RESULTS FROM COTTON INCORPORATED'S NATURAL RESOURCE SURVEY AND IMPLICATIONS FOR ENGINEERING RESEARCH

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Abstract

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. 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. The focus of this presentation is to review the survey results from the perspective of cotton engineering research successes and opportunities.

Introduction

Updated agriculture and natural resource data is needed to understand the efficiency of certain education initiatives, technology adoption, and current trends in farming practices. A Natural Resource Survey of U.S. cotton producers was conducted in 2015, to meet several different objectives, including supporting marketing claims made regarding U.S. cotton production practices, and to supply sustainability metrics for a global cotton life cycle assessment. The main objective of this paper is to inform those conducting cotton engineering research related to areas such as precision agricultural software and hardware, irrigation technologies, and tillage equipment.

Materials and Methods

A market research firm, Bellomy Research, assisted in executing the 2015 survey. 12,000 post cards were mailed to all the farmers that produced cotton in 2014, as identified by the Cotton Board. Post cards were mailed on the dates of March 6th, April 6, and May 25th of 2015. In addition to post cards, 1,800 emails were sent to cotton producers just prior to the post card mailing on March 5th and June 3rd. A total of 4,300 emails were sent soliciting the survey response. As a way to track communication channels, different survey links were provided in the post card and emails. To avoid extraneous responses, no external links to the survey were made available from a public website – the links were only provided through the postcard or email. The survey asked 66 questions in total, some of which had multiple parts. In total, 925 responses were recorded of which 88% came from those who entered the web address provided on the postcard. Reponses from the cotton growing states were proportional to the production of the states, with the highest concentration of respondents in Texas and Georgia. A similar survey was conducted in 2008 (Reed et al., 2009), that allows trends since to be examined. Additionally, a 2011 survey examining producer research priorities was also available for comparison to the 2015 results.

Several questions were used to estimate energy use by operation. Energy use for irrigation was estimated based on total lift (pumping depth to ground water plus distance to the water outlet), outlet pressure, volume of water applied and energy source based on the procedures of Hoffman et al. (1992). For operations involving tractors or other field equipment, grower survey data were combined with ASABE (2011) procedures to estimate fuel use. Data reported in Faulkner et al. (2011) to document fuel use in cotton strippers, and Willcutt et al. (2009) for modern spindle harvesters were used to estimate fuel use in harvest operations. Data for ginning electrical energy use was based on survey data reported by Valco et al. (2015), and dryer fuel used based on data measured by Hardin and Funk (2014). Energy contents for fuels used were taken from the DOE (2015), data in Pradhan et al. (2011) was used to estimate the energy embedded in all farm chemicals except for fertilizers data that came from Wang, (2007).

Results and Discussion

Producer Priorities

As part of the Natural Resource Survey, respondents were asked to review 27 randomly presented concerns or challenges and score whether each was a Major, Moderate or Not an Issue on their farm. Table 1 is a summary of the top 12 producers concerns in 2015, with a comparison to how that concern ranked in an earlier 2011 survey. Not surprisingly, input costs remained a top concern. From an engineering research perspective, there is continued opportunity to provide producers new precision agricultural tools and help them adopt existing ones to manage inputs efficiently as possible. Weed control is also a top concern, and any innovations in mechanical weed control would be welcome due to the extensive number of herbicide resistant weeds. With lower fiber prices, the value gained from cottonseed has become even more important, so research to preserve or increase seed value at the gin is needed. Issues with water and drought can be addressed through new irrigation technologies such as variable rate pivots and advances in irrigation scheduling (both from sensors and modeling). Finally, improved insect control could be facilitated by emerging technologies such as the "electronic nose".

Table 1. The top 12 issues that were a concern in 2015: percentage of 2015 respondents who indicated these issues were not a concern and where those issues ranked in the 2011 and 2015.

