INFLUENCE OF PRECISION AG ON COTTON SUSTAINABILITY

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Abstract

As the world population is growing exponentially and agriculture faces more environmental regulations, sustainability is going to be vital to cotton production systems. The term sustainability not only includes reducing environmental impacts, but also has economic and social goals. One path for agriculture to become more sustainable is by adopting nutrient stewardship practices to reduce the amount of nutrients entering and polluting our surface and groundwater resources. Precision agriculture technologies can be used to apply fertilizer where it is needed on a site-specific basis and at the right rates. While adopting site-specific soil sampling and variable rate application (VRA) technologies is an investment to producers, these precision agriculture technologies have the potential to make cotton production more sustainable through optimizing yields and reducing nutrient inputs, both of which increase profitability. One tool that can be used to promote precision agriculture technologies and demonstrate sustainability of implementing different management practices is the Field to Market Fieldprint Calculator. 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 that have adopted precision agriculture technologies have been analyzed using the Fieldprint Calculator. It was determined that utilizing 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 waterbodies. 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 generation's 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 fiber demands. The United Nations has estimated that the global population will increase by more than 2 billion people by 2050 and that agricultural production will have to double without an expanding land base. Another challenge agriculture is currently facing is environmental regulatory pressures, with certain groups pushing for regulations or bans on nutrient applications. By increasing the sustainability of agricultural production systems, yields can be maximized while environmental impacts can be reduced.

The 4R Nutrient Stewardship campaign was launched to promote sustainable practices regarding fertilizer application (The Fertilizer Institute, 2012). The 4R's refer to applying the right nutrient source, at the right rate, at the right time, and at the right place. Producers should consider all nutrient sources, including commercial fertilizers, manures and biosolids, and enhanced efficiency forms of fertilizers and choose the source(s) that are best suited to the particular crop and field. By applying only the nutrients that the crop needs and by considering incorporation of the nutrient product, the amount of excess nutrients moving off-site can be reduced. Nutrients should be available when the crop needs them, so application timing is very important. Soil conservation practices should be used to reduce erosion, thus reducing pollution by limiting the amount of soil-bound phosphorus from entering water bodies.

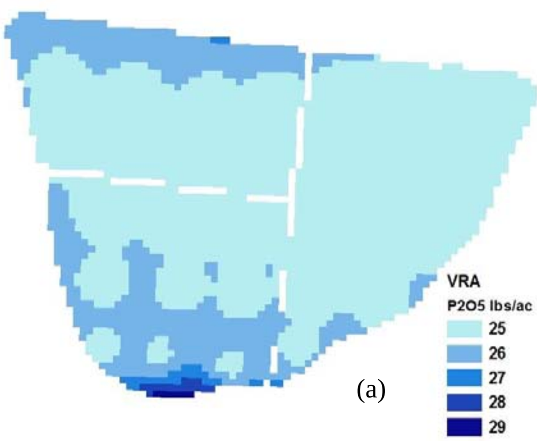
The Keystone Alliance for Sustainable Agriculture joins various food companies, agribusinesses, producers, commodity groups, and conservation programs to provide leadership, scientific information, and collaboration on improvements that can be made in crop productivity, environmental quality, and human 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 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 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 CO2e 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. Data from Tennessee cotton producers that utilize precision agriculture technologies was analyzed using the Calculator.

Materials and Methods

Using 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. For a particular field using VRA of fertilizer, data was entered into the Fieldprint Calculator as the VR scenario. The average rate used was determined from the VRA prescription map. A duplicate scenario was then created with all of the original data, but the fertilizer rates were changed to reflect the blanket rates the producer had traditionally applied before adopting VRA. Thus, there are two scenarios for each field: the current VR scenario and the traditional blanket rate scenario. The results from both of these scenarios can then be compared and any changes in sustainability can be attributed to VRA of the fertilizers.

Variable Rate P and K

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/ac P_2O_5 and 90 lbs/ac 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) and K_2O (51 lbs). 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.



