INFLUENCE OF MANAGEMENT STRATEGIES ON COTTON SUSTAINABILITY USING THE FIELD TO MARKET FIELDPRINT CALCULATOR

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Abstract

In a proactive effort to measure and promote sustainable agriculture, an initiative entitled The Keystone Alliance for Sustainable Agriculture has been formed. As a result of this initiative, the Field to Market Fieldprint Calculator has been developed to give producers the ability to see how their crop production management strategies impact the sustainability of their farming operation. This educational tool provides producers with general information on what management strategies are most likely to improve or lessen their impacts, or 'Fieldprint', on energy use, climate impact, soil loss and water use. Data from several Tennessee cotton producers have been analyzed using the Fieldprint Calculator. Certain factors were found to influence sustainability through the quantification of energy use and greenhouse gas emissions. For example, using variable rate application (VRA) of fertilizers has the potential to reduce the amount of energy used and greenhouse gases emitted because less fertilizer, on average, will be applied. In turn, this reduces the amount of nutrients that could ultimately pollute surrounding water bodies. Using the Fieldprint calculator in such a way demonstrates that being sustainable and reducing 'Fieldprints' can not only increase producers' profitability, but also reduce the impacts from agriculture on the environment.

Introduction

Increasing agricultural sustainability will enable the world to meet present needs while continuously improving future generations' ability to meet their own needs. This can be done not only by lessening our environmental impacts, improving human health, and improving the well-being of agricultural communities, but also by increasing productivity to meet current as well as future food, fuel, and clothing demands. The Keystone Alliance for Sustainable Agriculture joins various food companies, agribusinesses, producers, commodity groups, and conservation programs to provide leadership, scientific information, and collaboration on improvements that can be made in crop productivity, environmental quality, and human and community well-being. The Field to Market Fieldprint Calculator is a free, online resource for producers to see how sustainable their production system is and also identify ways it can be improved. To use the calculator, the field must be spatially located, and then information is entered pertaining to crop rotation, management system, transportation, and drying. The quantified output metrics and their corresponding units include: land use (derived from total land area used to produce the crop), soil conservation (tons of soil per year per pound of lint produced), soil carbon (soil conditioning index), irrigation water use (acre-inch of water applied per pound of lint produced), energy use (BTU per pound of lint produced), and greenhouse gas emissions (pounds CO_2e per pound of lint produced). These metrics are then plotted on a spidergram (Figure 1). Spidergram axes are relative indices representing the resource use per pound of lint produced in each of the resource metric areas. Lower values closer to the center of the spidergram indicate a lower impact on each resource. By entering data from Tennessee cotton producers into the Fieldprint Calculator, several production factors were identified that heavily influenced overall sustainability including, but not limited to: yield, fertilizer application, and irrigation. For this study, the Calculator was used to compare traditional management strategies to more sustainable strategies while also considering the economics of those management decisions.

Materials and Methods

For a particular field of interest, current production practices were entered into the Fieldprint Calculator as an original scenario. A duplicate scenario was created, and one management strategy was altered (fertilizer rate, irrigation, etc.) while keeping all of the other original data the same. Thus there are two scenarios for a particular field: the real-world scenario and that same scenario with one management change. The results from both of these scenarios can then be compared and any changes in sustainability can be attributed to that management change.

Yield

Because the calculator quantifies its sustainability indices on a per pound of lint produced basis, maintaining yield is an important factor. For example, although irrigation increases water usage, irrigating in a severe drought year may be more sustainable in terms of energy use and greenhouse gas emitted than dryland cotton because yields can be maintained. To evaluate the change in sustainability based on production, a field and corresponding data was entered into the Calculator and used for 3 scenarios—the field yielding 1 bale/ac, 1.5 bale/ac, and 2 bale/ac. Energy use and greenhouse gas emissions were compared for the 3 scenarios and any change was attributed to the difference in production.

Fertilizer

Using variable rate application (VRA) of fertilizers has the potential to reduce the amount of energy used and greenhouse gases emitted because less fertilizer, on average, will be applied. In turn, this reduces the amount of nutrients that could ultimately pollute surrounding water bodies. A 72-acre cotton field in West Tennessee was used for analysis of fertilizer application methods. Traditionally, this producer applied a blanket rate of 30 lbs P_2O_5 and 90 lbs K_2O. The producer began site-specific soil sampling on a 2.5-acre grid and chose to use VRA of P and K. An average application rate based on acreage was calculated from the prescription maps (Figure 1) for both P_2O_5 (25 lbs/ac) and K_2O (51 lbs/ac). Thus, there was a traditional scenario with the blanket rates and a variable rate scenario with the averaged application rates. All other management decisions, including N fertilizer applications, remained the same for both scenarios. Energy use and greenhouse gas emissions were compared, as well as the sustainability indices that make up the Fieldprint spidergram. Monetary savings/losses by using VRA were calculated using current market fertilizer prices. The amount reduced/added of nitrogen and phosphorus by using VRA compared to blanket rate application was also calculated. For this particular producer, data was combined to give a whole farm analysis.