How would you rate the following cotton production concerns or challenges on your farm?	Not an Issue	2011 Rank	2015 Rank
Cotton production input costs	3%	1	1
Weed resistance to herbicides	6%	5	2
Weed control	5%	4	3
Cottonseed value	8%	7	4
Spread of plant disease and weeds	14%	New	5
Seedling vigor and stand establishment	18%	6	6
Consumer attitudes about Ag's impact on the environment	22%	31	7
Cotton's tolerance to heat and drought	13%	3	8
Efficient use of fertilizer	20%	19	9
Adequate water supply	28%	15	10
Variety selection	23%	2	11
Plant bug control	24%	9	12

Sensor-based Irrigation Scheduling

Figure 1 illustrates the difference in irrigation water use efficiency and yield for irrigated survey respondents who indicated they were not using sensors for irrigation scheduling, compared to those who were using sensors. The examples of sensors listed in the survey were: tensiometers, pressure bombs, soil moisture blocks/gypsum blocks, and infrared guns. Those who were using sensors reported both a higher water use efficiency and yield compared to those who were not using sensors. This is a very positive outcome for those who are using sensors; however, as indicated by Figure 2, adoption of sensors for irrigation scheduling remains fairly low since the last survey. Therefore, the data in Figure 1 will be helpful in communicating the potential advantage of sensor-based scheduling. Further education and increasing the simplicity of sensor use is also needed, including recommendation for installation and data interpretation such as the information presented in Lieb et al. (2015).

