Abstract

Sustainability of agricultural production is an important issue with regard to the marketing of agricultural products in today’s world. Recently, numerous companies and organizations within the Keystone Alliance for Sustainable Agriculture began efforts to encourage sustainable practices in crop production. The Fieldprint Calculator is a tool—designed by Field to Market, the Keystone Alliance for Sustainable Agriculture—that computes the sustainability levels of a producer’s operations and aids in evaluating potential changes that may improve sustainability in the future. The objective of this study was to analyze the Fieldprint Calculator’s data output for fields in the Texas Cotton Pilot program sponsored by the National Cotton Council on sites in the Texas Alliance for Water Conservation project in the Texas High Plains region. A sustainability index was created from the data, and the sites were evaluated by producer across a time period of five years, 2007 – 2011. Analysis indicated that the method of irrigation appears to be an important factor in sustainability, and the level of output is important in the calculations of four of the calculator’s sustainability metrics. Further studies should determine the relevance of some of the calculator’s metrics to different regions and determine the producers’ profitability relative to sustainability.

Background

The sustainability of agricultural production has become an important issue for a diverse group of stakeholders in agriculture. These stakeholders represent agricultural producers, processors, marketing agents, food and fiber companies, retailers, commodity organizations, agricultural input suppliers and manufacturers, conservation organizations, and universities. The Fieldprint Calculator is a tool designed by Field to Market, the Keystone Alliance for Sustainable Agriculture, that aids in encouraging sustainable production practices by allowing producers to evaluate their sustainability metrics, determine the sustainability level of their farming practices, and evaluate changes that may improve sustainability in the future. The National Cotton Council (NCC), as a member of the Keystone Alliance, initiated two projects, in Louisiana and Texas, to evaluate the Fieldprint Calculator in measuring economic and environmental production metrics. The sustainability footprint generated by the Fieldprint Calculator is based on seven metrics—land use, irrigation water use, energy use, greenhouse gas emissions, soil conservation, soil carbon, and water quality—which are used to determine areas that are efficient or need improvement to produce at the highest level of sustainability possible. The NCC partnered with the Texas Alliance for Water Conservation (TAWC) project in the Texas High Plains region to evaluate cotton production fields using data over the period 2007 – 2011.

Methods

The TAWC is an on-farm demonstration project that compares crop production practices, technologies, and systems with the goal of improving water management to increase water use efficiency and maintain or increase profitability. Project sites represent field level, commercial production managed by cooperating producers located in Hale and Floyd counties of Texas. Extensive data was collected on each site, including tillage practices, fertilization, pest control, irrigation, growth regulators, harvest aids, and output. This data is available for the five year period, 2007 – 2011. For this study, a total of 22 grower sites were evaluated, consisting of approximately 6000 planted acres of cotton representing 107 observations. If a site had multiple fields, the fields were considered observations and combined to give an average for the site. Farming operations included practices from no-till to conventional tillage, and irrigation methods used were subsurface drip, center pivot, or furrow. The availability of five years of input and
production data allowed for the comparison of the sustainability profile for specific fields across time. For this analysis, only observations from irrigated fields that were harvested were used to compare the sustainability effects of different production practices.

The Fieldprint Calculator was used to evaluate each observation representing a given site for each year the site was in cotton production. The Fieldprint Calculator computes seven metrics: land use (ac/lb), irrigation water use (in/lb), energy use (gal of diesel/lb), greenhouse gas emissions (lb of CO₂/lb), soil conservation (tons of soil loss as % of T), soil carbon index, and water quality index. Figure 1 is an example of the spider-web graph that the Fieldprint Calculator generates to represent a producer’s sustainability “footprint” and shows the effect each metric has on sustainability for a particular field in a given year. The graph displays a blue area representing the individual producer, and the green, orange, and red lines represent the national, state, and county averages, respectively.

The Fieldprint Calculator expresses cotton yield on a lint equivalent basis. Cotton is a commodity with joint products, lint and seed, therefore, the calculator expresses seed yield in terms of lint yield based on percent revenue from each product and combines this equivalent yield with the actual lint yield to calculate the lint equivalent yield (LEY). Many of the calculations for the sustainability metrics within the Fieldprint Calculator are given on a per pound of LEY basis.

When computing the sustainability metrics, the Fieldprint Calculator expresses the metrics as a per unit of output measurement rather than a per acre measurement. Land use and irrigation water use are measured as acres per pound of LEY and inches per pound of LEY, respectively. Energy use is expressed in two forms, BTUs per pound of LEY and gallons of diesel equivalent per pound of LEY (only gallons of diesel per pound of LEY are used in this analysis). Greenhouse gas emission (GHG) is measured as pounds of CO₂ per pound of LEY. The soil conservation metric is expressed as soil erosion as a percent of the soil loss T-value. Simply stated, the soil loss T-value is the “tolerable erosion,” meaning it is the amount of soil that a particular soil type can lose through a combination of wind and water erosion in a given year and maintain productivity. For the soil carbon and water quality, the calculator produces an index of measurement.

