FIELD TO MARKET FIELDPRINTS FOR COTTON PRODUCTION IN GEORGIA

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Abstract

Cotton is an important commodity to the state of Georgia. In 2012, cotton was planted on 1.3 million ac. The total value of lint and seed combined for that year was estimated at $1.2 billion. To compete with synthetic fibers and maintain its global market share, the cotton industry must document the sustainability and environmental footprint of cotton production. The objective of this research was to develop a baseline of Field to Market Fieldprints for cotton production in Georgia. Field to Market is an alliance for sustainable agriculture that began in 2007 with the initiative to increase productivity of agriculture while lessoning environmental impacts. The Fieldprint Calculator is a confidential, free online tool promoted as an educational resource for producers to understand how their management practices impact the sustainability of their operation. Georgia cotton growers were identified and selected from across Georgia's cotton producing counties and represented the continuum of large, medium, and small cotton operations. Growers were interviewed and data they provided was assembled to populate the Fieldprint Calculator for at least 2 of their fields with multiple years of data. Data collected was analyzed and used to develop an index of per pound resource impacts to produce cotton lint on land use, soil conservation, soil carbon, irrigation, energy, greenhouse gas emissions, and water quality. Indices from individual producers were compared and contrasted to the national average. Based on the results of this pilot study, Georgia producers appear to have a smaller environmental footprint than cotton producers in other regions of the United States for most of the metrics in the Fieldprint Calculator.

Introduction

An increase in agricultural production is essential to ensuring the future food and fiber needs of consumers throughout the world. Improvements in efficiency and sustainability are key to achieving this goal. Field to Market has developed an educational tool that will provide producers with valuable information about current management techniques and allow them to alter scenarios in the system to see how they can lessen their environmental impact.

Field to Market is an alliance for sustainable agriculture that began in 2007 with the initiative to increase productivity of agriculture while lessoning environmental impacts. Field to Market, the Alliance for Sustainable Agriculture is a diverse membership comprised of agribusinesses, federal agencies, grower associations, universities, conservation organizations, retailers, food packagers and federal agencies dedicated to helping producers increase the productivity of agriculture while lessening the environmental impact. Field to market has created the Fieldprint Calculator, a confidential, free online tool promoted as an educational resource for producers to understand how their management practices impact the sustainability of their operation. The calculator provides producers with valuable information on their resource usage and efficiency. Producers can compare their management practices to others based on national, state, and local averages. The calculator is an essential tool to helping producers recognize the importance of sustainability in agriculture and the impact their management decisions can have on resources available and the environment.

Currently the Fieldprint Calculator is available for producers of corn, soybeans, cotton, wheat, and potatoes. The calculator uses metrics to evaluate the data entered based on soil conservation, water quality, soil carbon, greenhouse gas emissions, land use, irrigation water use and energy use. The calculator uses algorithms to provide producers with an assessment of their management practices that can be compared to other producers and state and national averages.

A spidergram (Figure 1) is used to plot the metrics and provide a detailed visualization or "fieldprint". The axes of the spidergram function as relative indices symbolizing the amount of resource used for each pound of lint produced based

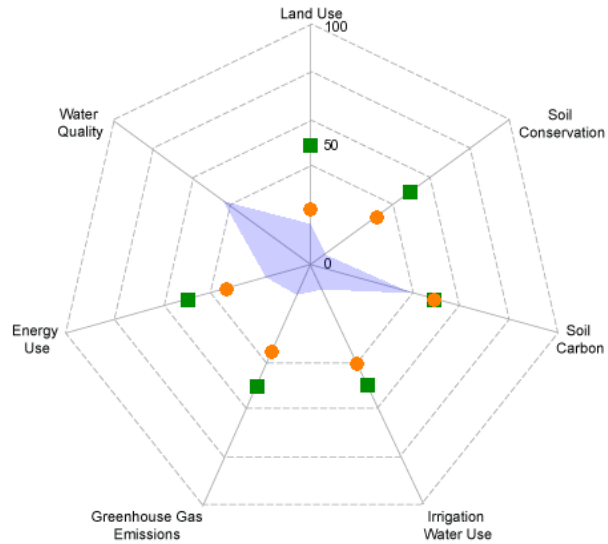

Figure 1. Spidergram that compares the national (green), state (orange), and producer's (blue) Fieldprint for cotton production in Georgia for 2014.

on each metric. The closer the values are to the center of the spidergram the lower the impact indicated on the resource being evaluated. Figure 1 shows an example of a spidergram from the Fieldprint Calculator.

