Taylor
63 Union
64 Volusia
65 Wakulla
66 Walton
67 Washington

Q58_GA DROPDOWN
CASE: ASK IF Q57=6
1 Carroll
2 Catoosa
3 Charlton
4 Chatham
5 Chattooga
6 Cherokee
7 Clay
8 Clayton
9 Clinch
10 Cobb
11 Coffee
12 Colquitt
13 Columbia
14 Columbia-Muscogee
15 Cook
16 Coweta
17 Crawford
18 Crisp
19 Cusseta-Chattahoochee
20 Dade
21 Dawson
22 Decatur
23 DeKalb
24 Dodge
25 Dooly

26 Dougherty
27 Douglas
28 Early
29 Echols
30 Effingham
31 Elbert
32 Emanuel
33 Evans
34 Fannin
35 Fayette
36 Floyd
37 Forsyth
38 Franklin
39 Fulton
40 Georgetown-Quitman
41 Gilmer
42 Glascock
43 Glynn
44 Gordon
45 Grady
46 Greene
47 Gwinnett
48 Habersham
49 Hall
50 Hancock
51 Haralson
52 Harris
53 Hart
54 Heard
55 Henry
56 Houston
57 Irwin
58 Jackson
59 Jasper
60 Jeff Davis
61 Jefferson
62 Jenkins
63 Johnson
64 Jones
65 Lamar
66 Lanier
67 Laurens
68 Lee
69 Liberty
70 Lincoln
71 Long
72 Lowndes
73 Lumpkin
74 Macon
75 Macon-Bibb
76 Madison
77 Marion
78 McDuffie

79 McIntosh
80 Meriwether
81 Miller
82 Mitchell
83 Monroe
84 Montgomery
85 Morgan
86 Murray
87 Newton
88 Oconee
89 Oglethorpe
90 Paulding
91 Peach
92 Pickens
93 Pierce
94 Pike
95 Polk
96 Pulaski
97 Putnam
98 Rabun
99 Randolph
100 Rockdale
101 Schley
102 Screven
103 Seminole
104 Spalding
105 Stephens
106 Stewart
107 Sumter
108 Talbot
109 Taliaferro
110 Tattnall
111 Taylor
112 Telfair
113 Terrell
114 Thomas
115 Tift
116 Toombs
117 Towns
118 Treutlen
119 Troup
120 Turner
121 Twiggs
122 Union
123 Upson
124 Walker
125 Walton
126 Ware
127 Warren
128 Washington
129 Wayne
130 Webster
131 Wheeler

132 White
133 Whitfield
134 Wilcox
135 Wilkes
136 Wilkinson
137 Worth

Q58_KS DROPDOWN
CASE: ASK IF Q57=7
In what county is MOST of your farm located?
Select one**.**
1 Allen
2 Anderson
3 Atchison
4 Barber
5 Barton
6 Bourbon
7 Brown
8 Butler
9 Chase
10 Chautauqua
11 Cherokee
12 Cheyenne
13 Clark
14 Clay
15 Cloud
16 Coffey
17 Comanche
18 Cowley
19 Crawford
20 Decatur
21 Dickinson
22 Doniphan
23 Douglas
24 Edwards
25 Elk
26 Ellis
27 Ellsworth
28 Finney
29 Ford
30 Franklin
31 Geary
32 Gove
33 Graham
34 Grant
35 Gray
36 Greeley
37 Greenwood
38 Hamilton
39 Harper
40 Harvey
41 Haskell

42 Hodgeman
43 Jackson
44 Jefferson
45 Jewell
46 Johnson
47 Kearny
48 Kingman
49 Kiowa
50 Labette
51 Lane
52 Leavenworth
53 Lincoln
54 Linn
55 Logan
56 Lyon
57 Marion
58 Marshall
59 McPherson
60 Meade
61 Miami
62 Mitchell
63 Montgomery
64 Morris
65 Morton
66 Nemaha
67 Neosho
68 Ness
69 Norton
70 Osage
71 Osborne
72 Ottawa
73 Pawnee
74 Phillips
75 Pottawatomie
76 Pratt
77 Rawlins
78 Reno
79 Republic
80 Rice
81 Riley
82 Rooks
83 Rush
84 Russell
85 Saline
86 Scott
87 Sedgwick
88 Seward
89 Shawnee
90 Sheridan
91 Sherman
92 Smith
93 Stafford
94 Stanton

95 Stevens
96 Sumner
97 Thomas
98 Trego
99 Wabaunsee
100 Wallace
101 Washington
102 Wichita
103 Wilson
104 Woodson
105 Wyandotte

Q58_LA DROPDOWN
CASE: ASK IF Q57=8
In what parish is MOST of your farm located?
Select one**.**
1 Acadia
2 Allen
3 Ascension
4 Assumption
5 Avoyelles
6 Beauregard
7 Bienville
8 Bossier
9 Caddo
10 Calcasieu
11 Caldwell
12 Cameron
13 Catahoula
14 Claiborne
15 Concordia
16 DeSoto
17 East Baton Rouge
18 East Carroll
19 East Feliciana
20 Evangeline
21 Franklin
22 Grant
23 Iberia
24 Iberville
25 Jackson
26 Jefferson
27 Jefferson Davis
28 Lafayette
29 Lafourche
30 LaSalle
31 Lincoln
32 Livingston
33 Madison
34 Morehouse
35 Natchitoches
36 Orleans