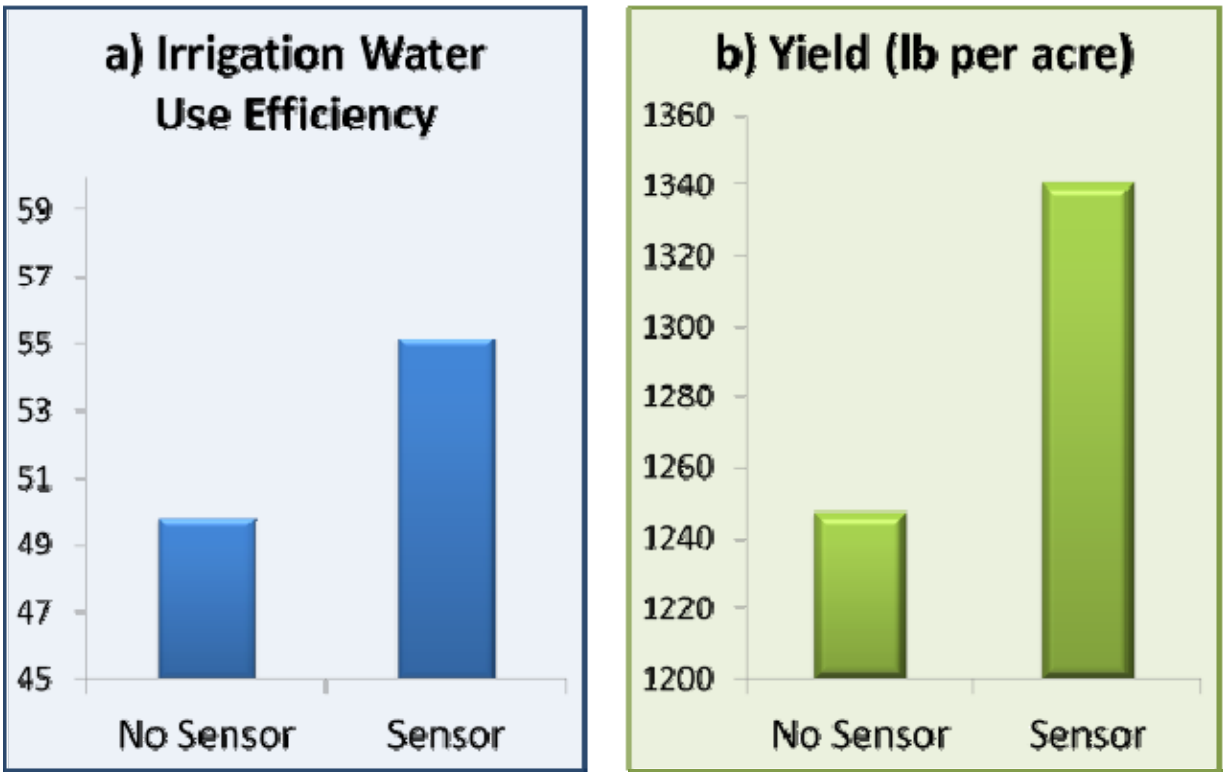

Figure 1. Water use efficiency (a) in pounds of cotton per inch of irrigation water use, and (b) yield for producers not using a senor for irrigation scheduling (No Sensor) and those reporting sensor use for irrigation scheduling (Sensor).

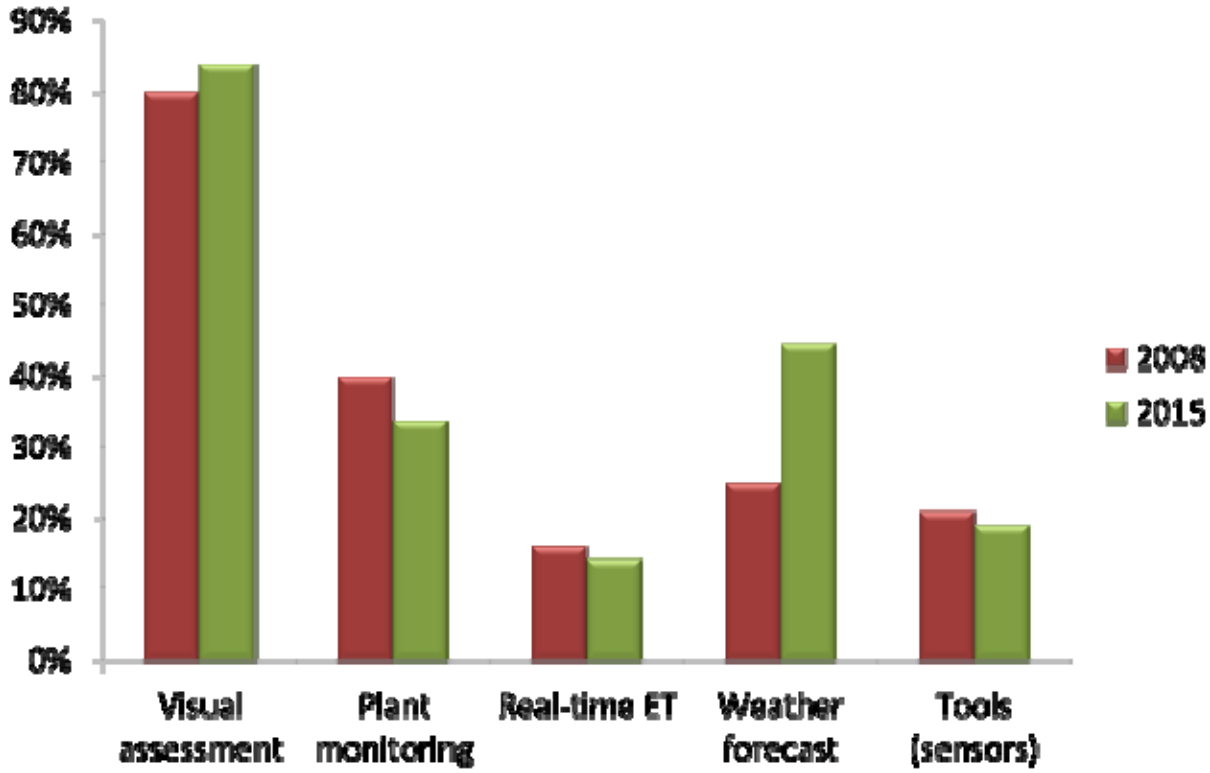

Figure 2. Percent of respondents with irrigated production systems who indicated they used one of the categories listed to schedule irrigations.