In the past few years cotton production has been portrayed as very resource intensive and "non-sustainable" by various organizations and individuals thus affecting the public's perception of the cotton industry as a whole. To counteract this negative image, the cotton industry is investing in programs that provide science-based data to assess the environmental footprint of the cotton industry. The goal for this project is to gather data from producers about their field management practices to develop a baseline in Georgia for Field to Market data. Currently, Georgia is the 2nd largest cotton producer in the United States so it is important to assess the efficiency and sustainability of its current production systems.

Materials and Methods

The work reported here is a pilot study which we will use as a precursor to a larger study on cotton fieldprints in Georgia. We identified several Georgia cotton producers with the assistance of University of Georgia (UGA) county agents and other UGA faculty and staff. From these we selected five individual producers who were willing to participate in the study and had the records necessary to populate the Fieldprint Calculator. We constructed a worksheet that directly correlated with the questions used in the Fieldprint Calculator and used it to collect the necessary data from the participating producers. Meeting times were scheduled and growers were guided through the questions and asked to provide the most relevant data available about their management practices. Any questions that were unclear were reevaluated and rephrased so growers would have a better understanding of the concept. Growers were then contacted and presented with the new revised questions. Once the data sets were collected from a producer they were analyzed and entered into the Field Print Calculator using a code established for each producer and producer field. The state baseline was developed using the data provided by the producers selected.

Results and Discussion

The 10 fields represented in this pilot study were chosen from counties that produce at least 4,000 bales of cotton to those producing over 70,000 bales of cotton in a given year. We collected data from fields from 2011 to 2014. Yield data ranged from 1000 lb/ac of lint to 1833 lb/ac.

Land Use Metric

The Land Use Resource metric represents the complete area used in crop production. The total land use includes all factors that can potentially impact the land being used in production during a specific rotation year. Some influential factors that may contribute to changes in land use are: fallow land, whole field abandonment, and the use of green manure (fertilizer made up of growing plant material that has been incorporated into the soil). Yield data is required to be entered based on a planted acre basis. Cotton's current share in the Fieldprint Calculator is 83% lint and 17% seed to represent the economic yield. Increasing yields allow for land to be used more efficiently and reduce the land use fieldprint score.

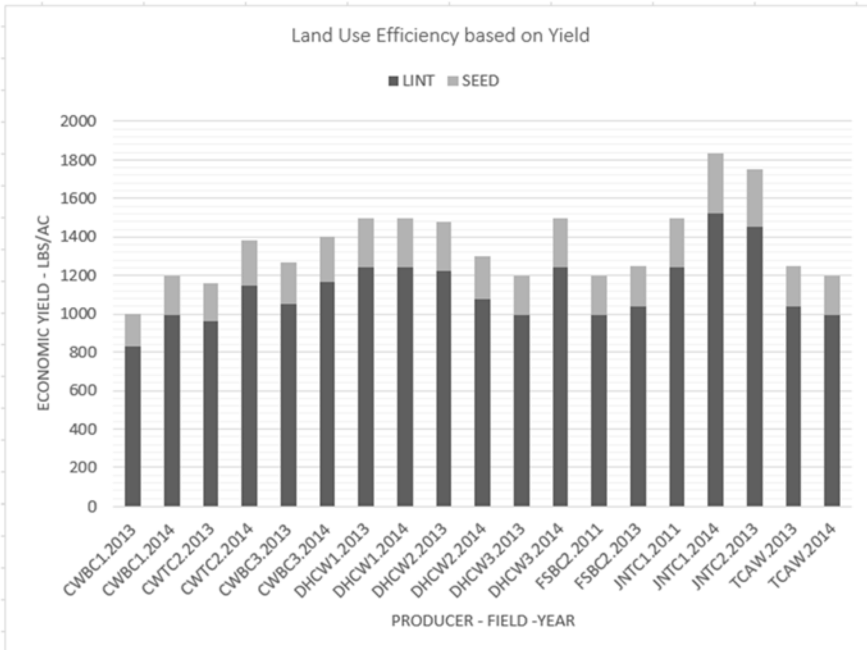

Figure 2. Land use efficiency for producer fields based on production year.