37 Ouachita
38 Plaquemines
39 Pointe Coupee
40 Rapides
41 Red River
42 Richland
43 Sabine
44 St. Bernard
45 St. Charles
46 St. Helena
47 St. James
48 St. John the Baptist
49 St. Landry
50 St. Martin
51 St. Mary
52 St. Tammany
53 Tangipahoa
54 Tensas
55 Terrebonne
56 Union
57 Vermilion
58 Vernon
59 Washington
60 Webster
61 West Baton Rouge
62 West Carroll
63 West Feliciana
64 Winn

Q58_MS DROPDOWN
CASE: ASK IF Q57=9
In what county is MOST of your farm located?
Select one.
1 Adams
2 Alcorn
3 Amite
4 Attala
5 Benton
6 Bolivar
7 Calhoun
8 Carroll
9 Chickasaw
10 Choctaw
11 Claiborne
12 Clarke
13 Clay
14 Coahoma
15 Copiah
16 Covington
17 DeSoto
18 Forrest
19 Franklin

20 George
21 Greene
22 Grenada
23 Hancock
24 Harrison
25 Hinds
26 Holmes
27 Humphreys
28 Issaquena
29 Itawamba
30 Jackson
31 Jasper
32 Jefferson
33 Jefferson Davis
34 Jones
35 Kemper
36 Lafayette
37 Lamar
38 Lauderdale
39 Lawrence
40 Leake
41 Lee
42 Leflore
43 Lincoln
44 Lowndes
45 Madison
46 Marion
47 Marshall
48 Monroe
49 Montgomery
50 Neshoba
51 Newton
52 Noxubee
53 Oktibbeha
54 Panola
55 Pearl River
56 Perry
57 Pike
58 Pontotoc
59 Prentiss
60 Quitman
61 Rankin
62 Scott
63 Sharkey
64 Simpson
65 Smith
66 Stone
67 Sunflower
68 Tallahatchie
69 Tate
70 Tippah
71 Tishomingo
72 Tunica

73 Union
74 Walthall
75 Warren
76 Washington
77 Wayne
78 Webster
79 Wilkinson
80 Winston
81 Yalobusha
82 Yazoo

Q58_MO DROPDOWN
CASE: ASK IF Q57=10
In what county is MOST of your farm located?
Select one.
1 Adair
2 Andrew
3 Atchison
4 Audrain
5 Barry
6 Barton
7 Bates
8 Benton
9 Bollinger
10 Boone
11 Buchanan
12 Butler
13 Caldwell
14 Callaway
15 Camden
16 Cape Girardeau
17 Carroll
18 Carter
19 Cass
20 Cedar
21 Chariton
22 Christian
23 Clark
24 Clay
25 Clinton
26 Cole
27 Cooper
28 Crawford
29 Dade
30 Dallas
31 Daviess
32 DeKalb
33 Dent
34 Douglas
35 Dunklin
36 Franklin
37 Gasconade

38 Gentry
39 Greene
40 Grundy
41 Harrison
42 Henry
43 Hickory
44 Holt
45 Howard
46 Howell
47 Iron
48 Jackson
49 Jasper
50 Jefferson
51 Johnson
52 Knox
53 Laclede
54 Lafayette
55 Lawrence
56 Lewis
57 Lincoln
58 Linn
59 Livingston
60 Macon
61 Madison
62 Maries
63 Marion
64 McDonald
65 Mercer
66 Miller
67 Mississippi
68 Moniteau
69 Monroe
70 Montgomery
71 Morgan
72 New Madrid
73 Newton
74 Nodaway
75 Oregon
76 Osage
77 Ozark
78 Pemiscot
79 Perry
80 Pettis
81 Phelps
82 Pike
83 Platte
84 Polk
85 Pulaski
86 Putnam
87 Ralls
88 Randolph
89 Ray
90 Reynolds

91 Ripley
92 St. Charles
93 St. Clair
94 St. Francois
95 St. Louis (county)
96 St. Louis city
97 St. Genevieve
98 Saline
99 Schuyler
100 Scotland
101 Scott
102 Shannon
103 Shelby
104 Stoddard
105 Stone
106 Sullivan
107 Taney
108 Texas
109 Vernon
110 Warren
111 Washington
112 Wayne
113 Webster
114 Worth
115 Wright

Q58_NM DROPDOWN
CASE: ASK IF Q57=11
In what county is MOST of your farm located?
Select one**.**
1 Bernalillo
2 Catron
3 Chaves
4 Cibola
5 Colfax
6 Curry
7 De Baca
8 Doña Ana
9 Eddy
10 Grant
11 Guadalupe
12 Harding
13 Hidalgo
14 Lea
15 Lincoln
16 Los Alamos
17 Luna
18 McKinley
19 Mora
20 Otero
21 Quay
22 Rio Arriba

23 Roosevelt
24 Sandoval
25 San Juan
26 San Miguel
27 Santa Fe
28 Sierra
29 Socorro
30 Taos
31 Torrance
32 Union
33 Valencia