Precision Technologies

It was also determined that producers who reported yield monitor use had higher reported yields than those who were not using yield monitors (Figure 3). In every region, the growers using a yield monitor reported higher cotton yields. Similar trends were seen for other precision technology adoptions such as imaging and GPS use. It is important to note that the use of precision agriculture may not be solely responsible for the increased yield; however, these results suggest that adopting these new technologies could have a positive effect on cotton yield.

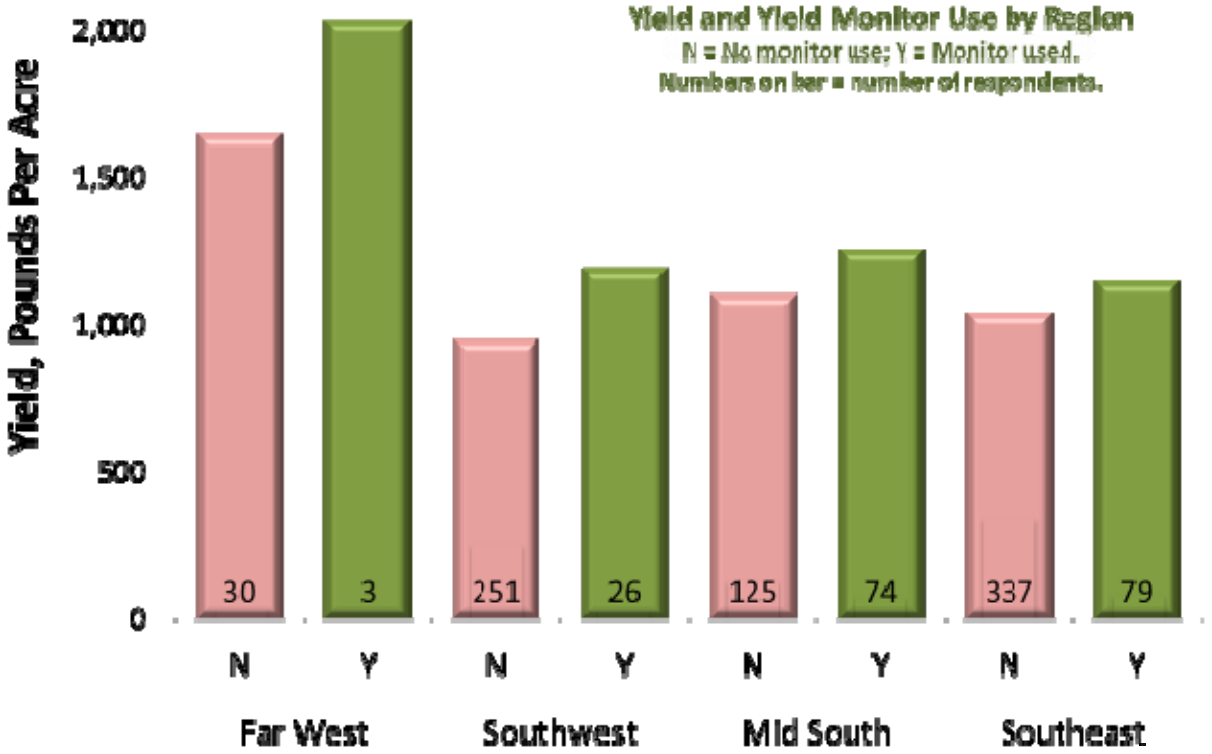

Figure 3. Regional comparison of yields by producers not using (N) and using (Y) yield monitors.

The survey also provided insights into different precision technology adoption rates. In Table 2, the percent of producers who used listed technology is presented from the 2008 and 2015 surveys. There has been a strong increase in the use of auto-steer systems, swath control and grid-based soil sampling since the 2008 survey. The basis for increased adoption may vary for each of the technologies, but all have documented improvements in input use efficiency. For example, Bergtold et al. (2009) reported on the increased yield associated with improved ability to plant over the previous tillage pass when using automatic steering systems. Thus, yield was increased by acting on better knowledge of the field, and resulted in an increase for the efficiency of all inputs applied to the field. In terms of swath control, Velandia et al. (2013) found that swath control on planters reduced seed use and increased yields due to harvest losses associated with double planting areas of the field.