The sustainability metrics are expressed such that the smaller the value the more sustainable the production practices. Therefore, the goal for producers is to shrink each field’s “footprint.” In order to compare sites in this study for various production practices, an index was constructed for each sustainability metric based on the mean value of the metric for all observations. For example, the land use metric is expressed as acres per pound of LEY. An index value for each individual observation was constructed by dividing by the average of acres per pound of LEY for all observations and multiplying by 100. An overall index, that includes all metrics, was constructed for each observation by calculating the average of the metric index values; therefore, each metric was given equal weight in the overall index. The smaller the overall index value the smaller the field’s sustainability “footprint.” The water quality index was not considered in this study.

Results/Discussion

Figure 2 shows the sustainability metric indices for each of the 22 sites evaluated. These results show that for some sites there is considerable variation in the level of the various sustainability metrics. Figure 3 shows the overall index value of the sustainability metrics for each site. Eight sites were above the base value of 100 and 14 sites were below the base value. Of the sites above the base value, four sites were more than 10 index points above the base value, and four sites were between one and eight index points above the base value.

A comparison was made between three sites, A, N, and P, representing center pivot, furrow, and subsurface drip irrigation methods, respectively. These sites were chosen because they had multiple observations across the five years, and a similar soil type, Pullman clay loam. The significant difference between the sites is the irrigation method.
Figure 2. Values of sustainability metric indices for each site.

Figure 3. Average overall sustainability index for each site.
Site A has a center pivot system using the LEPA method of irrigation. There were seven observations over the five years, 2007 – 2011, from two fields. The average LEY was 1317 lbs/ac and the average irrigation rate was 10.5 in/ac. The overall average sustainability index value was 93.6. Figure 4 shows the average index values of the various metrics for Site A. Land use and GHG emissions were the only metrics above the base value.

Site N was furrow irrigated and had 12 observations over the five years, 2007 – 2011, from three fields. The average LEY was 1185 lbs/ac and the average irrigation rate was 15.0 in/ac. The overall average sustainability index value was 125.3. Figure 5 shows the average index values of the various metrics for Site N. Four of the six sustainability metrics were above the base value—land use, irrigation water use, energy use, and GHG emissions.
Site P was irrigated using subsurface drip and had five observations over the five years, 2007 – 2011, from one field. The average LEY was 2037 lbs/ac and the average irrigation rate was 19.0 in/ac. The overall average sustainability index value was 85.6. Figure 6 shows the average index values of the various metrics for Site P. All sustainability metrics were below the base value. When looking at the average sustainability index of these three sites, site P overall had a smaller index value than sites A and N.

![Figure 6. Sustainability metrics index values for Site P.](image)

The level of output is an important factor in the calculation of four of the seven Fieldprint Calculator metrics: land use, irrigation water use, energy use, and GHG emissions. This means that the higher the output relative to the metric, the more sustainable the field is going to appear.

Figures 7 through 9 show the annual index values for sites A, N and P, respectively. A comparison of the annual indices of the four metrics for each of the sites may show a trend in a particular metric over time. The metrics for Site A (Figure 7) and Site P (Figure 9) were relatively stable across years with the exception of 2011 which was an extreme drought year. However for Site N (Figure 8) the metrics steadily increased from 2008 – 2011. These sites represent center pivot, subsurface drip, and furrow irrigation systems, thus implying, the method of irrigation may have had an impact on the overall sustainability. However, this impact is related to the level of output, given that these four metrics are expressed in terms of output. This can be seen for the 2011 year when drought lowered yields; thus, the metric values increased significantly. Also seen in Figures 7 through 9 is a high correlation between energy use and GHG emissions. Energy use and GHG emissions result mainly from energy used in tillage operations, irrigation, and the manufacture of fertilizers and chemicals.
Figure 7. Annual metric indices for Site A.

Figure 8. Annual metric indices for Site N.
The Fieldprint Calculator computes the soil conservation metric based on estimated soil erosion from water; however, in the Texas High Plains region wind erosion is the main source of soil erosion. The index calculated in this study expressed the estimated soil erosion as a percent of the tolerable soil loss (T-value) for a given soil type; however, given that wind erosion was not included, the value for the soil conservation metric may be underestimated. The soil carbon index is the estimated change in soil carbon based on the crop produced and the tillage practices used.

**Conclusion/Comments**

The objectives of this study were to understand the metrics produced by the Fieldprint Calculator and how these related to cotton production in the Texas High Plains region. Indices of the various sustainability metrics were constructed to allow for comparison of certain production practices across 22 field level sites. The results indicate that the method of irrigation appears to be a factor in sustainability and the level of output is important in the calculations of several of the metrics.

This study provided an indication of the level and variability of the metrics from the Fieldprint Calculator for the Texas High Plains region. There was an indication that irrigation methods may influence the level of certain metrics. In particular, the furrow irrigated site had an overall greater sustainability “footprint” compared to the center pivot and subsurface drip sites.

Future studies should address whether particular metrics, such as the water quality metric, are relevant to this region. The soil conservation metric needs to consider wind erosion to fully capture the effects of erosion in the region. Analysis of the weighting of the metrics in the overall index should be considered. In this study the mean value of each metric was used as the base level of the index. However, the index could be constructed on a fixed value that is feasible for the region. Also, it is important to determine and compare profitability relative to sustainability.