Q58_NC DROPDOWN
CASE: ASK IF Q57=12
In what county is MOST of your farm located?
Select one.
1 Alamance
2 Alexander
3 Alleghany
4 Anson
5 Ashe
6 Avery
7 Beaufort
8 Bertie
9 Bladen
10 Brunswick
11 Buncombe
12 Burke
13 Cabarrus
14 Caldwell
15 Camden
16 Carteret
17 Caswell
18 Catawba
19 Chatham
20 Cherokee
21 Chowan
22 Clay
23 Cleveland
24 Columbus
25 Craven
26 Cumberland
27 Currituck
28 Dare
29 Davidson
30 Davie
31 Duplin
32 Durham
33 Edgecombe
34 Forsyth
35 Franklin
36 Gaston

37 Gates
38 Graham
39 Granville
40 Greene
41 Guilford
42 Halifax
43 Harnett
44 Haywood
45 Henderson
46 Hertford
47 Hoke
48 Hyde
49 Iredell
50 Jackson
51 Johnston
52 Jones
53 Lee
54 Lenoir
55 Lincoln
56 Macon
57 Madison
58 Martin
59 McDowell
60 Mecklenburg
61 Mitchell
62 Montgomery
63 Moore
64 Nash
65 New Hanover
66 Northampton
67 Onslow
68 Orange
69 Pamlico
70 Pasquotank
71 Pender
72 Perquimans
73 Person
74 Pitt
75 Polk
76 Randolph
77 Richmond
78 Robeson
79 Rockingham
80 Rowan
81 Rutherford
82 Sampson
83 Scotland
84 Stanly
85 Stokes
86 Surry
87 Swain
88 Transylvania
89 Tyrrell

90 Union
91 Vance
92 Wake
93 Warren
94 Washington
95 Watauga
96 Wayne
97 Wilkes
98 Wilson
99 Yadkin
100 Yancey

Q58_OK DROPDOWN
CASE: ASK IF Q57=13
In what county is MOST of your farm located?
Select one**.**
1 Adair
2 Alfalfa
3 Atoka
4 Beaver
5 Beckham
6 Blaine
7 Bryan
8 Caddo
9 Canadian
10 Carter
11 Cherokee
12 Choctaw
13 Cimarron
14 Cleveland
15 Coal
16 Comanche
17 Cotton
18 Craig
19 Creek
20 Custer
21 Delaware
22 Dewey
23 Ellis
24 Garfield
25 Garvin
26 Grady
27 Grant
28 Greer
29 Harmon
30 Harper
31 Haskell
32 Hughes
33 Jackson
34 Jefferson
35 Johnston
36 Kay

37 Kingfisher
38 Kiowa
39 Latimer
40 Le Flore
41 Lincoln
42 Logan
43 Love
44 Major
45 Marshall
46 Mayes
47 McClain
48 McCurtain
49 McIntosh
50 Murray
51 Muskogee
52 Noble
53 Nowata
54 Okfuskee
55 Oklahoma
56 Okmulgee
57 Osage
58 Ottawa
59 Pawnee
60 Payne
61 Pittsburg
62 Pontotoc
63 Pottawatomie
64 Pushmataha
65 Roger Mills
66 Rogers
67 Seminole
68 Sequoyah
69 Stephens
70 Texas
71 Tillman
72 Tulsa
73 Wagoner
74 Washington
75 Washita
76 Woods
77 Woodward

Q58_SC DROPDOWN
CASE: ASK IF Q57=14
In what county is MOST of your farm located?
Select one.
1 Abbeville
2 Aiken
3 Allendale
4 Anderson
5 Bamberg
6 Barnwell

7 Beaufort
8 Berkeley
9 Calhoun
10 Charleston
11 Cherokee
12 Chester
13 Chesterfield
14 Clarendon
15 Colleton
16 Darlington
17 Dillon
18 Dorchester
19 Edgefield
20 Fairfield
21 Florence
22 Georgetown
23 Greenville
24 Greenwood
25 Hampton
26 Horry
27 Jasper
28 Kershaw
29 Lancaster
30 Laurens
31 Lee
32 Lexington
33 Marion
34 Marlboro
35 McCormick
36 Newberry
37 Oconee
38 Orangeburg
39 Pickens
40 Richland
41 Saluda
42 Spartanburg
43 Sumter
44 Union
45 Williamsburg
46 York

Q58_TN DROPDOWN
CASE: ASK IF Q57=15
In what county is MOST of your farm located?
Select one**.**
1 Anderson
2 Bedford
3 Benton
4 Bledsoe
5 Blount
6 Bradley
7 Campbell

8 Cannon
9 Carroll
10 Carter
11 Cheatham
12 Chester
13 Claiborne
14 Clay
15 Cocke
16 Coffee
17 Crockett
18 Cumberland
19 Davidson
20 Decatur
21 DeKalb
22 Dickson
23 Dyer
24 Fayette
25 Fentress
26 Franklin
27 Gibson
28 Giles
29 Grainger
30 Greene
31 Grundy
32 Hamblen
33 Hamilton
34 Hancock
35 Hardeman
36 Hardin
37 Hawkins
38 Haywood
39 Henderson
40 Henry
41 Hickman
42 Houston
43 Humphreys
44 Jackson
45 Jefferson
46 Johnson
47 Knox
48 Lake
49 Lauderdale
50 Lawrence
51 Lewis
52 Lincoln
53 Loudon
54 Macon
55 Madison
56 Marion
57 Marshall
58 Maury
59 McMinn
60 McNairy

