



2015 Cotton Natural Resource Survey

Executive Summary Report

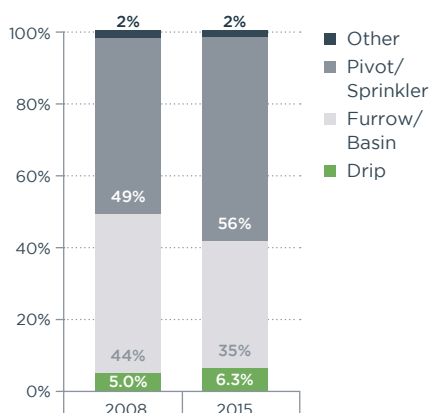
In order to better understand the challenges that U.S. cotton growers face and to develop technologies to address those challenges, the U.S. cotton industry conducted the Natural Resource Survey (NRS). U.S. cotton producers were surveyed to assess cotton's impact on the environment, providing an effective means to understand farm inputs, production trends and grower concerns. A similar study was conducted in 2008 allowing the industry to benchmark and measure progress over the past six years. The 925 survey responses were representative of the seventeen U.S. cotton growing states.

The 2015 Natural Resource Survey findings indicate the technologies adopted by U.S. cotton growers are contributing to continuous improvement, both in terms of increased yields and reducing environmental impacts, due to increased resource use efficiency. Improvements in water use efficiency, soil management and precision technology adoptions are highlighted in this summary with more details provided in the full report.



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A low-pressure irrigation pivot system resulting in low energy use and maximum water use efficiency.

FIGURE 1
Irrigation systems used in 2008 and 2015



Water Use Efficiency

Irrigation methods are an important factor for conserving water resources and maximizing water use efficiency. Since 2008, U.S. growers have used less surface irrigation and more pressurized systems such as center pivots and drip irrigation, which are easier to precisely control and operate. Most center pivots are operated at low pressure to save energy and reduce evaporative water loss and can be turned on with the touch of a switch, making it easy for producers to irrigate exactly when water is needed. However, a well-designed surface system, such as a furrow, can be just as efficient as a center pivot. Most U.S. producers who still use surface irrigation systems use computer model simulations to determine the exact flow rate of water needed for each furrow to maximize water use efficiency. Additionally, 62% of growers with furrow irrigation systems used tail water recovery systems, which reduce nutrient runoff, lower sedimentation in streams, and decrease water usage requirements. Drip irrigation is one of the most efficient technologies a grower can employ to maximize water use efficiency. With the increased adoption of drip irrigation and improvements to the other irrigation methods, there is great opportunity for continuous improvement in water use efficiency by U.S. cotton producers.

Land Use and Soil Management

Conservation tillage and no till practices, employed by 64% of U.S. growers, have led to effective soil conservation while improving soil health. From 2008 to 2015, growers using no-till practices increased from 36% to 45%. The move from conventional tillage practices to conservation/no-till in many cases saves the grower money as less time and energy is required compared to conventional tillage methods. In three of the four U.S. cotton producing regions, these conservation practices had little to no effect on yield, while energy and labor inputs were decreased significantly.

In the cotton offseason, farm land can be used for various crops or cover that can increase revenue as well as create benefits to the land, such as suppressing weeds, building the soil's organic matter, and supporting beneficial soil microbes. Growers using winter cover crops (48% of respondents) produced higher cotton yields, especially with native vegetation (5% increase) and planted cover crops (4% increase) compared to farms with no winter crops.

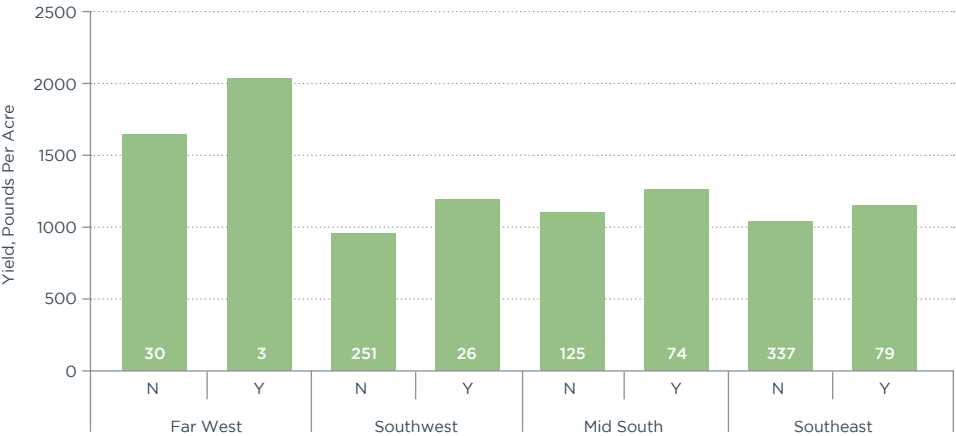
Precision Farming Technology

Growers' use of precision farming technologies significantly increased from 60% in 2008 to 84% in 2015. These types of technologies, such as yield monitoring, auto-steer and GPS guidance systems, enable growers to more accurately manage agriculture inputs (e.g., fertilizer, water, and herbicides) and increase the probability that a plant gets the correct level of inputs at the correct time. These technologies can require significant financial investment, however, survey data did indicate growers using these technologies reported higher cotton yields than those who did not (see *Figure 2* for an example related to yield monitor use). Field monitoring, such as soil moisture sensors, GPS enabled soil sampling, and computer-based decision aids are being adopted by U.S. growers in order to increase the accuracy and precision of their water and nutrient application rates.