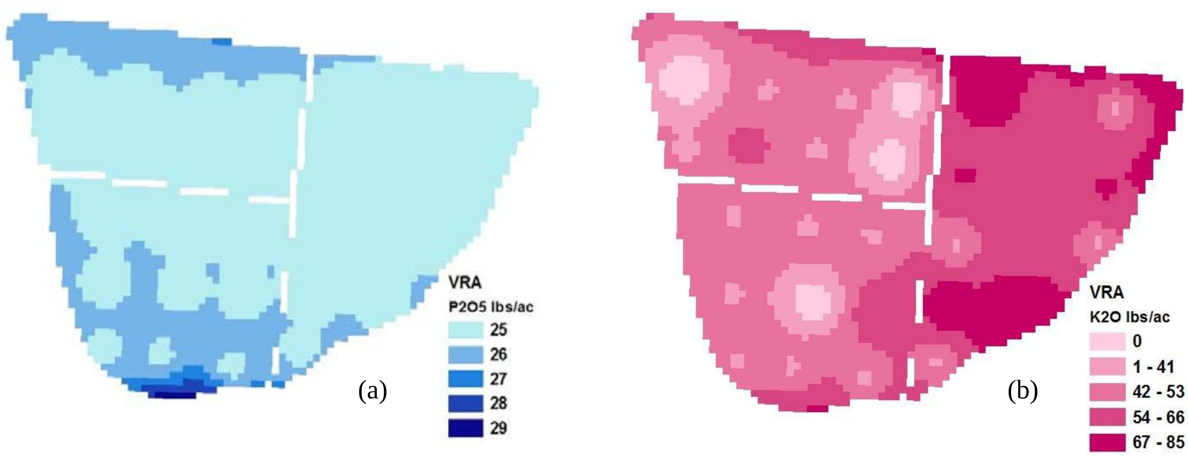

Figure 1. Prescription maps for (a) P_2O_5 with average rate of 25 lbs/ac and (b) K_2O with an average rate of 51 lbs/ac.

Irrigation

Irrigation is possibly the most influential factor in the Fieldprint calculator, thus comparisons of different scenarios and metrics can illustrate to producers the importance of proper irrigation. A 200-acre cotton field under center pivot irrigation was analyzed and used in two different scenarios (irrigated and dryland) for comparison. From a yield map (Figure 2), the average yield from the irrigated area was determined as 1125 lb/ac for the regular scenario and the average yield in the field corners was determined as 750 lb/ac to be used in the dryland scenario. All other field management was held constant.

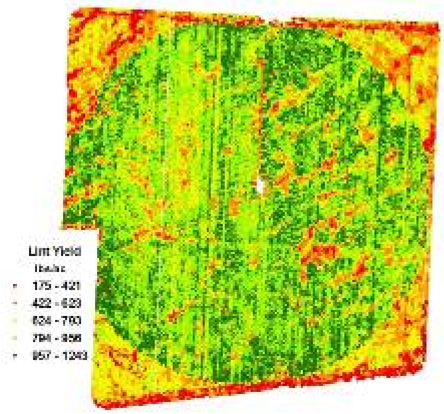

Figure 2. Yield map from an irrigated field to determine irrigated and dryland (corners) yield.

Results and Discussion

Yield

For this field, energy use and greenhouse gas emissions increased substantially as yields decreased (Figure 3). The total energy used (BTU) and greenhouse gas emissions (lb CO_2e) was approximately the same for each yield scenario, but the higher yielding scenarios were more sustainable on a lb of lint basis. This is based on the definition of sustainability per the creators of the Fieldprint Calculator—reducing environmental impacts while improving productivity.