61 Meigs
62 Monroe
63 Montgomery
64 Moore
65 Morgan
66 Obion
67 Overton
68 Perry
69 Pickett
70 Polk
71 Putnam
72 Rhea
73 Roane
74 Robertson
75 Rutherford
76 Scott
77 Sequatchie
78 Sevier
79 Shelby
80 Smith
81 Stewart
82 Sullivan
83 Sumner
84 Tipton
85 Trousdale
86 Unicoi
87 Union
88 Van Buren
89 Warren
90 Washington
91 Wayne
92 Weakley
93 White
94 Williamson
95 Wilson

Q58_TX DROPDOWN
CASE: ASK IF Q57=16
In what county is MOST of your farm located?
Select one.
1 Anderson
2 Andrews
3 Angelina
4 Aransas
5 Archer
6 Armstrong
7 Atascosa
8 Austin
9 Bailey
10 Bandera
11 Bastrop
12 Baylor
13 Bee

14 Bell
15 Bexar
16 Blanco
17 Borden
18 Bosque
19 Bowie
20 Brazoria
21 Brazos
22 Brewster
23 Briscoe
24 Brooks
25 Brown
26 Burleson
27 Burnet
28 Caldwell
29 Calhoun
30 Callahan
31 Cameron
32 Camp
33 Carson
34 Cass
35 Castro
36 Chambers
37 Cherokee
38 Childress
39 Clay
40 Cochran
41 Coke
42 Coleman
43 Collin
44 Collingsworth
45 Colorado
46 Comal
47 Comanche
48 Concho
49 Cooke
50 Coryell
51 Cottle
52 Crane
53 Crockett
54 Crosby
55 Culberson
56 Dallam
57 Dallas
58 Dawson
59 Deaf Smith
60 Delta
61 Denton
62 DeWitt
63 Dickens
64 Dimmit
65 Donley
66 Duval

67 Eastland
68 Ector
69 Edwards
70 Ellis
71 El Paso
72 Erath
73 Falls
74 Fannin
75 Fayette
76 Fisher
77 Floyd
78 Foard
79 Fort Bend
80 Franklin
81 Freestone
82 Frio
83 Gaines
84 Galveston
85 Garza
86 Gillespie
87 Glasscock
88 Goliad
89 Gonzales
90 Gray
91 Grayson
92 Gregg
93 Grimes
94 Guadalupe
95 Hale
96 Hall
97 Hamilton
98 Hansford
99 Hardeman
100 Hardin
101 Harris
102 Harrison
103 Hartley
104 Haskell
105 Hays
106 Hemphill
107 Henderson
108 Hidalgo
109 Hill
110 Hockley
111 Hood
112 Hopkins
113 Houston
114 Howard
115 Hudspeth
116 Hunt
117 Hutchinson
118 Irion
119 Jack

120 Jackson
121 Jasper
122 Jeff Davis
123 Jefferson
124 Jim Hogg
125 Jim Wells
126 Johnson
127 Jones
128 Karnes
129 Kaufman
130 Kendall
131 Kenedy
132 Kent
133 Kerr
134 Kimble
135 King
136 Kinney
137 Kleberg
138 Knox
139 Lamar
140 Lamb
141 Lampasas
142 La Salle
143 Lavaca
144 Lee
145 Leon
146 Liberty
147 Limestone
148 Lipscomb
149 Live Oak
150 Llano
151 Loving
152 Lubbock
153 Lynn
154 McCulloch
155 McLennan
156 McMullen
157 Madison
158 Marion
159 Martin
160 Mason
161 Matagorda
162 Maverick
163 Medina
164 Menard
165 Midland
166 Milam
167 Mills
168 Mitchell
169 Montague
170 Montgomery
171 Moore
172 Morris

173 Motley
174 Nacogdoches
175 Navarro
176 Newton
177 Nolan
178 Nueces
179 Ochiltree
180 Oldham
181 Orange
182 Palo Pinto
183 Panola
184 Parker
185 Parmer
186 Pecos
187 Polk
188 Potter
189 Presidio
190 Rains
191 Randall
192 Reagan
193 Real
194 Red River
195 Reeves
196 Refugio
197 Roberts
198 Robertson
199 Rockwall
200 Runnels
201 Rusk
202 Sabine
203 San Augustine
204 San Jacinto
205 San Patricio
206 San Saba
207 Schleicher
208 Scurry
209 Shackleford
210 Shelby
211 Sherman
212 Smith
213 Somervell
214 Starr
215 Stephens
216 Sterling
217 Stonewall
218 Sutton
219 Swisher
220 Tarrant
221 Taylor
222 Terrell
223 Terry
224 Throckmorton
225 Titus

226 Tom Green
227 Travis
228 Trinity
229 Tyler
230 Upshur
231 Upton
232 Uvalde
233 Val Verde
234 Van Zandt
235 Victoria
236 Walker
237 Waller
238 Ward
239 Washington
240 Webb
241 Wharton
242 Wheeler
243 Wichita
244 Wilbarger
245 Willacy
246 Williamson
247 Wilson
248 Winkler
249 Wise
250 Wood
251 Yoakum
252 Young
253 Zapata
254 Zavala