Table 2. Precision technology adoption rates.

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%

Soil Management

Similar to the previous results on irrigation and precision technology use, it was also determined that producers who use soil test to determine fertilizer rates had higher yields than those who did not while maintaining similar nitrogen use efficiencies (Figure 4). There continues to be a high rate of soil sampling to determine fertilizer application rates, where 80% of producers indicated soil sampling at least once every two years in 2015 (75% in 2008).

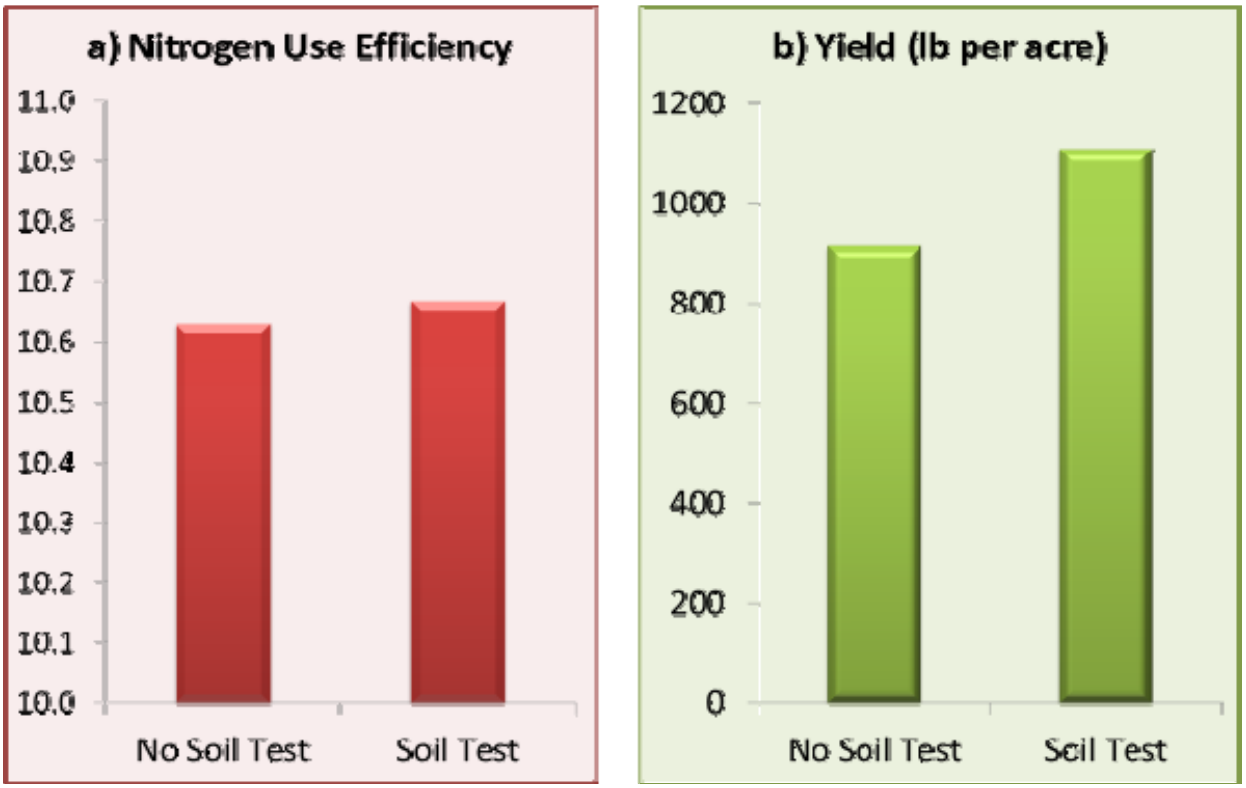

Figure 4. Nitrogen use efficiency (mass of cotton fiber produced per mass of N applied) and yield for producers who did not perform soil test (no soil test) versus those who did use soil test (soil test) for fertility rate determination.

