Farmer Joe Dan Luck reviews yield monitor settings. Photo courtesy of Joe David Luck.

Yield Monitoring for Profitability Mapping, On-Farm Research, and Precision Conservation

By Joy Drohan

Yield-monitoring data can figure in consequential decisions that make a difference in the farm's bottom line. Nowadays, most harvesters are equipped with yield-monitoring technology. Some farmers are using yield maps to develop variable-rate seeding and nutrient prescriptions while others have been reluctant to use the technology. This article will discuss using yield data for on-farm decisions, calibrating yield monitors, and cleaning, managing, and standardizing data. This article focuses primarily on corn and soybean grown in the Midwest. But yield monitors are also used in harvesting other grain crops and are standard on new cotton pickers and sugarcane harvesters, so this discussion also applies to those crops. Earn 1.5 CEUs in Crop Management by reading the article and taking the quiz at https://web.sciencesocieties.org/Learning-Center/Courses.

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Yield-monitoring data can figure in consequential decisions that make a difference in the farm's bottom line. The University of Nebraska On-Farm Research Network is using yield-monitoring data to determine the economic optimum nitrogen rate in different parts of the field and collecting valuable information about how much that varies. "I think that's taking yield-monitoring capabilities to the next level," says Laura Thompson, extension educator and director of the network.

Nowadays, most harvesters are equipped with yield-monitoring technology. Some farmers are using yield maps to develop variable-rate seeding and nutrient prescriptions while others have been reluctant to use the technology. They may see calibration as difficult and time consuming. Maybe they've done things a certain way for years, and they're reluctant to change. Many farmers have been collecting yield data and other data layers for years, but they lack the technological know-how to put that data to use.

Nevertheless, the number of farmers gathering high quality yield monitor data and using it to inform on-farm decisions is growing, especially in the Midwest. Many of them hire a CCA or another consultant to help them put yield data to work.

Analyzed with other data from the growing season, yield monitor data can help, among other things:

- **create profitability maps, identifying areas that aren't returning on their investment**
- **with on-farm research to determine how agronomic practices, products, or hybrids affect yield**
- **increase fertilizer efficiency to reduce costs and environmental impacts**
- **assess the impact of planting date and harvest date on yield**

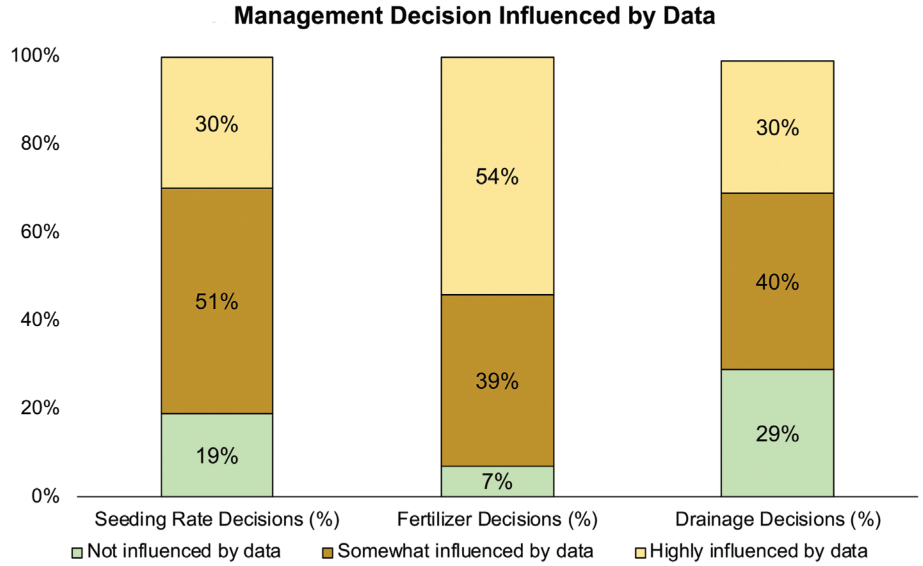

Figure 1. The extent to which different farm management decisions are influenced by data, as calculated in a Purdue University survey. Image courtesy of Nathan Delay, Purdue Center for Commercial Agriculture.

This article focuses primarily on corn and soybean grown in the Midwest. But yield monitors are also used in harvesting other grain crops and are standard on new cotton pickers and sugarcane harvesters, so this discussion also applies to those crops.

Taking Yield Monitor Data to the Next Level

In 2017, Purdue University researchers surveyed representatives of 800 large (>1,000 ac) corn and soybean farms about their collection, analysis, and use of farm data. Ninety-three percent of respondents reported that their fertilizer decisions were "somewhat" or "highly" influenced by data (Figure 1). Eighty-one percent of respondents said their seeding rates were at least somewhat influenced by data. On smaller farms, effective data usage is undoubtedly lower.