Q58_VA DROPDOWN
CASE: ASK IF Q57=17
In what county is MOST of your farm located?
Select one**.**
1 Accomack
2 Albemarle
3 Alleghany
4 Amelia
5 Amherst
6 Appomattox
7 Arlington
8 Augusta
9 Bath
10 Bedford
11 Bland
12 Botetourt
13 Brunswick
14 Buchanan
15 Buckingham
16 Campbell
17 Caroline
18 Carroll

19 Charles City
20 Charlotte
21 Chesterfield
22 Clarke
23 Craig
24 Culpeper
25 Cumberland
26 Dickenson
27 Dinwiddie
28 Essex
29 Fairfax
30 Fauquier
31 Floyd
32 Fluvanna
33 Franklin
34 Frederick
35 Giles
36 Gloucester
37 Goochland
38 Grayson
39 Greene
40 Greensville
41 Halifax
42 Hanover
43 Henrico
44 Henry
45 Highland
46 Isle of Wight
47 James City
48 King and Queen
49 King George
50 King William
51 Lancaster
52 Lee
53 Loudoun
54 Louisa
55 Lunenburg
56 Madison
57 Mathews
58 Mecklenburg
59 Middlesex
60 Montgomery
61 Nelson
62 New Kent
63 Northampton
64 Northumberland
65 Nottoway
66 Orange
67 Page
68 Patrick
69 Pittsylvania
70 Powhatan
71 Prince Edward

72 Prince George
73 Prince William
74 Pulaski
75 Rappahannock
76 Richmond
77 Roanoke
78 Rockbridge
79 Rockingham
80 Russell
81 Scott
82 Shenandoah
83 Smyth
84 Southampton
85 Spotsylvania
86 Stafford
87 Surry
88 Sussex
89 Tazewell
90 Warren
91 Washington
92 Westmoreland
93 Wise
94 Wythe
95 York
96 Independent city

Q59 INTEGER
MIN = 18
MAX = 99
What is your age?
Enter a number.

Q59b HIDDEN DO NOT DISPLAY
AUTOPUNCH BASED ON ANSWER TO Q59 –
1 18-30
2 31-40
3 41-50
4 51-60
5 61+

Q60 RADIOBUTTON
How many total years have you been growing cotton?
Select one.
1 0-5
2 6-10
3 11-20
4 21-30
5 31+

Q61 RATING_GRID
REPEAT HEADERS EVERY 5 ROWS
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.
Select one for each.

COLUMNS
1 1 - None
2 2 - Slightly
3 3 - Moderately
4 4 - Greatly
ROWS
RANDOMIZESTUBS
1 Ag. magazines such as Cotton Grower, Cotton Farming, Progressive Farmer
2 University/Extension specialists or agents
3 Crop consultants
4 Other cotton producers
5 Agribusiness sales representatives
6 Cotton industry organizations such as the U.S. Cotton Trust Protocol, National Cotton Council, Cotton Incorporated
7 Internet websites
8 Smartphone apps
13 Twitter
14 Facebook
15 LinkedIn
16 YouTube
17 Other social media such as Instagram, TikTok, or Snapchat
9 Email newsletters
10 Field days/ Demonstrations
11 Technical publications/ Journals/ Fact sheets
12 Agricultural conferences

Q62 RADIOBUTTON
Are you interested in or already participating in an ecosystem service market program (i.e., carbon markets)?
Select one.
1 Yes, I am already participating
2 No, I am not participating but I am interested
3 No, I am not participating nor interested

END PAGES

TERM DISPLAYONLY
Thank you for your time. You have completed the survey.

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

Please follow this link to claim your 30oz. Cotton Yeti:
https://forms.office.com/r/EGiZntEwLR

APPENDIX 2
Supplementary Tables (ST):

ST1: Cotton Production Challenges
ST2: Primary Tillage Methods
ST3: Practices to Mitigate Soil Erosion
ST4: Irrigation Systems
ST5: Practices to Handle Tailwater
ST6: Precision Agriculture Technologies
ST7: Spray Events
ST8: Herbicide/Insecticide/Fungicide Management
ST9: Target Insects
ST10: Target Pathogens

Abbreviations:

SE - Southeast
MS - Midsouth
SW - Southwest
FW – Far West

Q – Question

ST 1.
Q26: How would you rate the following cotton production concerns or challenges on your farm? Please, select a rating for each concern or challenge.