Compared to the 2008 survey, conventional tillage system use was about the same (35%), but there was a definite increase in no-tillage / strip tillage systems from 31% in 2008 to 45% in 2015. The benefits from no-tillage systems are numerous and well documented, including reduced soil erosion, increased soil organic matter, and reduced fuel use (e.g., Triplett and Dick, 2008). In most regions, reported cotton yields were not significantly different across tillage systems. However, in the mid-south, there was an average of 200 pounds per acre lower yield associated with no-tillage / strip tillage use compared to those using conventional or conservation tillage. Coupled with other reports in the mid-south of high cone penetrometer readings (Kulkarni et al., 2008), and several on-farm reports of poor water infiltration during furrow irrigation events (personal communications with Dr. Joe Henggeler, University of Missouri; Dr. Bill Robertson, University of Arkansas; Steve Stevens, Arkansas producer; Dr. Ken Fisher, USDA-ARS Stoneville, MS; Dr. Darrin Dodds, Mississippi State University; and Dr. Tyson Raper, University of Tennessee), there is evidence that some improvements are needed for this tillage system when applied to mid-south conditions. Raper et al. (2000) found soil compaction was responsible for lower cotton yields in no-tillage cotton in northern Alabama. In that area, in-row sub-soiling combined with a winter cover crop helped improve yields in no tillage systems. Due to incentives by the USDA Natural Resource Conservation Service, there will soon be more data on the impact of cover crops in the mid-south and this will hopefully correct the yield loss for no-till systems.

Energy Use

Similar to the 2008 analysis of energy use, cotton's footprint from field to gin continued to be dominated by fertilizer use for both irrigated and non-irrigated production systems (Figure 5 – irrigated systems shown as the example). The primary fertilizer impact is associated with the energy intensive nitrogen production process. Figures

for greenhouse gas emissions 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, a strong 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 that producers are aware of the importance of good nitrogen management. Progress has also been made in developing tractor-mounted sensors to vary nitrogen application rates to match crop needs real-time in the field. Such advancements should continue to improve nitrogen use efficiencies and lower cultivation energy requirements.

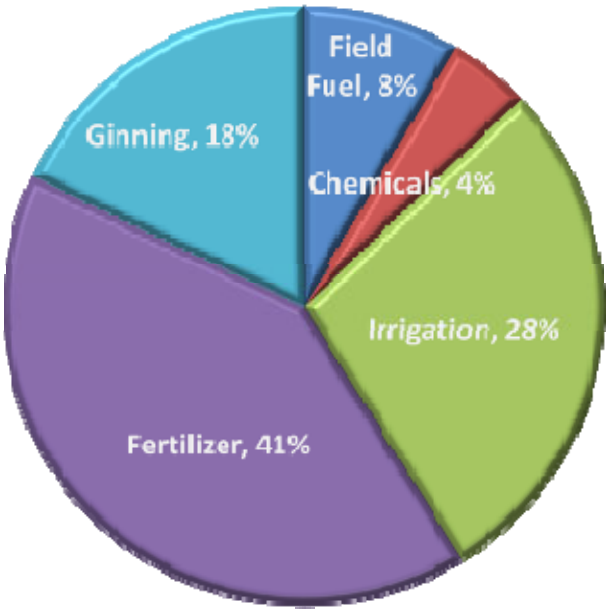

Figure 5. Distribution of estimated energy use on a per land area basis for producer's with irrigated production systems.

Grower Information Sources

In order to continue to supply producers with new information to maintain the positive trend in efficiency and productivity identified in the survey, it is important to understand where producers receive their information on new technologies and practices. The survey participants were asked to rank 12 information sources based on their dependence level: none; slightly, moderately or greatly. The percent selecting a source as moderately or greatly important are shown in Figure 6, with the most highly rated in 2015, at the top of the chart. The 2015 results were fairly consistent with what was reported in 2008. Producers tend to prefer face-to-face interaction: other producers, consultants, and extension agents. There was some increase in the Internet as a preferred source of information since 2008, but it was still ranked fairly low, with only 50% of respondents indicating it as an important source of information. Smart phone apps were the least important source of information as the number of apps for cotton is still limited.