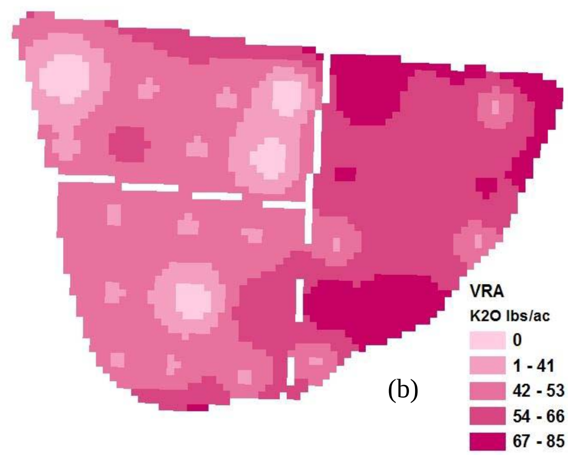


Figure 1. Prescription maps for (a) P2O5 with average rate of 25 lbs/ac and (b) K2O with an average rate of 51 lbs/ac.

For this producer, about 850 acres were analyzed using the Fieldprint Calculator. 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. Data was combined to give a whole farm analysis.

Variable Rate N

Two years of data from a 92 acre cotton field in West Tennessee was used for analysis of fertilizer application methods. Traditionally, this producer applied a blanket rate of 120 lbs/ac N and 30 lbs/ac of P_2O_5. The producer began using zone management as a site-specific soil sampling regime and chose to use VRA of N and to reduce his

P and K inputs. An average N application rate based on acreage was calculated from the prescription maps (Figure 2) in both 2011 (104 lbs/ac) and 2012 (71 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 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.

(a)

(b)

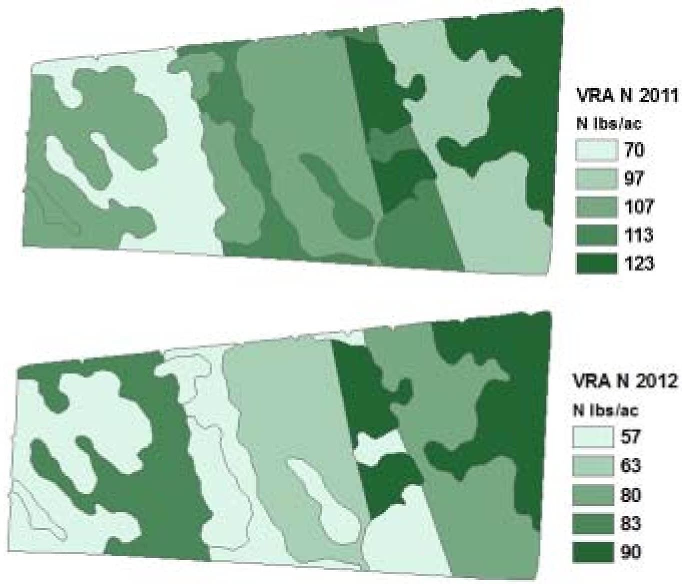


Figure 2. VR N prescription maps for (a) 2011 and (b) 2012.

For this producer, about 500 acres in 2011 and 2012 were analyzed using the Fieldprint Calculator. 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. Data was combined to give a whole farm analysis.

Results and Discussion

Variable Rate P and K

By using VRA of P and K, the production in this field resulted in 1100 BTU/lb lint less energy used and 0.194 lb CO2e/lb lint less greenhouse gas emitted than the traditional blanket rate (Figure 3).