Soil Conservation Metric

The Soil Conservation Resource metric relates the loss of soil from erosion by water and wind. It successfully equates this loss by implementing the loss of soil in weight in a given year by the unit of production. Thus in cotton production, it would relate to tons of soil lost per year either per pound or per bale of cotton produced. Field characteristics as well as producer management decisions are extremely important to determining the rate at which soil is lost. Essential factors that can be attributed to soil loss that are not dependent upon producer decisions are: the slope of the field, slope length, and the texture of the soil.

In Georgia, producers are faced with soils that are low in organic matter content. Many of the soils in the cotton producing regions of the state are classified as sandy-loam. This type of soil has a lower water holding capacity and less organic matter than the richer soils located in the Midwestern United States. Figures 3 and 4 compare an actual producer field in Southwest Georgia with an alternate scenario. For the 2014 growing season the producer implemented a conventional tillage system. This field has a sandy-loam soil type, a slope length of 25%, and a slope percent of 3.5. For the scenario, only the tillage practice was altered. Based on the fieldprints for the producer's actual 2014 growing season and the scenario developed if the tillage practice were changed to a no-till system for that year the producer would have a smaller fieldprint. When comparing the soil water erosion derived from RUSLE2 the original conventional tillage system is losing 2.2 tons of soil/ac-yr. compared to the alternate scenario of a no-till system where the producer would only be losing 1.1 tons of soil/ ac-yr. This difference shows the relative importance of tillage systems to soil conservation.

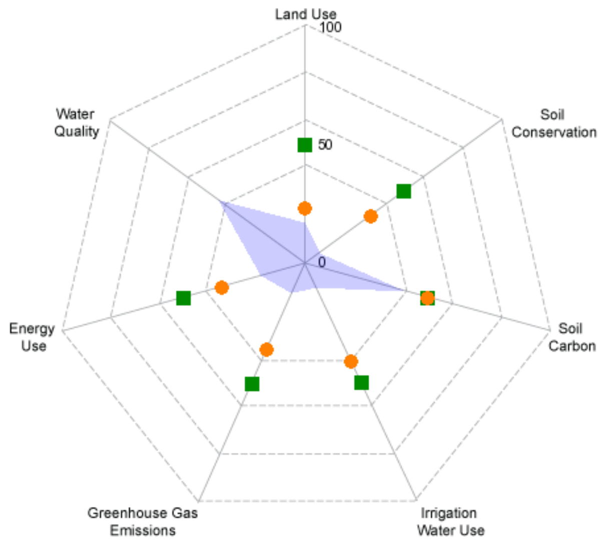

Figure 3. 2014 – Conventional cotton system.

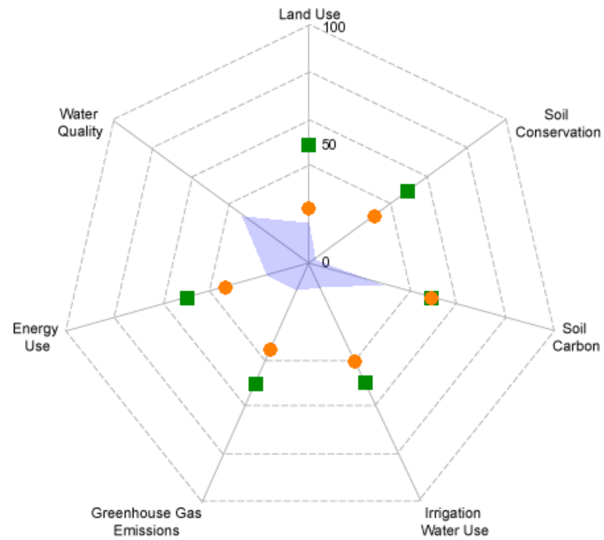

Figure 4. 2014 – Alternate scenario – no-till system.