Cotton Production Challenges in the 2023 Survey	Not an Issue					Moderate Issue					Major Issue				
	SE	MS	SW	FW	U.S.	SE	MS	SW	FW	U.S.	SE	MS	SW	FW	U.S.
Cotton production input costs	4%	5%	4%	8%	**4%**	19%	16%	19%	12%	**18%**	77%	80%	77%	80%	**78%**
Weed resistance to herbicides	7%	5%	3%	8%	**5%**	36%	29%	26%	40%	**31%**	57%	65%	72%	52%	**65%**
Weed control	9%	0%	4%	8%	**7%**	43%	39%	33%	48%	**38%**	48%	54%	63%	44%	**55%**
Cottonseed value	10%	8%	8%	4%	**8%**	42%	44%	39%	60%	**42%**	48%	48%	53%	36%	**50%**
Increased frequency of drought and extreme weather events	13%	16%	7%	12%	**11%**	46%	53%	30%	20%	**39%**	41%	32%	63%	68%	**50%**
Seedling vigor and stand establishment	14%	17%	9%	12%	**12%**	40%	44%	41%	48%	**42%**	46%	39%	50%	40%	**46%**
Adequate water supply	33%	50%	13%	4%	**27%**	41%	33%	24%	8%	**31%**	25%	16%	63%	88%	**42%**
Cotton's tolerance to heat and drought	14%	22%	14%	8%	**15%**	49%	47%	42%	44%	**45%**	37%	32%	44%	48%	**40%**
Consumer attitudes about agriculture's impact on the environment	20%	24%	20%	32%	**21%**	43%	43%	39%	24%	**41%**	37%	33%	41%	44%	**38%**
Lack of new crop protection products (insecticides, herbicides, etc.)	19%	15%	18%	32%	**18%**	46%	45%	51%	52%	**48%**	35%	40%	31%	16%	**34%**
Spread of plant diseases and weeds	13%	12%	14%	20%	**14%**	53%	58%	57%	72%	**56%**	34%	29%	29%	8%	**30%**
Insect resistance to insecticides and Bt cotton	18%	13%	27%	28%	**21%**	49%	47%	50%	44%	**49%**	33%	40%	23%	28%	**30%**
Efficient use of fertilizer	17%	22%	23%	24%	**21%**	52%	51%	49%	56%	**51%**	31%	26%	27%	20%	**28%**

Cotton Production Challenges in the 2023 Survey	Not an Issue					Moderate Issue					Major Issue				
	SE	MS	SW	FW	U.S.	SE	MS	SW	FW	U.S.	SE	MS	SW	FW	U.S.
Herbicides drift	29%	19%	18%	24%	**22%**	48%	49%	52%	60%	**51%**	23%	32%	30%	16%	**27%**
Disease concerns related to nematodes, target spot, virus etc.	11%	12%	25%	32%	**18%**	54%	63%	59%	48%	**57%**	35%	25%	16%	20%	**24%**
Variety selection	29%	33%	30%	40%	**31%**	43%	41%	48%	44%	**45%**	27%	26%	22%	16%	**24%**
Plant bug control	16%	9%	36%	28%	**24%**	61%	40%	52%	52%	**53%**	22%	52%	11%	20%	**23%**
Soil erosion	27%	22%	26%	64%	**27%**	55%	57%	54%	32%	**54%**	18%	21%	20%	4%	**19%**
Harvest aid materials and application timing	31%	36%	29%	28%	**31%**	51%	45%	53%	40%	**51%**	18%	19%	18%	32%	**19%**
Stinkbug control	15%	32%	52%	48%	**35%**	54%	48%	40%	40%	**46%**	31%	20%	8%	12%	**19%**
Monitoring cotton's plant growth	29%	33%	35%	28%	**32%**	51%	45%	51%	64%	**51%**	19%	22%	14%	8%	**17%**
Soil sampling and analysis for fertilization	37%	39%	44%	40%	**40%**	39%	38%	47%	44%	**43%**	24%	23%	9%	16%	**17%**
Soil compaction	28%	21%	28%	16%	**26%**	57%	59%	57%	72%	**58%**	15%	20%	15%	12%	**16%**
Insecticides drift	51%	51%	56%	44%	**53%**	41%	35%	31%	40%	**36%**	8%	14%	12%	16%	**11%**
Water salinity of irrigation wells	80%	74%	50%	40%	**65%**	16%	19%	32%	32%	**24%**	4%	7%	18%	28%	**11%**
Effects of agriculture on wildlife	51%	53%	59%	80%	**56%**	36%	36%	34%	20%	**35%**	13%	12%	7%	0%	**10%**
Soil salinity	72%	65%	47%	44%	**59%**	26%	27%	39%	32%	**32%**	2%	8%	14%	24%	**9%**
Water quality protection from agricultural runoff	48%	49%	58%	60%	**53%**	41%	41%	36%	36%	**39%**	11%	10%	6%	4%	**8%**
Dust from harvesting, farming, gins	70%	67%	65%	40%	**66%**	28%	27%	31%	48%	**30%**	1%	5%	4%	12%	**4%**

ST 2.
Q43. What is the primary tillage method used in this field? Select one.

Primary Tillage Systems	% of respondents by region				
	Southeast	**Midsouth**	**Southwest**	**Far West**	**U.S.**
No-till/strip-till	68%	46%	50%	33%	**56%**
Conservation till	16%	33%	19%	33%	**21%**
Conventional till	15%	21%	31%	33%	**23%**
Other	1%	1%	0%	0%	**1%**

ST 3.
Q8. What practices are used to minimize soil erosion on your farm? Select all that apply.

