Has Bio-Tech Cotton Production Reduced Carbon Emissions?  
A Scan Level Cotton Carbon Life Cycle Assessment  

L.L. Nalley¹, D.M. Danforth¹, Z. Niederman¹, T.G. Teague²

RESEARCH PROBLEM

Given increased consumer awareness and demand for products with lower greenhouse gas (GHG) emissions coupled with the increasing reality of a government policy to lower net GHG emissions, row crop producers in the United States may have to adjust to both consumer wants and government demands. There are two distinct ways to reduce GHG per pound of cotton produced: (1) increase yield per acre holding inputs constant, and (2) decrease inputs per acre while maintaining yield. Advances in cotton breeding have simultaneously captured the benefits of both of these attributes. While there are existing studies on GHG emissions from cotton production, there is a void in the literature on what the effect of the adoption of advanced seed technology has had on total GHG emissions per acre and GHG emissions per pound of cotton produced. The objective of this project was to determine the GHG emissions of cotton production across the range of seed technology available to producers from 1997 to 2008.

RESEARCH DESCRIPTION

Using a scan level Life Cycle Assessment (LCA) approach, this analysis assessed GHG emissions, in their carbon-equivalents, in cotton production. The analysis included emissions, direct and indirect, required to produce a pound of cotton from field preparation through harvest. Using actual application records, estimates were made of direct GHG emissions from combustion of diesel and N₂O emissions from N-fertilizer as well as indirect emissions from embedded carbon in agrochemical, fertilizer and fuel inputs.

Data are from approximately 100 fields in a northeast Arkansas farm with detailed production and yield records for over 7,000 acres of cotton in 1997, 2005 and 2008. Seed types were conventional in 1997, Roundup Ready® Bollgard® in 2005, and Roundup Ready® Flex Bollgard II® in 2008. Tillage was conventional

¹Assistant professor, program associate III, and graduate research associate, respectively, Department of Agricultural Economics and Agribusiness, Fayetteville.  
²Professor, Arkansas State University, University of Arkansas Agricultural Experiment Station, Jonesboro.
in 1997. With adoption of herbicide tolerant cultivars conservation tillage practices were expanded across the farm, and by 2005 and 2008 most of the farm was either reduced till, ridge-till or no-till. Fuel use was estimated from the Mississippi State Budget Generator using the specific tractors and implements combined with the number of passes per acre per tractor and implement. Tractor efficiencies were standardized across years by using the same fuel estimates for the same operation. Fertilizer and agrochemical application rates were based upon the actual application of the active ingredient. Carbon equivalent emissions estimates were taken from engineering literature for each of the different inputs (Ecoinvent, 2009; Lal, 2004; US EPA, 2009; West and McBride, 2005). Average emissions per acre and per pound of lint were weighted by their acreage for three years. Yields were adjusted each year based upon the farm’s yearly yield trend to account for higher or lower production than typical due to weather, pest pressure or other factors.

RESULTS AND DISCUSSION

Table 1 shows yield, GHG emissions, and agrichemical use for the three analyzed years. Results show that total GHG emissions per acre, in their carbon equivalents, decreased from an average of 536 lb/acre in 1997 to 464 lb/acre in 2008. These comparisons are based on differences in input usage for over 300 individual fields. One of the main drivers of this GHG reduction is the adoption of imbedded seed technology which required fewer trips across the field for pesticide applications and tillage. As input usage decreased over time, the observed yields increased. This can be attributed to many factors (efficiency, management practices, boll weevil eradication, etc.) as well as increased yield potential from seed technology. The combination of increased yield and decreased input usage resulted in a reduction in the amount of GHG emitted to produce a pound of lint. The carbon equivalents per pound of cotton produced reduced from 0.67 lb in 1997 to 0.34 in 2008.

PRACTICAL APPLICATION

Many agricultural commodities face increased consumer, industry, and government pressure to reduce GHG emissions. It just takes one of these three entities to gain enough momentum to bring about changes in agricultural production. This study analyzed technological change in imbedded seed technology from 1997 through 2008 for one farm in northeast Arkansas with over 100 fields of monoculture cotton. The carbon equivalents required to produce one pound of cotton decreased by 49% from 1997 to 2008. This decrease can be attributed to both an increase in yield and a decrease in inputs. Producers did not adopt new cotton cultivars based on carbon emissions; cultivar selection was based on yield potential and production input requirements, which is directly tied to carbon emissions. That is, producers’ main motive for seed adoption is driven by profitability not
GHG levels. This study concludes that while profitability is the motive, a positive externality of this adoption of imbedded seed technology (Roundup Ready, Bollgard, etc.) has been a reduction in GHG emissions both per acre and per pound of cotton produced. While the results of this study are from only one farm, this farm is representative of the Mid-south in adoption of technology and representative of best management practices for northeast Arkansas cotton production.

ACKNOWLEDGMENTS

This research would not have been possible without the support and cooperation of David and Justin Wildy and the staff at Wildy Farms. The authors thank David Wildy for providing access to the extensive farm production data used in this study. The project was supported through a Sustainability grant from the Cotton Incorporated Arkansas State Support Committee.

LITERATURE CITED

Ecoinvent Center. 2009. Ecoinvent 2.0 Life Cycle Inventory Database. Swiss Center for Life Cycle Inventories, St Gallen, Switzerland.
Table 1. The average and standard deviation of yield, greenhouse gas emissions in their carbon equivalent (CE) per acre, CE per pound of cotton produced, and use of agricultural chemicals per acre.

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>2005</th>
<th>2008</th>
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<tbody>
<tr>
<td>Average Yield (lb/acre)</td>
<td>822</td>
<td>1251</td>
<td>1362</td>
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<tr>
<td>St. Dev of Yield (lb/acre)</td>
<td>118</td>
<td>242</td>
<td>167</td>
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<tr>
<td>Avg CD/acre</td>
<td>536</td>
<td>561</td>
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<tr>
<td>St. Dev CD/acre</td>
<td>37</td>
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<td>30</td>
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<tr>
<td>Avg CD/lb of Cotton</td>
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<td>0.34</td>
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<tr>
<td>St. Dev CE/lb of Cotton</td>
<td>0.10</td>
<td>0.09</td>
<td>0.05</td>
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<tr>
<td>Avg oz AgChemicals/acre</td>
<td>173</td>
<td>198</td>
<td>153</td>
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<tr>
<td>St Dev oz AgChemicals/acre</td>
<td>97</td>
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