SUSTAINABILITY IN UW SPECIALTY CROP PRODUCTION

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Agricultural sustainability means different things to different people. In reality, it is only in hindsight that we can know what is actually sustainable. How can anyone really know how we should farm today to ensure that we will be able to still be farming 100 or more years from now? Differences in strategies for dealing with this uncertainty are at the root of much of the debate and disagreement surrounding agricultural sustainability. Here we are not going to overview or summarize this debate and some of the main strategies, but rather focus on results – what have we accomplished at UW and in Wisconsin for research and related activities. First, we briefly describe the conceptual framework we use for agricultural sustainability assessment. Second, we present specific results for Wisconsin potato growers and Midwestern processing green bean and sweet corn growers. Finally, we overview some research in progress.

Conceptual Framework for a Practical Agricultural Sustainability Program

This framework was developed based on the experiences of the authors and multiple stakeholders with Healthy Grown® and agricultural sustainability programs over the years, based on numerous discussions and debates among many stakeholders in a variety of contexts; we are merely the summarizers of this collective knowledge, not the originators.

First and foremost, farmers prefer a grass-roots approach that actively engages them in the design and management of an agricultural sustainability program. Farmers bear the brunt of the economic outcomes of their sustainability choices, plus many of the environmental and social outcomes on their farms and in their communities, and so should be an integral part of program design. Their active participation and leadership helps ensure a practical program that is balanced among the three components of sustainability and that can be reasonably implemented by a large portion of growers. Furthermore, farmers generally want a practice-based approach to agricultural sustainability because it is consistent with many other agricultural programs, but the practices to be adopted must be science-based with demonstrated benefits. As a result, this approach requires scientific experts and farmers to collaborate to ensure that practices are both practical and enhance sustainability.

Farmer effort to satisfy value-chain sustainability requirements will be consistent with the value they realize. Existing sustainability programs are generally cost centers for farmers – they are expected to complete assessment paperwork as a cost of doing business or for market access. Thus farmers want a cost-effective sustainability program. Because most farmers sell to multiple buyers and grow multiple crops, they also want a harmonized

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program that is acceptable to the entire food supply chain and uses a whole-farm approach. A harmonized whole-farm approach will improve the efficiency of assessment, as much of the information needed is often similar, regardless of the crops or market. Most farmers also want a program that incorporates the non-crop lands on their farms that they manage and that generate important sustainability benefits, an aspect missing from crop-oriented sustainability assessments.

Farmers also desire a program that is regionally appropriate and flexible, so that it can adapt to changing technology and a rapidly evolving marketplace. Most farmers are also uncomfortable reporting detailed information about their operations to corporations, government agencies, or other third parties. Their concerns include maintaining personal privacy and confidential business information regarding methods of production, costs, and profits. They do not want their information used against them by the media or various activists, or by corporations to extract gain. Farmers want a sustainability program to collect only necessary data and to maintain confidentiality. Also, farmers desire a program that enhances communication with the supply chain and consumers, so that the general public becomes more aware of their long-term commitment to sustainability and their stewardship accomplishments. Finally, farmers want a program that is educational, not a program that tells then to adopt certain practices or achieve certain outputs with no explanation as to why these are desirable.

Over the years, several people in Wisconsin and the region have devoted a lot of energy and effort to develop a program to satisfy these requirements. Potatoes and processing vegetables have been the focus of a lot of this effort, as have cranberries and soybeans. The process of developing a practical agricultural sustainability program begins with forming a leadership team that includes farmers, as well as university faculty and private crop consultants, and representatives from the value chain (processors, distributors, handlers, and retailers), plus government agencies and NGOs. The team identifies overall goals and desired outcomes for the sustainability program and then acquires and allocates resources to begin developing and implementing the program. These steps should be known to those familiar with the development and establishment of the Healthy Grown® program.

The process begins with the working group taking sustainability priorities and outcomes that are general and national in scope and regionalizing them by identifying specific practices appropriate to local production systems that are both practical to adopt and will help achieve the more general national goals. The output created is a regionally-appropriate self-assessment tool of science-based practices with demonstrated sustainability benefits that are relevant to farmers – in other words, a list of good farming practices for that region and cropping system.