Practices to minimize soil erosion	% of respondents by region				
	Southeast	**Midsouth**	**Southwest**	**Far West**	**U.S.**
Strip-till/No-till	85.5%	50.4%	57.4%	36.0%	**65.7%**
Planted cover crops	72.7%	62.8%	59.9%	52.0%	**64.8%**
Ground cover	56.7%	48.1%	56.5%	44.0%	**54.7%**
Irrigation management	37.5%	47.3%	48.2%	68.0%	**44.8%**
Contour terraces/Plant rows	46.9%	27.1%	38.0%	28.0%	**39.0%**
Grassed waterways/Buffer strips	52.7%	36.4%	16.4%	16.0%	**33.1%**
Planted wheat/Vegetation as a windbreak	13.1%	21.7%	42.0%	20.0%	**27.2%**
Sand fighters	0.0%	3.9%	49.4%	20.0%	**22.6%**
Drain design	21.1%	36.4%	8.3%	16.0%	**18.1%**
Precisely level fields	3.6%	38.0%	7.4%	48.0%	**12.6%**
No practices	0.7%	3.9%	3.4%	4.0%	**2.5%**
Other	0.4%	1.6%	0.6%	12.0%	**1.1%**

ST 4.
Q32. What type of irrigation system was used? Select all that apply.

Irrigation Systems	% of respondents by region				
	Southeast	**Midsouth**	**Southwest**	**Far West**	**U.S.**
Sprinkler with low pressure drop nozzles	**68.0%**	**9.3%**	**44.9%**	**29.4%**	**45.1%**
Sprinkler with high-pressure nozzles	**14.4%**	**7.4%**	**8.0%**	**0.0%**	**9.5%**
Surface (Furrow/Basin)	**3.1%**	**66.7%**	**10.1%**	**58.8%**	**20.6%**
Drip (Surface/Subsurface)	**2.1%**	**5.6%**	**20.3%**	**5.9%**	**11.1%**
Other*	**12.4%**	**11.1%**	**16.7%**	**5.9%**	**13.7%**

*****Other- The majority of respondents claimed the "other" category as Central Pivot (Sprinkler) systems

ST 5.
Q5. What management practices are used to handle tailwater or surface run-off? Select all that apply.

Management practices	% of respondents by region				
	Southeast	**Midsouth**	**Southwest**	**Far West**	**U.S.**
Field slope/length	72.7%	70.5%	64.5%	56.0%	**68.3%**
Holding pond	16.4%	8.5%	12.7%	24.0%	**13.7%**
Tailwater run-off	6.6%	17.1%	9.9%	24.0%	**10.4%**
Surge system	1.5%	19.4%	2.8%	16.0%	**5.6%**
Tailwater return system	2.2%	4.7%	6.5%	32.0%	**5.4%**

ST 6.
Q19. Which of the following precision agriculture technologies do you use in your cotton operation? Select all that apply

Precision Technologies	% of respondents by region				
	Southeast	**Midsouth**	**Southwest**	**Far West**	**U.S.**
Autosteer/GPS	83%	85%	89%	72%	**86%**
Soil sampling	66%	72%	21%	20%	**46%**
Soil map	47%	49%	27%	28%	**38%**
Yield monitor	33%	58%	28%	20%	**35%**
Imagery	17%	24%	18%	24%	**19%**
Hand-held GPS	17%	22%	16%	44%	**18%**
Other	3%	1%	1%	0%	**1%**
New additions to the 2023 survey question	**Southeast**	**Midsouth**	**Southwest**	**Far West**	**U.S.**
Swath control on the spray boom	70%	78%	71%	56%	**71%**
Swath control on a planter	43%	49%	34%	40%	**40%**
Unpiloted Aerial Vehicles (UAVs)	5%	7%	6%	12%	**6%**
See and spray system: Weed-IT, Weed seeker, John Deere see and spray.	4%	5%	6%	4%	**5%**
Not using precision technologies	4%	1%	4%	16%	**4%**

ST 7.
Q44. Please list the number of applications of the following used in this field during the 2021-22 season.
Q45. Please list the total number of spray events made (either a total of above or less than the above if using tank mixes).

Application practices	**The average number of applications during the 2021/22 growing season**				
	SE	**MS**	**SW**	**FW**	**U.S.**
Herbicides	3.5	4.4	3.7	3.1	**3.7**
Insecticides	2.9	4.6	1.7	1.6	**2.7**
Fungicides	1.2	1.1	0.5	0.1	**0.8**
Nematicides	1.2	1.3	0.4	1.7	**2.2**
Harvest aids	1.4	2.8	1.7	1.5	**1.8**
Plant growth regulators	3.3	4.1	2.2	2.0	**3.0**
Spray events using tank mixes	**SE**	**MS**	**SW**	**FW**	**U.S.**
Ground	6.7	7.8	5.5	3.5	**6.3**
Aerial	1.1	1.7	1.3	1.3	**1.3**

ST 8.

Q13. How do you decide you need to apply a foliar herbicide/insecticide to cotton fields?
Q14. Were there any cotton fields that did NOT require foliar herbicides/insecticides in the most recent year you grew cotton?
Q15. Approximately, how many cotton acres did NOT require foliar herbicides/insecticides in the most recent year you grew cotton?
Q16. How do you decide you need to apply a foliar fungicide to cotton fields?
Q17. Were there any cotton fields that did NOT require foliar fungicides in the most recent year you grew cotton?
Q18 Approximately how many cotton acres did NOT require foliar fungicides in the most recent year you grew cotton?