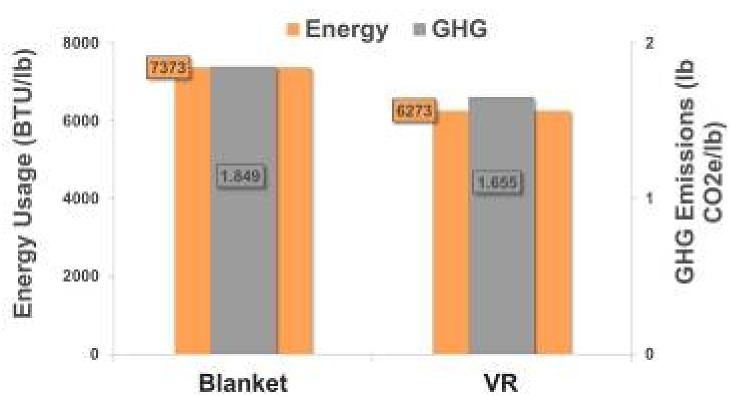
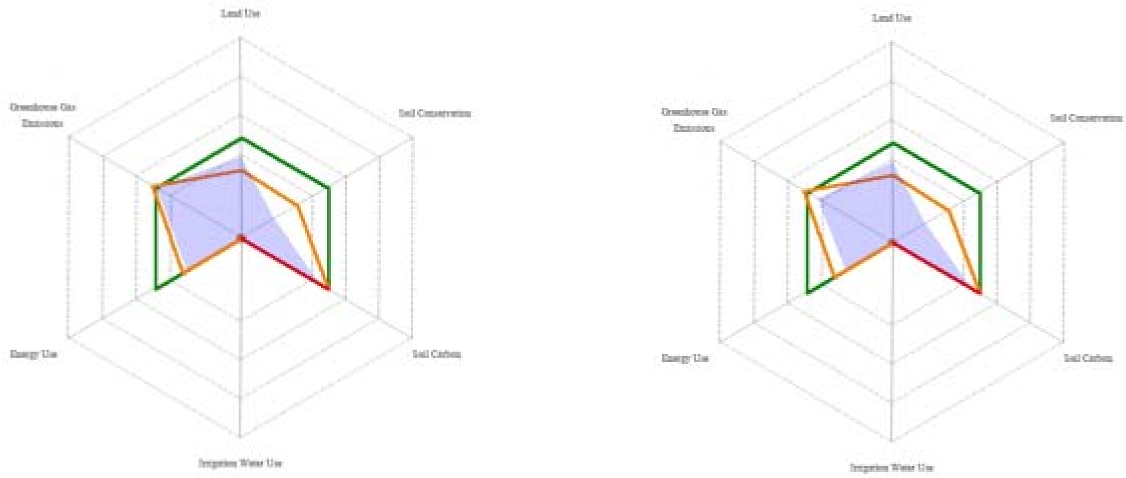


Figure 3. Energy use (BTU/lb) and greenhouse gas emissions (lb CO2e/lb) for a blanket rate and a VR scenario for the same field.

This reduction can also be seen in the spidergrams for the two scenarios (Figure 4).



(a) (b)

Figure 3. 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

<u>Variable Rate N</u>
By using VRA of N and reducing the amount of P and K applied, the production in this field used 4091 BTU/lb lint less energy and emitted 0.444 lb CO2e/lb lint less greenhouse gas than the traditional blanket rates in 2011 (Figure 5).