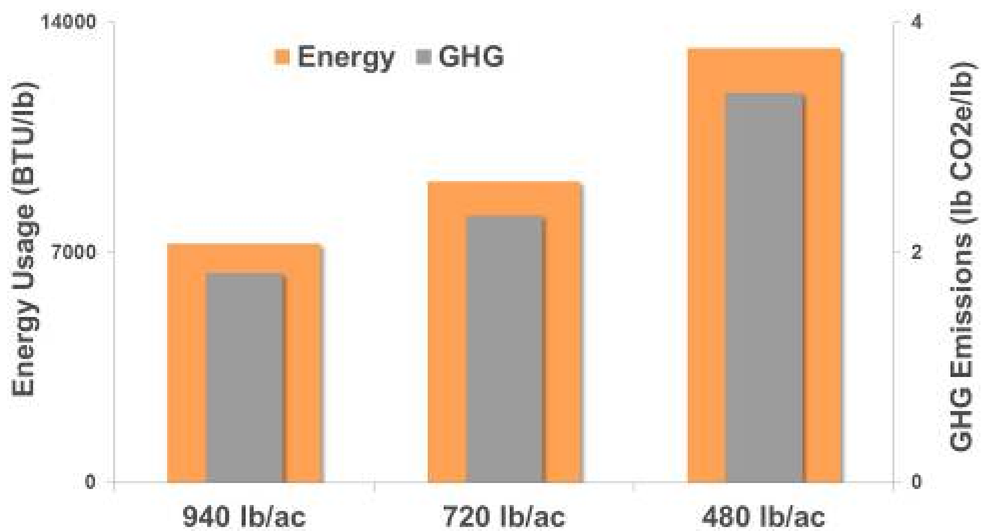

Figure 3. Energy use (BTU/lb) and greenhouse gas emissions (lb CO_2e/lb) for different yield scenarios on the same field.

Fertilizer

By using VRA of P and K, the production in this field used 1100 BTU/lb lint less energy and emitted 0.194 lb CO_2e/lb lint less greenhouse gas than the traditional blanket rate (Figure 4).

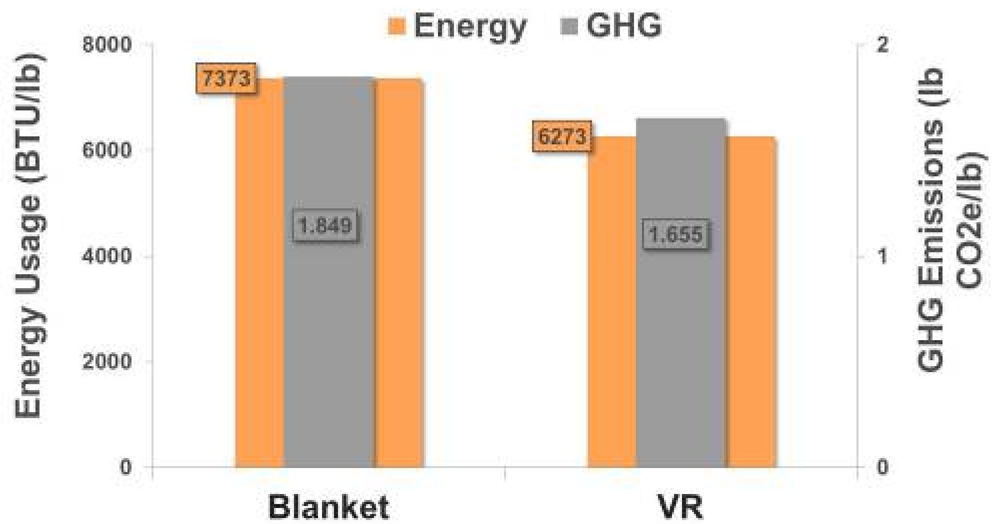

Figure 4. Energy use (BTU/lb) and greenhouse gas emissions (lb CO_2e/lb) for a blanket rate and a VR scenario for the same field.

This reduction in energy use and greenhouse gas emissions can also be seen in the spidergrams for the two scenarios (Figure 5).