The farmer association then works with individual farmers to measure their practice adoption based on this self-assessment tool. These self-assessment data are pooled over all farmer members and analyzed to establish a best-practices frontier in order to evaluate how the farmer members are doing as a group. Next, the farmer association uses the population

summary of these data to identify practices to target for outreach and education for its members and to determine knowledge gaps that need further research. The association then implements these plans, which may include helping farmers change plans and integrate new practices into their operations. Finally, the cycle returns to its beginning as the leadership team re-evaluates the self-assessment tool, the data collection and analysis, and the effectiveness of outreach and research, potentially updating or adjusting any of these in order to improve the overall program.

From the perspective of a farmer, you fill out a quick on-line survey of the practices you use on your farm, then receive personalized feedback on how the practices you use compare to the practice your fellow farmers use, with specific practices identified that you could adopt to improve and become more like the "best" farmers in your state or region. These comparisons and recommendations are delivered to farmers using a personalized scorecard with a sustainability dashboard. Key to being effective is the creation of a self-assessment tool that makes sense to the farmer members and getting good participation in the data collection, hence the focus on farmer engagement and maintaining data anonymity and confidentiality. Peer-pressure is used in a positive way and combined with education to encourage adoption of good farming practices. In simple terms, this program is a way for a grower association and an industry to operationalize continuous improvement – a process to identify where they need to improve both individually and as a group and a way to help make positive changes happen.

Data Analysis

The practice adoption data from the sustainability self-assessment are analyzed using innovative algorithms developed at UW. The raw adoption data from the self-assessments are first pre-processed using non-negative, polychoric principal component analysis, a mathematical process that reduces the number of variables, makes them continuous, and removes correlation among them. Next, common-weight data envelope analysis is used to generate individual farmer sustainability scores – a number between 0 and 1 that indicates how intensely each farmer adopts the good farming practices in the self-assessment relative to his peers. The process determines a weight or "points" for each practice in the original self-assessment, with the weights depending on the adoption profile of all the farms in the assessment. The process generates two main types of output. First is the distribution of sustainability scores for farms, showing how intensely the group of farms adopts the good farming practices in the original self-assessment. Second is a personalized grower scorecard that shows how each farmer compares to his peers in the different aspects of sustainability (sustainability dashboard), with specific recommendations of practices the grower can adopt to most improve his score based on the practice weights.

This analysis process was developed specifically for sustainability assessment, so that farmers could measure their current status and document improvement over time. A simple analogy helps make the essence of the process clear. The self-assessment tool is like a "test" with the farmers as "students" with the students/farmers helping to write the test they want to use to assess themselves. The analytical process "grades" this test on a

curve, with best students getting a 1.0 and everyone else graded relative to these top students. The distribution of the scores shows how the "class" does as a whole, while each student's individualize report indicates where they did well and where they need to improve to keep up with the rest of the class.

Wisconsin Potato and Vegetable Results

We have conducted two sustainability self-assessments for Wisconsin's potatoes and processing vegetable growers. These self-assessments were developed in consultation with UW extension and research specialists, crop consultants, processing company field mangers, with farmer leadership from the WPVGA and the Midwest Food Processing Association. In January 2013, 44 green bean growers and 67 sweet corn growers from Wisconsin, Minnesota and Illinois completed a self-assessment, in total representing about 10% of the planted acres in the region for each crop. In October and November of 2013, 71 Wisconsin potato growers completed a potato self-assessment, representing 90% of the acres in the state. The processing vegetable assessment contained questions about use of almost 180 practices, while the potato assessment asked about use of almost 160 practices.

The focus was to determine farmer use of good management practices with documented positive outcomes, such as integrated pest management, basing nutrient applications on soil and plant tissue tests, and comparable labor and farm business management practices. The specific practices on each assessment are available from the authors. The processing vegetable assessments were collected by farmers completing paper copies, while the potato assessment was completed using a web-based survey tool. Summaries of results based on simple data averages are available online (http://wisconsinpotatoes.com/growing/sustainable-practices/; http://nisa.cals.wisc.edu/wp-content/uploads/2013/11/SCRIreport_2page_FINAL.pdf). For example, 97% of the potato farmers used soil sampling to determine crop nutrient needs, 90% rotate insecticide modes of action to manage pest resistance, and 70% plant winter cover crops, with 87% using living windbreaks.