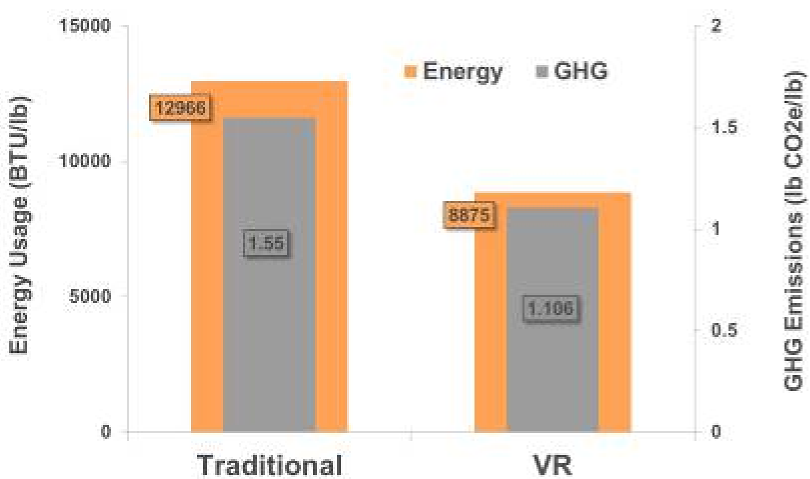
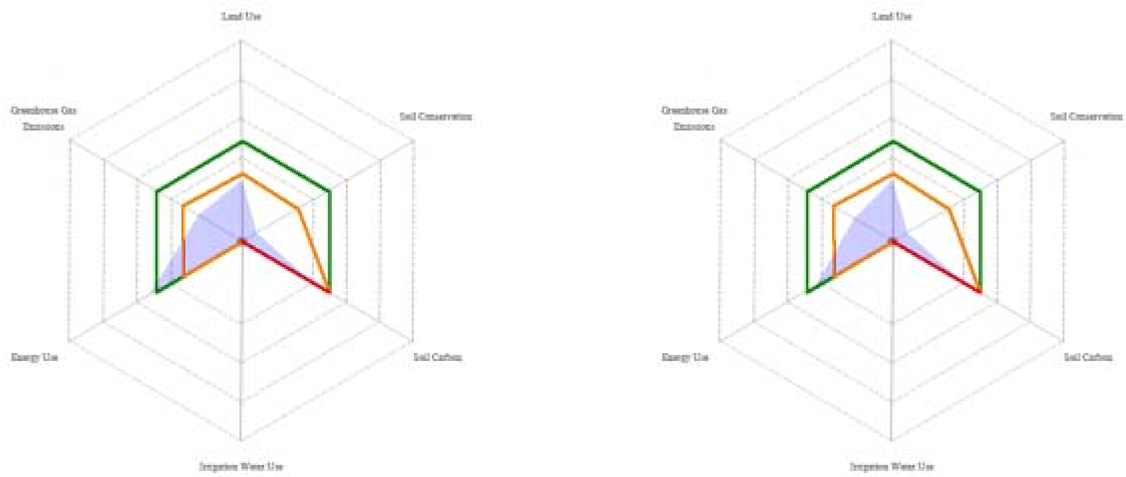


Figure 4. Energy use (BTU/lb) and greenhouse gas emissions (lb CO2e/lb) for traditional rates and a VR scenario for the same field.

This reduction in energy use and greenhouse gas emissions can also be seen in the spidergrams for the two scenarios (Figure 6).



(a) (b)

Figure 5. Spidergram for the (a) traditional rates scenario and (b) VR scenario.

On this field alone, the producer saved around \$50/ac/yr in fertilizer costs and in two years reduced the amount of N applied by almost 3 tons and P_2O_5 applied by around 2 tons. Approximately 500 acres covering 5 fields in 2011 and 2012 were analyzed in the calculator for this producer. By site-specific soil sampling and switching to VRA of N and reducing the amount of P and K fertilizer, the producer reduced:

- greenhouse gas emissions by 425,000 lb CO2e
- energy usage by 4.2 billion BTU
- the amount of N applied by 19 tons
- the amount of P_2O_5 applied by 15 tons and
- input costs by \$60,000

Summary

In order to meet our food and fiber demand while reducing environmental impacts, producers need to be reconsidering management strategies they have traditionally used. Nutrient management is one area that could strongly influence reduction of nutrients moving off-site, optimizing yields, and profitability. Site-specific soil sampling is possibly the most simple, yet beneficial precision agriculture management strategy. It provides information on the spatial variability within a field, which can then be addressed by technologies such as VRA of input products.

By analyzing fields with the Fieldprint Calculator, sustainability of production systems can be quantified. Because the Calculator defines it's metrics on a per unit of crop produced basis, it can be demonstrated that practices 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.

References

The Fertilizer Institute. 2012. Nutrient Stewardship: The Fertilizer Institute, International Plant Nutrition Institute, Canadian Fertilizer Institute, and International Fertilizer Industry Association. Available at: http://www.nutrientstewardship.com/. Accessed November 2012.