Soil Carbon Metric

The Soil Carbon Resource metric was developed to allow producers to see the impact their management decisions can make on the carbon levels in the soil. Soil carbon is measured using the Soil Conditioning Index (SCI). The index uses values from -1 to +1 to indicate the rise and fall of carbon in the soil. If a value between -0.05 and +0.05 is reported it is understood that no discernable change has happened to the carbon in the soil and is representative of zero. When the value begins to move in either a positive or negative direction from zero it is understood that either soil carbon is being added or taken away from the soil. However, no conclusion can be drawn about the rate of change occurring. To provide a valuable output to the producer, the index relies upon the rate of soil erosion, the addition of organic matter, and operations occurring in the field.

Soil carbon content is directly related to soil health and therefore vital to the productivity of the soil. Agricultural systems have proven over time to negatively impact the soil carbon level. A variety of common practices in agricultural production can reduce soil carbon content. Burning and tillage of the soil tend to be two of the most common practices that deplete the soil of carbon reserves.

In Georgia many cotton producers are now relying on systems that reduce tillage practices. Although the main purpose of incorporating systems that support minimal or no-till systems in Georgia is to reduce the dependency on herbicides alone for controlling resistance in weed populations the technique has garnered a positive impact on the soil carbon level based on this baseline study. With limited soil disturbance, producers can affect the soil carbon level in two different ways. By reducing tillage less carbon is lost in the atmosphere through soil disturbance and crop residues are left on the soil surface to degrade and increase the soil carbon level. Increasing the soil carbon can also lead to an improvement in soil texture, increase the water and nutrient holding capacity of the soil, increase infiltration and decrease erosion. No-till systems in this study appear to have a positive impact on the amount of carbon in the soil. Both producers who practice no-till cotton production either experienced an increase in the amount of carbon in the soil or experienced no change to carbon levels from one cotton production year to the next.

As illustrated in Figure 5, soil carbon can fluctuate within in the soil with each new growing season. There are many factors to consider to understand the rate at which carbon can increase or decrease in the soil. This could be attributed to the type of tillage system used, the establishment of a cover crop, or the level of organic matter in the soil. For

Producer FSBC2 in Figure 5, the negative soil carbon level can be attributed to a high soil water erosion factor. Implementing more soil conservation practices, such as no-till and cover crops, should result in an increase in the producer's soil carbon levels.

Irrigation Water Use Metric

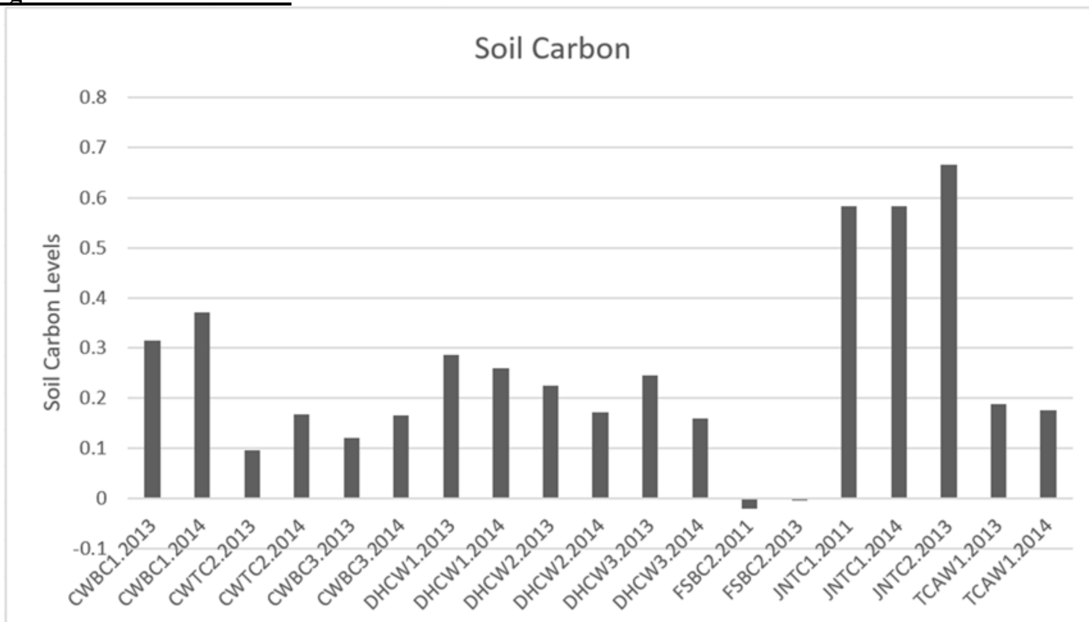

Figure 5. Soil carbon levels for the study's fields.