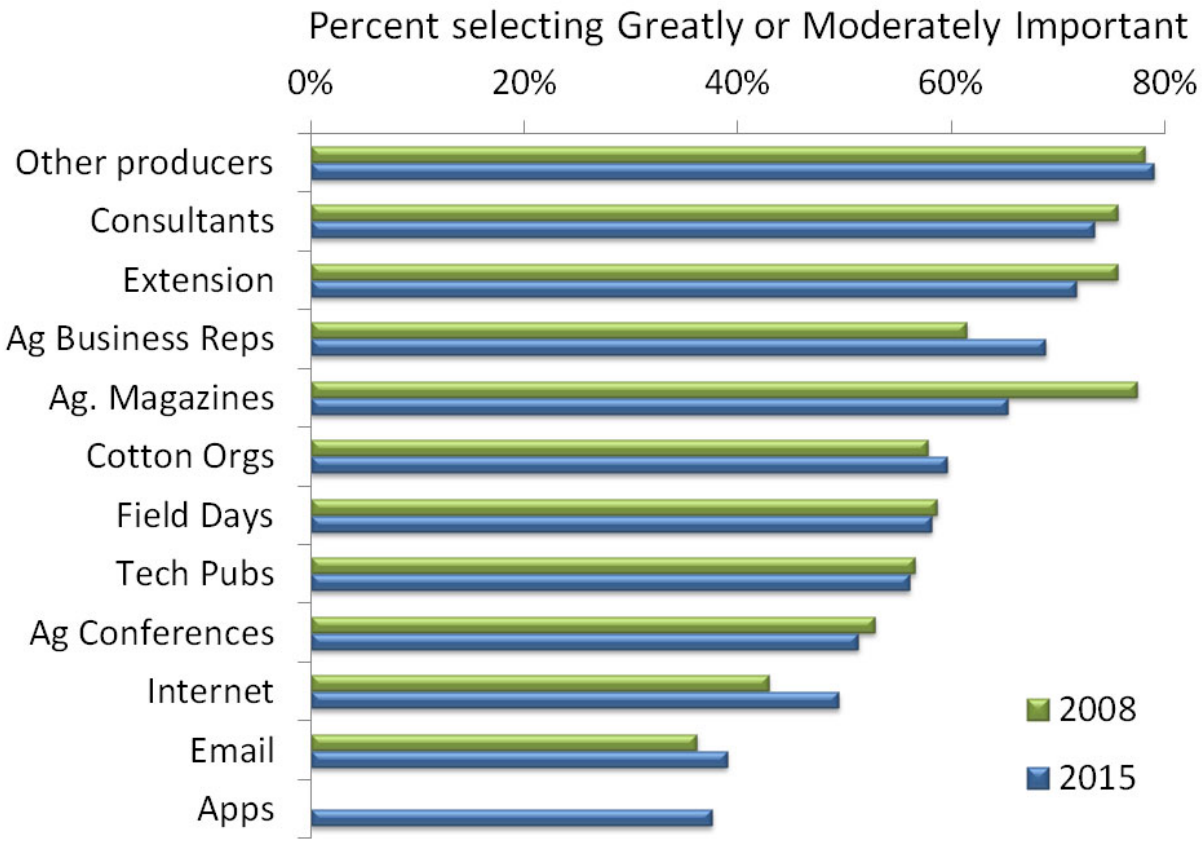

Figure 6. Percent of respondents who indicated they viewed the listed information source as greatly or moderately important in the 2008 and 2015 surveys.

Summary

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 and some technologies that are not fully adopted. There needs to be continued technology transfer of sensor-based irrigation scheduling and more advanced precision technology adoption such as yield monitor interpretation and application of that data to management decisions. Also, the large energy footprint associated with fertilizer use indicates that efforts to improve fertility management need to continue, particularly for nitrogen. Much of this technology transfer will need to take place through face-to-face interaction in the short-term. Efforts should continue to be focused on opportunities to improve electronic information delivery through web sites and apps, as resources to provide in-person information delivery will likely continue to decrease in the future.