TABLE 1
Use of Precision Technologies Increased from 2008 to 2015

Technology Used	2008	2015
Auto-Steer GPS guidance	46%	69%
Real-time flow control	55%	60%
GPS-based swath control	32%	51%
Grid soil sampling	NA	46%
Soil map	31%	37%
Yield Monitor	11%	20%
Aerial or Satellite Imagery	12%	13%
Hand-held GPS	10%	9%

FIGURE 2
Reported cotton yields for growers using yield monitors by region



The numbers at the bottom of the bar indicate the number of responses in each scenario (N = No, not using a yield monitor; Y = yes, using a yield monitor). All regions reported at least an increase of 100 pounds per acre for growers using a yield monitor.

The NRS data enables a comparison of irrigation scheduling, moisture monitoring and nitrogen soil testing practices to field level yields. The recorded yields and water use efficiency (WUE) were higher for growers using irrigation scheduling. Similarly, the yield and WUE values were higher for growers using moisture monitoring programs. The data suggests that the use of these techniques not only reduces the strain on water resources, but also increases yield creating a direct benefit to the grower. Increased field monitoring also had benefits in regards to nitrogen use in most cases. Growers conducting soil fertility test typically had higher yields and nitrogen use efficiencies (NUE) than those not testing.

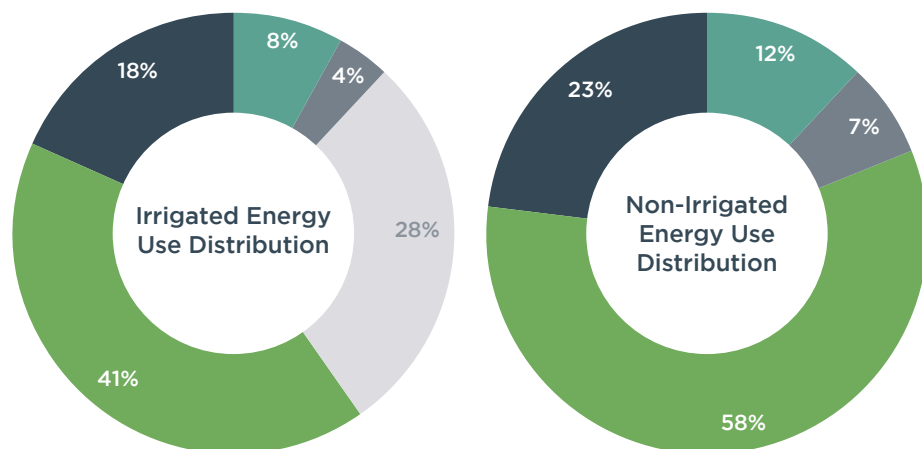
Herbicide resistant weeds continue to be a concern for many U.S. cotton producers who use a variety of integrated pest management solutions and technologies to address the issue. Since 2008, producers are taking advantage of new technologies to be more precise and efficient

in their weed control applications with 92% reporting at least one upgrade in the last 10 years. This includes GPS-based swath control, guidance systems and real-time flow control. Most applications are done with a ground rig system (85%) as opposed to aerial (similar results in 2008). In addition to technologies used in management of weed issues, 71% of growers rely on a professional consultant to advise them when to treat with a foliar insecticide and less than 6% indicated using a calendar based spray schedule. Since 2008, more growers (33%) indicated they had fields that received no foliar insecticides during the season, representing 21% of reported cotton acres. These improvements in technologies have led to more efficient use of farm inputs and more precise application enabling growers to apply plant health products only where they are needed.

FIGURE 3

Energy use distribution for irrigated and non-irrigated production systems

■ Fertilizer ■ Ginning ■ Field Fuel ■ Chemicals ■ Irrigation



Trends in Energy Use and Greenhouse Gas Emissions

Similar to the 2008 analysis of energy use and greenhouse gas (GHG) emissions, cotton's footprint from field to gin continued to be dominated by fertilizer use for both irrigated and non-irrigated production systems (Figure 3). The primary fertilizer impact is associated with the energy intensive nitrogen production process. Figures for GHG distribution are not shown as they were closely correlated to energy, with the exception of nitrogen which becomes even more dominant due to assumed "in field" emissions of

nitrous oxide, which is a highly potent greenhouse gas. Since the 2008 survey, Cotton Incorporated has conducted extensive research into nitrogen management recommendations for modern cotton varieties. The 2015 survey data shows that producers are achieving nitrogen use efficiencies very close to university recommendations across the Cotton Belt indicating producers are aware of the importance of good nitrogen management. Progress has also been made in developing tractor-mounted sensors to vary nitrogen application rates to match the crop needs in the field real-time. Such advancements should continue to improve nitrogen use efficiencies and lower cultivation energy requirements.

Summary and Conclusions

Based on this most recent survey of U.S. cotton producers there is strong evidence that the technologies adopted by these growers are contributing to continuous improvement both in terms of increased yields and reducing environmental impacts due to increased resource use efficiency. This trend is expected to continue as there are still many new tools and technologies in the cotton research pipeline.