The Irrigation Water Use metric represents the increase in crop yield from water applications applied to the crop. By entering both an actual yield for the field and an estimated yield if the crop were to be non-irrigated, water use for the crop can be calculated. An irrigation fieldprint for cotton is indicated by the volume of water applied in terms of ac-in of water applied per pound of additional production over non-irrigated yield. Non-irrigated yields were estimated by the producer. If a producer does not irrigate a field no footprint is evident therefore reflecting no yield information and a 0 ac-in/lb fieldprint.

Rainfall in Georgia can be variable thus many Georgia producers rely on irrigation to supplement rainfall activity. Most of the producers who participated in this baseline study used irrigation practices to increase and stabilize their potential yield. However, there were a few non-irrigated fields in this study. Most producers in the state irrigate using center-pivots with either surface water or groundwater serving as the source. Based on data collected in the 2012 Georgia Agricultural Census issued by USDA (NASS, 2014), irrigated Georgia farmland equated to 1,125,355 ac. Approximately half the cotton acreage in Georgia is irrigated.

To illustrate the difference irrigation rates and yield potential can make in a fieldprint two producers from different parts of the state were compared for the same growing season. Figure 6 represents Producer A's fieldprint with an irrigated yield of 1833lb/ac. Figure 7 illustrates Producer B's fieldprint with a slightly lower irrigated yield of 1384 lb/ac. Producer A irrigated at a slightly higher rate than producer B. Although rainfall is entered under the crop rotation tab it is not factored into the irrigation metric and is not reflected in the fieldprint. Therefore, rainfall could not be factored into the equation for Producer A's higher yield potential. Although Producer A's yield was greater than Producer B the fieldprint for this producer also increased. Thus, the higher the irrigation rate the greater the irrigation fieldprint.

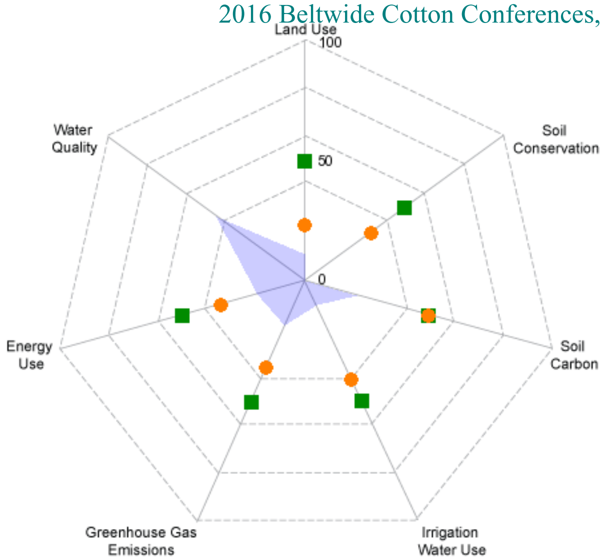

Figure 6. 2014 – Producer A fieldprint.

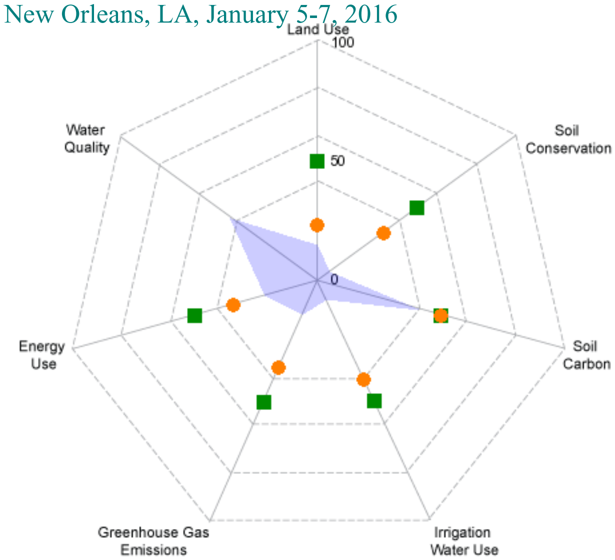

Figure 7. 2014 – Producer B fieldprint.

