Research in agricultural systems occurs on a range of time spans. Some experiments are carried out for a single growing season while others are maintained with little change for decades. Data from short-term experiments are often used to extrapolate the results researchers would expect to see in the future. However, the response of soil properties, yields, and pests can change in unexpected ways.

Long-term research is essential to determine how agricultural systems change over time. Measuring the same data for years, decades, and even centuries can help researchers build accurate models of long-term processes. Discussing several examples of long-term experiments with members of ASA, CSSA, and SSSA reveals common challenges in conducting long-term research and great optimism for these plots to continue.

More than a Century of Data

Some of the longest-running agricultural experiments were established at a time when farmers were fortunate to have animals to pull plows and before the introduction of chemical fertilizers and herbicides. Examples of agricultural experiments running for more than 100 years include the Broadbalk wheat experiment at Rothamsted Research in the United Kingdom, the Morrow Plots in Illinois, and the Old Rotation in Alabama. Although historical in nature, these plots are not museum pieces farmed using historical practices. All exist...
as working trials, which have been updated over time to reflect changing agricultural practices.

The Broadbalk wheat experiment was established in 1843 to compare the use of inorganic fertilizers and manure on wheat crop yields and soil properties. Over time, the wheat cultivars have been changed and plots were split to compare continuous wheat to rotational practices. Some of the treatments have also been changed, such as the inclusion of higher rates of nitrogen fertilizer. But one thing that has remained consistent since 1843 is the subset of plots that do not receive any inputs.

SSSA member David Powlson, a professor and Lawes Trust Senior Fellow at Rothamsted Research, says it is surprising to see wheat growing in plots that have not been fertilized in more than 100 years. Most people would predict “by not adding anything, you should run out [of soil nutrients],” he notes. These plots demonstrate that while yields will indeed drastically decline without input from farmers, there is enough atmospheric deposition of nitrogen to maintain a small crop year after year.

Rothamsted also hosts an archive of plant, fertilizer, and soil samples dating back to the mid-1800s from not only the Broadbalk experiment, but also other long-term experiments managed by the station. These provide researchers an opportunity to test ideas about changes in genetics, soil properties, etc. over time as new hypotheses and methods are developed.

In the late 1800s, some corn and cotton farmers in the United States were observing declines in productivity and topsoil loss, which led researchers to experiment with different farming techniques.

The Morrow Plots on the University of Illinois campus were established in 1876 to compare continuous corn to corn crop rotations. Three of the original 10 plots are maintained today with the cultivars and crop rotations changing over time. For example, the original corn–oat rotation was changed to a corn–soy rotation in 1968, and the three-year rotation of corn–oat–alfalfa has been in place since 1953. The plots also benefit from the use of modern fertilizer and herbicides.

“The three-year rotation [has] maintained far better soil quality and gets much greater yield per unit input—it’s a much more efficient system,” says ASA, CSSA, and SSSA member Michelle Wander, a professor at the University of Illinois Urbana–Champaign. And although the plots lack replication, the observed differences can lead to the development of hypotheses to be tested in other experiments. “I think [the Morrow Plots] can give [researchers ideas] that we can go then and try to drill down and better design and replicate in trials,” Wander says.

In Alabama, an experiment was established in 1896 to try to help farmers sustain cotton production in the Deep South by demonstrating that they could rotate crops and plant a winter cover crop, primarily a legume, to add nitrogen to the soil, says ASA and SSSA member and CCA Charles Mitchell, an Extension Specialist Professor in Crop, Soil, and Environmental Sciences at Auburn University. Referred to as the Old Rotation, these plots are located on the Auburn University campus, which Mitchell points out “is the only place on campus where you can see agronomic crops.”

Similar to the Morrow Plots, the Old Rotation does not have replicate treatments. “You have to realize, this is one of the challenges of long-
Decades of Data

“If you have something that’s 100 years old, it’s pretty hard to step away from it,” notes ASA and SSSA member and CCA and CPAg Charles Shapiro, Professor of Agronomy and Horticulture at the University of Nebraska–Lincoln. But what about a study that has 10 or 20 years of data?

Worldwide, individual researchers, properties, or research groups have maintained experimental plots for decades. Many of these experiments have a robust experimental design, with replication of treatments but lack any guarantee that they will be continued if an individual retires or funding is reduced.

Shapiro has been running an experiment in Nebraska since 1986. Treatments include different tillage and nitrogen treatments for continuous corn and a corn–soybean rotation, and the experiment consists of 240 individual plots.