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References

ASABE. (2011). ASAE D497.7. Agricultural Machinery Management Data Standard. ASABE, 2940 Niles Road, St. Joseph, MI.

Bergtold, J.S., R.L. Raper, and E.B. Schwab. 2009. The economic benefit of improving the proximity of tillage and planting operations in cotton production with automatic steering. Applied Engineering in Agriculture 25(2): 133-143.

DOE. 2015. Alternative Fuels Data Center – Fuel Properties Comparison. http://www.afdc.energy.gov/fuels/fuel_comparison_chart.pdf U.S. Department of Energy. Site confirmed December 15, 2015.

Faulkner, W., J. Wanjura, R. Bowman, B. Shaw, and C. Parnell (2011). Evaluation of modern cotton harvest systems on irrigated cotton: harvester performance. Applied Engineering in Agriculture, 27(4): 497-506.

Hardin, B., and P. Funk. (2014). Energy Monitoring in Gins – 2013 Update. Proceedings of the 2014 Beltwide Cotton Conferences, (pp. 576-583). New Orleans.

Hoffman, G., T. Howell, and K. Solomon (1992). Management of Farm Irrigation Systems. ASAE Monograph Number 9, 723 & 724.

Kulkarni, S., L. Espinoza, M. Ismanov, and T. Griffin. 2008. Comparison of soil compaction patterns by on-board module builders. 2008 Beltwide Cotton Conferences, Nashville, Tennessee, January 8-11, 2008. P. 801.

Leib, B., J. Payero, L. Pringle, J. Bordovsky, W. Porter, and E. Barnes. 2015. Placement and Interpretation of Soil Moisture Sensors for Irrigated Cotton Production in Humid Regions. Cotton Incorporated, Cary, NC. https://cottoncultivated.cottoninc.com/wp-content/uploads/2015/12/Soil-Moisture.final-web1.pdf. 8 pp.

Pradhan, A., D.S. Shrestha, A. McAloon, W. Yee, M. Haas, and J.A. Duffield. 2011. Energy life-cycle assessment of soybean biodiesel revisited. Transactions of the ASABE 54(3): 1031-1039.

Raper, R.L., D.W. Reeves, C.H. Burmester, and E.B. Schwab. 2000. Tillage depth, tillage timing, and cover crop effects on cotton yield, soil strength, and tillage energy requirements. Applied Engineering in Agriculture VOL. 16(4): 379-385

Reed, J.N., E.M. Barnes, and K.D. Hake. 2009. Technical Information Section. US Cotton Growers Respond to Natural Resource Survey. International Cotton Advisory Committee, The ICAC Recorder. XXVII(2), June.

Triplett, G.B., and W.A. Dick. 2008. No-Tillage Crop Production: A Revolution in Agriculture! Agronomy Journal. 100:S-153–S-165.

Valco, T., H. Ashley, D. Findley, J. Green, R. Isom, T. Price, and J. Fainnin. (2015). Cost of ginning 2013 survey results. 2015 Cotton Beltwide Conferences. San Antonio Texas: National Cotton Council, Memphis, TN.

Velandia, M., M. Buschermohle, J. Larson, , N. Thompson, and B. Jernigan. 2013. The economics of automatic section control technology for planters: A case study of middle and west Tennessee farms. Computers and Electronics in Agriculture 95:1-10.

Wang, M. 2007. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model. Argonne National Laboratory, Chicago, IL. http://www.transportation.anl.gov/software/GREET/index.html.

Willcutt, M., M. Buschermohle, E. Barnes, F. To, J. Field, and P. Allen. (2009). In field time in motion comparisons of conventional, John Deere 7760, and Case 625 Module Express cotton pickers. Beltwide Cotton Conferences. San Antonio, Texas: National Cotton Council, Memphis, TN.