Energy Use Metric

The Energy Use metric considers all embedded and direct sources of energy to calculate an energy use fieldprint. The direct sources of energy are: irrigation application systems, equipment operations, tillage, manure applications, transportation and drying. Embedded factors used in the energy use metric are lime, fertilizers, crop protectants and seed. All energy factors are added together to establish a total energy use fieldprint expressed in BTU/lb of cotton fiber. Calculations are used for the crop protectants and seed embedded energies while the energy referenced in the metric for lime and fertilizer is established from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation or commonly referred to as the GREET model. Another model is used to derive the energy values for manure applications, equipment operations, and tillage. However the values for transportation, drying, and the irrigation application system are determined from calculations from published formulations that are established when users enter information. Based on the data collected from Georgia producers the energy use metric reflects that the largest portion of energy expended in the field comes from irrigation, fertilizer, crop protectants, field equipment operations, and drying. A comparison was done from a producer's 2011 growing season and his 2014 growing season to show how the energy use fieldprint can change with different growing seasons. For this producer his energy usage went down 754 BTU/pound of cotton in the 2014 season. This was due to a reduction in the amount of crop protection trips and a reduction in irrigation energy. A producer can use this metric as an educational tool to determine where most of their energy usage for a season is going and determine if an adjustment could be made to reduce any of the factors. Below is the producer's fieldprint for each growing season. The growing season reflected in Figure 9 displays a much smaller fieldprint for energy use than the earlier season shown in Figure 8.

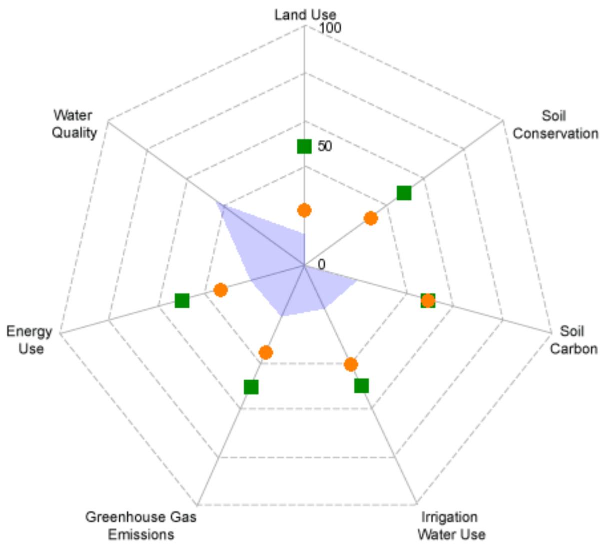

Figure 8. Field A fieldprint for 2011.

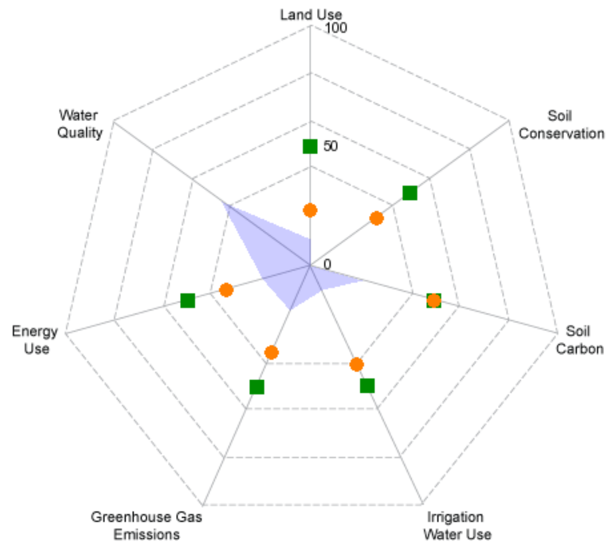

Figure 9. Field A fieldprint for 2014.