The potato assessment analyzed all practices at once and only focused on generating a summary of the farmer population. The processing vegetable assessments not only generated a population summary, but also individualized grower scorecards that were sent to the growers anonymously in April 2015. The practices for the processing vegetable assessments were separated into ten different categories (see example scorecard for the list). The 10-20 practices in each sustainability category were then analyzed separately, to give each farm a score for each category, and then data envelope analysis was used over the scores for the ten categories to give a single grand sustainability score for each farm. The figures below show the distribution of the grand scores for the Midwestern sweet corn and green bean growers and the Wisconsin potato growers, and then the example grower scorecard for one random Wisconsin green bean grower and the associated recommended practices for each sustainability category.

Discussion and Interpretation

The average sustainability score was 0.939 for Wisconsin potatoes, 0.905 for Midwestern sweet corn growers, and 0.887 for Midwestern green bean growers, while the respective minimum scores are 0.759, 0.700, and 0.744. These high averages and minimums imply that in general, these potato and vegetable growers are fairly similar in terms of practice adoption and most growers adopted most or many of the practices considered good farming practices. Average growers adopt these good farming practices at a level of about 90% as intense as the best growers among their respective groups, with the lowest only getting to as low as 70%.

The plots of the score distributions show there are some differences among the crops. Many potato growers are tightly clumped at scores near the maximum of 1.0, with only a few growers in the lower tail. Sweet corn scores are similar, but have a smaller clump of scores near the maximum of 1.0 and a thicker distribution for the lower tail. However, scores for green bean growers show little clumping and are fairly evenly distributed between the maximum and minimum. All three of these distributions are rather tight. Similar assessments for Wisconsin cranberry growers and for Wisconsin and Illinois soybean growers (not shown) have lower averages and longer tails, implying that these potato and vegetable growers are more similar in terms of practice adoption.

An advantage of the analytical process used to derive these scores is that it can identify the specific practices that contribute most to farmer scores. The analysis of the potato practice adoption data did not separate practices into categories or develop specific recommendations. However, the five practices with the largest weights in the potato analysis were: (1) following guidelines for nutrient management applications, (2) using insect scouting to determine when to treat, (3) maintaining irrigation and water use records, (4) attending science-based field days and educational meetings to learn about farm, crop, and ecosystem management, and (5) having the ability to trace product from field to the distribution chain. Around 90% of Wisconsin potato farmers completing this assessment use these practices already, so that those farmers with lower scores likely were not using one of more of these practices.

The assessment data for sweet corn and green beans were analyzed in more detail. The figures show the grand scores for the whole farm, but for each of the ten sustainability categories, distributions like below were generated (i.e., 20 plots). This is too much information to digest, and so the "sustainability dashboard" was created. For each sustainability category, the band runs from 0 to 1. The red star and vertical bar indicate the farmer's score, while the darker horizontal bar indicates the score range for the middle half of the farmers (the 25^{th} to the 75^{th} percentile), which we call the industry average range. For example, the farmer has a score in community sustainability just above the average range, with most farmers receiving high scores overall, but over a fairly wide range. On the other hand, for ecosystem restoration sustainability, the farmer has a score just below

the average range, with low scores typical among all farmers, while for production management, the scores are on average higher and fall in a narrow average range.

Another advantage of the grower scorecard is a set of personal practice recommendations – two practices for each sustainability category that the farmer does not use, but if adopted, would most improve his score for that category. These farmer-specific recommendations take more effort to create, but are a key element motivating adoption of new practices to drive continuous improvement in an industry. Grower scorecards were sent to cooperating growers this spring (later than we had hoped) through the Midwest Food Processors Association, so some Wisconsin processing vegetable growers should have received these cards in the mail. We would appreciate any feedback growers may have.

What's Next?

At this time, we have various research papers in progress to get the algorithms published in the peer-reviewed literature as a way to validate the process and develop academic credibility. The only paper published at this time describes the fundamental algorithms, with the application to Wisconsin cranberry farmers. In review is a paper on Wisconsin and Illinois soybeans that shows the impact on the industry score distribution if low-scoring farmers adopt more practices. Another in review describes desirable program characteristics, grower scorecards and the algorithms for doing the analysis using separate categories, using green beans and sweet corn as the empirical example. This was presented at a conference in the Netherlands and in this article. Finally, we have a paper started on the impact of increasing the sustainability score on the optimal cost of production. This paper will be the first attempt to get at the tradeoff between increasing sustainability and economic outcomes. This paper proves that we can conceptually and empirically estimate this tradeoff and we will be seeking funding to collect more data, maybe from Wisconsin potato and vegetable growers! Sustainability is an area of active research for us and we expect more research and outreach to come that will help make a practical agricultural sustainability program a reality for farmers.