Pesticide Management Practices	**Herbicides**					**Insecticides**					**Fungicides**				
	SE	**MS**	**SW**	**FW**	**U.S.**	**SE**	**MS**	**SW**	**FW**	**U.S.**	**SE**	**MS**	**SW**	**FW**	**U.S.**
Cotton fields that did not require foliar pesticides (% of responses)	8.9%	4.7%	15.6%	7.9%	**11.0%**	22.9%	9.3%	59.2%	53.9%	**36.7%**	69.8%	69.8%	77.3%	76.9%	**73.1%**
Cotton acres did not require foliar pesticides (total acres)	1,920	1,825	28,884	105	**32,734**	8,811	2,315	139,168	1,605	**151,899**	55,787	40,678	203,726	2,250	**302,441**
Cotton fields did not require foliar pesticides (% of total acres by region)	1%	1%	5%	1%	**3%**	4%	1%	26%	9%	**16%**	26%	24%	38%	13%	**32%**
Decision to apply a foliar pesticide (% of responses)															
After scouting a crop	71.9%	58.1%	76.8%	76.9%	**71.7%**	57.8%	33.7%	63.5%	46.2%	**55.8%**	53.1%	31.4%	40.3%	46.2%	**43.8%**
Consultant recommendations	51.6%	83.7%	49.3%	61.5%	**56.4%**	65.1%	90.7%	58.3%	53.9%	**66.3%**	51.6%	72.1%	44.1%	38.5%	**51.6%**
Treating only part of a field hotspots	18.2%	32.6%	22.8%	7.7%	**22.3%**	12.5%	25.6%	20.4%	15.4%	**18.1%**	12.0%	5.8%	2.4%	0.0%	**6.6%**
Calendar spray schedule (only for herbicides and insecticides)	22.9%	8.1%	9.5%	0.0%	**14.1%**	13.0%	2.3%	4.7%	7.7%	**7.6%**					
Based on cultivar selected (only for fungicide)											9.4%	3.5%	6.2%	0.0%	**6.8%**
None of the above	0.0%	1.2%	4.3%	0.0%	**2.0%**	0.0%	1.2%	6.6%	7.7%	**3.2%**	11.5%	16.3%	31.3%	23.1%	**20.9%**

ST 9.
Q46. What are your target insect pests? Select all that apply.

Target insect pests	% of respondents by region			
	SE	MS	SW	FW
Thrips	69.5%	75.2%	66.7%	64.0%
Aphids	48.7%	53.5%	59.3%	64.0%
Stink Bugs	87.3%	49.6%	28.7%	32.0%
Plant Bugs	61.8%	86.1%	14.8%	24.0%
Cotton Fleahopper	3.6%	7.0%	59.0%	12.0%
Bollworm/Budworm	28.4%	37.2%	23.8%	4.0%
Spider Mites	21.8%	46.5%	13.9%	40.0%
Grasshoppers	19.6%	5.4%	25.3%	8.0%
Fall Armyworm	13.1%	14.0%	10.8%	0.0%
Lygus	6.6%	10.9%	2.0%	56.0%
Boll Weevil	8.0%	10.9%	10.5%	4.0%
Cutworms	6.2%	19.4%	6.8%	12.0%
Beet Armyworm	6.9%	7.8%	9.0%	4.0%
Loopers	9.8%	5.4%	2.2%	0.0%
Banded Winged Whitefly	8.0%	0.8%	2.5%	20.0%
Pink Bollworm	5.1%	6.2%	2.5%	12.0%
Silverleaf Whitefly (Bemesia)	6.9%	0.8%	1.9%	16.0%
Southern Armyworms	4.4%	3.9%	2.5%	0.0%
Cotton Leaf Perforator	1.5%	1.6%	1.9%	4.0%
European Cornborer	1.8%	0.8%	0.3%	0.0%
Saltmarsh Catepillars	0.7%	2.3%	0.3%	4.0%
Other	0.0%	0.0%	1.5%	4.0%

ST 10.
Q47. What are your target pathogens? Select all that apply.

Target pathogens	% of respondents by region			
	SE	MS	SW	FW
Boll rots (Hard lock)	60.7%	58.1%	17.0%	20.0%
Seedling disease	32.7%	39.5%	35.8%	20.0%
Root-knot nematode	36.4%	27.9%	25.6%	20.0%
Verticillium wilt	11.3%	20.9%	39.8%	68.0%
Target spot	34.9%	31.0%	4.0%	0.0%
Reniform nematode	25.1%	16.3%	8.0%	4.0%
Alternaria leaf spot	12.7%	7.0%	6.5%	8.0%
Fusarium (FOV), other than FOV Race 4 (FOV 4)	7.6%	6.2%	9.3%	12.0%
Areolate mildew (Grey mold, Ramularia)	16.7%	2.3%	1.5%	0.0%
Other diseases	2.9%	1.6%	8.6%	12.0%
Ascochyta blight (wet weather blight)	4.4%	4.7%	4.6%	0.0%
Stemphylium leaf spot	9.5%	1.6%	0.6%	0.0%
Cercospora leaf spot	6.6%	1.6%	2.8%	0.0%
Fusarium Race 4 (FOV 4)	2.2%	1.6%	2.8%	20.0%
Cotton leaf roll dwarf virus	6.6%	7.0%	2.5%	4.0%