Greenhouse Gas Emissions Metric

The Greenhouse Gas Emissions Resource metric was developed in much the same way as the Energy Use metric. Both metrics use embedded and on-farm greenhouse gas emissions (GHG) subtotals. The embedded factors include crop protectants, seed, and lime and fertilizer. While the on-farm factors consist of manure applications, the drying and burning of any crop residue, transportation, tillage and any other equipment operations. All on-farm values are developed from energy quantities except for the burning of crop residue which is established using a derivation from the Environmental Protection Agency (EPA).

Some of the factors that lead to an increase in the amount of greenhouse gas emissions cannot be directly controlled by the producer. Therefore, it was more important to focus on specific areas where management decisions could result in the decrease or increase in gas emissions. Three specific areas were chosen to show how producer decisions can impact the rate of emissions: fertilizers, protectants, and tillage practices. Figure 10 shows the impact specific management practices can have on the amount of greenhouse gas emissions per pound of cotton fiber. GHGs include the following gases: methane, carbon dioxide, sulfur hexafluoride, nitrous oxide, and hydrofluorocarbons. The

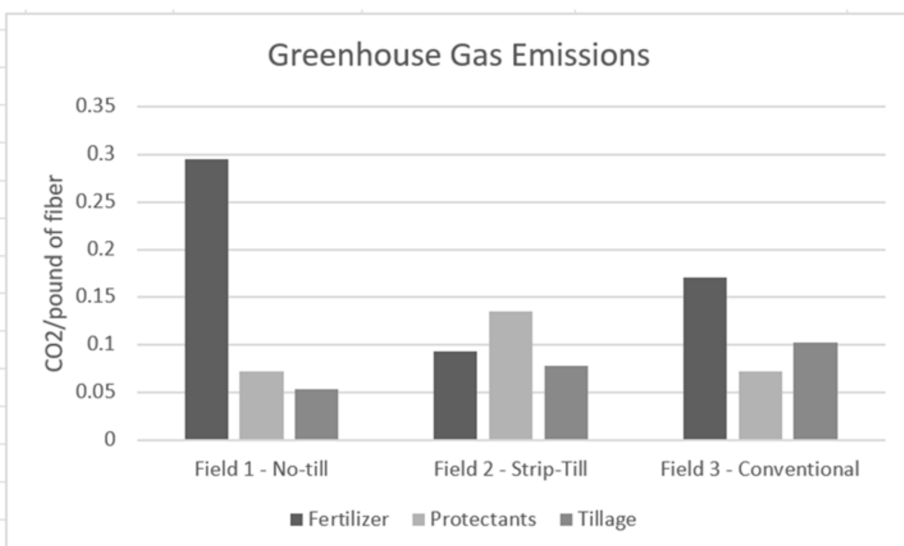

Figure 10. A comparison of producer emissions based on fertilizer, protectants and tillage practices.

combination of greenhouse gases are referred to as CO2e, which are greenhouse gas equivalents. The usage of more organic type fertilizers can drastically increase the amount of CO2e emitted into the atmosphere. In Field 1, the producer was applying chicken litter yearly as an alternate to man-made fertilizers. With the usage of poultry litter, nitrous oxide emissions were elevated leading to the higher level of GHG's for the fertilizer application in Field 1.

The number of trips made in the field distributing protectants is also important to consider when discussing greenhouse gas emissions. Crop protectant trips include the spraying of insecticides, herbicides, fungicides, and plant growth regulators. For producers in Georgia the number of crop protectant trips are heavily dependent on the impact resistant weed populations can have on cotton production. Most of Georgia cotton fields face a moderate to high weed infestation during the growing season due to resistant Palmer amaranth populations. Depending on the control tactics established most producers will spray at least 4 to 5 times to control weed populations however depending on the rate of control established more applications may be necessary. Most of the producers who participated in this pilot study made at least 3 applications of herbicides some made many more to establish proper weed control. As noted the more application trips made the higher the CO2e emissions are for a given field.

Tillage practices can also impact the rate of CO2e emissions. Figure10 also shows systems that implement a higher tillage rate can increase the rate of emissions. With a conventional tillage system the producer is making more trips into and across the field to prepare the soil for planting a season's crop. A no till system will essentially cut out at least 3 trips into a field therefore decreasing the amount of emissions generated from the operation of a tractor in the field. This indication can be observed in the difference between the conventional and no-till system in Figure 10.