Although one of the driving questions for this experiment was the impact of tillage, the experiment has also been used to look at how precipitation interacts with cropping systems. “Without a lot of data, it’s hard to predict [the impact of weather],” Shapiro says. “In a three-year project, you could all have wet years, all dry years, or everything in between.”

Having consistency in the experimental treatments allows researchers to determine how weather interacts with different cropping systems.

Shapiro’s data shows that when drought lasts for more than one year, continuous corn performs better than a corn–soybean rotation. He thinks this is the result of “the soybeans drying the soil out more and corn residue capturing more snow in the winter.” Seeing these patterns and developing these hypotheses is something that is made possible by continuously monitoring these plots.

Long-term data sets can also help detect when there is not a difference among treatments over many years. From Shapiro’s work, he has found that there “really hasn’t been, over the long term, any difference in the yields between the low-till 0 N and the plowed 0 N.” While single-year treatments will respond differently depending upon precipitation, Shapiro says, “When you look at the sum total, you’re not seeing much difference.”

Ezra Aberle, a Research Specialist at Carrington Research Extension Center, North Dakota State University, has a similar perspective on how long it takes for crop rotation experiments to mature. “If you’re looking at a crop rotation, you have to go through that rotation probably about three times [before] you can actually discover what their inherent benefits and weaknesses are,” Aberle says.

Aberle, a member of ASA, CSSA, and SSSA, has been at the Carrington center for 14 years, and one of his main duties is to maintain a long-term cropping system study that began in 1987. This 45-ac study consists of three tillage systems, three crop rotations (with seven crops), and five fertility treatments. For Aberle, one of the challenges to managing this experiment is being “certain that we’re managing all the nuances of each system for each crop.”

Establishing Long-term Experiments

Establishing an experiment with the goal of long-term treatments and sampling can be challenging. Long-term funding sources, the responsibility of management and data collection, thinking ahead to how data will be used and how co-authorship will be determined—all of these details and more need to be considered.

Wander and some of her colleagues at the University of Illinois went through this recently as they worked together to establish a new agroforestry experiment. “Designing it in a team and the whole long-term thing, it really was a tremendous learning [experience],” Wander says. The project is a student-driven idea that focuses on food-producing species, including hazelnut and chestnut, and was supported by an interdisciplinary faculty team. Given the use of trees, it will take years for the project to become established, which required the group to design a plan for the future, not just a short-term experiment.
Another example of a recently established study with long-term goals comes from Minnesota. The project in Minnesota has established plots at three locations across the state, all with same treatments and data collection to ensure the compatibility of data. “The idea with those is that we have precipitation and temperature gradients, and we really have three different soil types that we’re working on,” says ASA and SSSA member Jeffrey Strock, a professor at the University of Minnesota who was involved in the project. “Establishing new [long-term experiments] takes a huge amount of effort and thought put into data management and plot management.”

“The problems that we get into are changing technology over time and how you manage a long-term experiment to take into account the effect of changing culture and knowledge, and yet have some consistency throughout the life of the project,” Shapiro says. When establishing a new experiment, researcher leaders cannot anticipate all of the future scenarios but can develop a process and guidelines to aid in future decision making.

New Opportunities in Old Plots

Long-term experiments are not necessarily limited in what data can be collected from them. Powlson says he sees the long-term plots at Rothamsted as a resource to be used, much like “a shared piece of equipment, which is useful to many people.” Similarly, Aberle sees opportunities at Carrington where there is potential for, “collaboration with people who have the expertise to come and utilize the study to quantify what they want to quantify.”

Another approach could be making comparisons across a geographic range or cropping system. Strock says, “I would think that in many places, there are controlled plots or there are plots of similar treatment and behavior that could be compared.” He also suggests long-term experiments are places where scientists from different disciplines can work together and evaluate the system as a whole. Studying soils, crops, weeds, insects, climate, and other variables in the same long-term plots could provide a comprehensive data set to look for linkages among response variables.

There is also a historical value to long-term research experiments. In discussing the changes in the Morrow Plots, Wander says, “It’s really a wonderful story about what we’re thinking in agronomy. The splits reflect changes in our thinking and our assumptions and our perspectives about what’s going on. They really mark changes in production ag paradigms . . . and are a really good record of us.”

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Further Reading

Read more about this topic in the 2013 CSA News magazine article on the Long Term Agroecosystem Research (LTAR) Network. See http://bit.ly/2gA90sV.