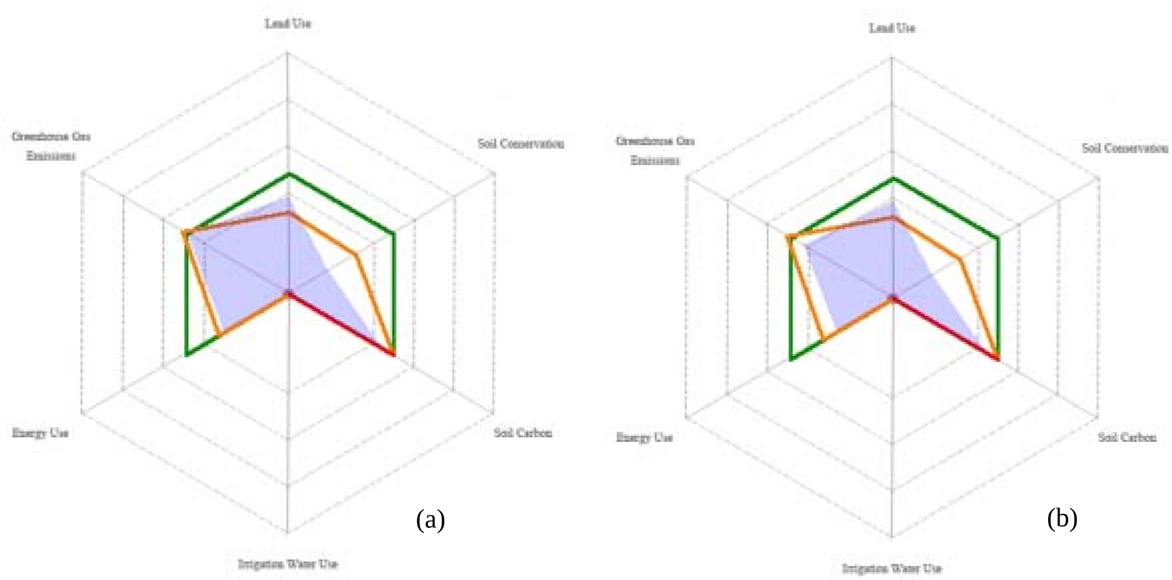

Figure 5. Spidergram for the (a) blanket rate scenario and (b) VR scenario.

On this field alone, the producer saved nearly $25/ac in fertilizer costs and reduced the amount of P_2O_5 applied by over 350 lbs. Approximately 850 acres covering 24 fields from 2011 were analyzed in the calculator for this producer. By site-specific soil sampling and switching to VRA of P and K fertilizer, the producer reduced:

- greenhouse gas emissions by 124,000 lb CO2e
- energy usage by 650 million BTU
- the amount of P_2O_5 applied by 7 tons and
- input costs by $25,000

Irrigation

By irrigating, the production in this field resulted in 2837 BTU/lb lint less energy used and 0.28 lb CO2e/lb lint less greenhouse gas emitted than if it had not been irrigated (Figure 6). Again, this is because the irrigated field yielded 1125 lb/ac, while the hypothetical dryland situation was assumed to yield 750 lb/ac as discussed in the materials and methods. From this example, the conclusion can be drawn that as long as irrigation is used to optimize yields, it can potentially be a more sustainable practice in terms of energy usage and greenhouse gas emissions than dryland cotton.

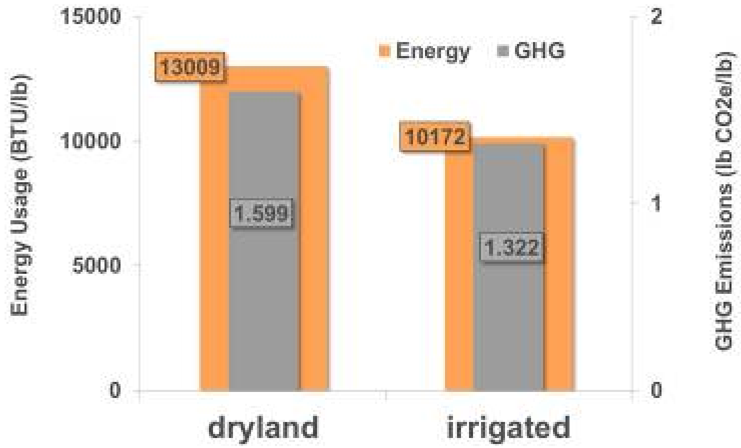

Figure 6. Energy use (BTU/lb) and greenhouse gas emissions (lb CO_2e/lb) for a dryland and an irrigated scenario for the same field.

Summary

By analyzing fields with the Fieldprint Calculator, sustainability of production systems can be quantified. Because the Calculator defines its metrics on a per unit of crop produced basis, it can be demonstrated that practices (such as irrigation) that are generally considered energy-intensive, expensive, and/or having negative impacts on the environment can actually be used in a sustainable manner. Adopting precision agriculture technologies such as site-specific soil sampling and variable rate application of fertilizer also has the potential to reduce the 'Fieldprint' from cotton production systems. Using the Fieldprint Calculator to quantify how changes in management practices influence production sustainability will provide the cotton industry with the necessary information to demonstrate to producers that being sustainable and reducing their 'Fieldprints' can not only increase their profitability, but also reduce the impacts from agriculture on the environment.