Water Quality Use Metric

The Water Quality Index (WQI) was developed by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). This index provides an effective method to communicate the impact of agricultural management decisions on water quality. Multiple factors are combined into a single number ranging from 0-10, 1 being the lowest score and 10 the best. Each increasing number directly corresponds with the probability that practices are positively associated with higher water quality. For the purpose of the Fieldprint Calculator the NRCS WQI score has been changed to a score of 0-100. For the calculator 0 is the lower impact factor while 100 represents the lowest score. To achieve the Fieldprint Index Score the following formula is used: 100 – (WQI Score x 10).

For the purpose of this paper, the WQI metric was analyzed based on tillage practices that are conducted in the field: conventional, strip tillage, and no-till systems. Since none of the producers switched their tillage practices in the last 5 years a comparison was developed between 3 different producers. As indicated in Table 1, for each field the WQI score was broken down into the WQI Agricultural Subtotal and the official WQI Quality Index Score. The WQI Agricultural Subtotal consists of the field physical sensitivity, nutrient management, tillage management, and pest management. The producer implementing the conventional tillage system saw a higher score of 10 for tillage management compared to the strip- till producer, and the no-till producer. This indicates that no-till producer can increase their WQI Score by implementing a practice that results in better water quality since there is no disturbance to the soil.

Table 2. Georgia's current baseline estimation.

Resource Area	Producer Baseline	State	National
Land Use Index	15	23	50
Soil Conservation Index	6	33	50
Soil Carbon Index	37	50	50
Irrigation Index	12	41	50
Energy Use Index	22	34	50
Greenhouse Gas Index	17	36	50

The Water Quality Index is calculated by adjusting the Agricultural Subtotals for irrigation and the implementation of conservation practices. Therefore, the use of conservation practices can greatly benefit a producer's WQI score. When producers were asked about the types of conservation practices implemented in their fields, most were able to provide at least 2 methods they implemented during each growing season. Of the 5 producers who participated in this pilot study 3 of the producers used a conservation cover. The more practices used in the field the greater the positive impact on water quality. It is noted that a producer executing 3 different conservation practices can greatly reduce their water quality environmental footprint.

Comparison with Estimated State and National Fieldprint Metrics

Table 2 compares the producer-specific metrics we calculated in this study to and compares them to the estimated state and national metrics. The Producer Baseline is an average of the producer fieldprints for each metric with the exception of the Water Quality Use metric. The State and National averages are for educational purposes only. They provide a benchmark and are calculated from datasets that are made available to the public. Data sets used included those provided by USDA Natural Agricultural Statistics Service (NASS) and USDA Natural Resources Conservation Service (NRCS).

Conclusions

The Fieldprint Calculator is an essential tool to effectively measure the impact farm management practices can have on the environment. By developing a pilot study that gathered producers from across the state we were able to

Table 1. Water quality metric comparison for 3 production systems.

FACTORS	Field 1 -NRCS WQI SCORE (Conventional)	Field 2 -NRCS WQI SCORE (Strip Till)	Field 3 -NRCS WQI SCORE (No Till)
Field Physical Sensitivity	6.81	6.13	7.65
Nutrient Management	7.5	7	3.75
Tillage Management	5	7.5	10
Pest Management	7	2	2
WQI AG Subtotal	**6.58**	**5.66**	**5.85**
Irrigation Adjustment	5.59	5.09	5.56
Conservation Practice	N/A	6.49	7.11
Conservation Practice	N/A	7.72	8.2
Conservation Practice	N/A	N/A	8.83
Water Quality Index	**5.59**	**7.72**	**8.83**
Fieldprint Index Score	44.1	22.8	11.7

understand how the fieldprint calculator takes producer management information and provides feedback in the form of a fieldprint. Analyzing the data within each metric at the individual producer level provided the base knowledge to then compare producer fields and develop alternate scenarios to understand how management practices can affect sustainability. The Georgia producers selected to participate in this study had relatively low fieldprint scores with the exception of soil carbon. With further research conducted on a larger scale we will be able to provide a more detailed understanding of the potential impact management decisions has on the sustainability of cotton production in Georgia.

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