More farmers could take on-farm decision-making to the next level by analyzing yield data with other growing season data. "There are more benefits to that data than what a lot of farmers have used it for," says Nathan Mueller, CCA and water and integrated cropping systems extension educator at the University of Nebraska (NU).

Ryan Lee grows corn and soybeans on about 2,800 acres in west-central Ohio with his brother and father. When he first started yield monitoring in 1998, he planned to analyze the data himself over the winter. That didn't happen. In about 2007, he started working with a consultant from Integrated Ag Services, Inc., and they've written variable-rate seeding and nutrient prescriptions for him since then.

"I think producers are really starting to recognize the value of having an independent agronomist if they're going to be paying for agronomic services," says Brunel Sabourin, owner and lead agronomist at Antara Agronomy Services Ltd., St Jean-Baptiste, Manitoba. "We're working with producers who want us to help them become more efficient

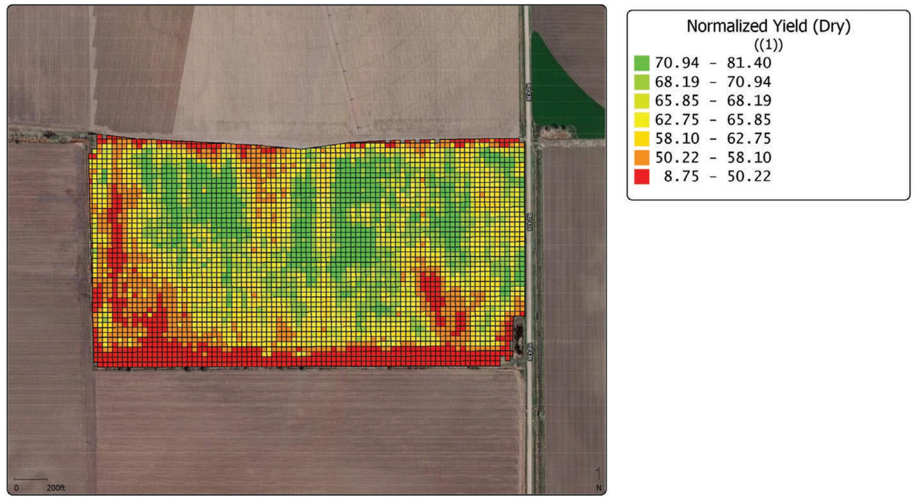

Figure 2. Normalized corn yields since 2008 for a field on the farm of Don Batie, owner of Batie Cattle Company in south-central Nebraska. "Normalized" means that the best yield in each year gets a 100, even if the actual yields are different. This is a way of showing the relative productivity throughout the field across years. Image courtesy of the Nebraska On-Farm Research Network.

and more profitable. As margins get thinner and the prices of inputs go up, there's more interest in doing more with what we have and getting more out of our land, or more production in a more sustainable fashion."

How Can Growers Use Yield Data for On-Farm Decisions?

"Yield maps help tell us where to go look in the field" Sabourin says, for example, where to ground-truth problems with fertility. "We always knew there was variability," he says, "but now we can quantify it using yield maps and yield monitors. We can make much better decisions on whether it's economic to fix a problem or to just cut our losses and quit spending extra money that we don't have to."

The first step is often intensive soil sampling, followed by increased surveillance for disease, insects, or poor drainage.

It's best to collect data every year and reanalyze key questions to see if a new pattern shows up based on the latest growing season's conditions. It's valuable to have yield data throughout the rotation because different conditions may cause different responses depending on the crop.

Most yield data analysis is done through interactive online platforms to which yield data is uploaded and integrated with costs and crop prices to inform decisions.

"I use my yield data to make decisions on how I'm going to both plant and fertilize in future years," says Don Batie, owner of Batie Cattle Company in south-central Nebraska. He uses 13 years of yield data for each field to help write seeding and nutrient prescriptions. "Certain parts of the field, no matter what you do with, they're just not going to yield because of the soil or water conditions. Other parts of the field are very productive. Those areas, we try to spend a little bit more—more seed, more fertilizer—just to hopefully increase the yield on that area and decrease costs on the poor areas of the field" (Figure 2).

Batie has been increasing his farm's profitability for years through NU on-farm research. "The biggest advantage of on-farm research is that you get a chance to try products on your own farm," he says.

On-Farm Research

"The goal for the On-Farm Research Network," says Thompson, "is for producers to be able to evaluate different products or practices that impact their productivity, their profitability, or the sustainability of their operation. Yield monitoring provides a lot of convenience in collecting that type of data to make those informed decisions."

On-farm research experiments at NU are driven by farmer interest and performed on the farmer's field with their equipment. The treatments are randomized and replicated. The university's scientists and technicians help with setup, data collection, and analysis of different treatments using yield monitor data.

The University of Nebraska is just one of numerous universities that have seen the value of on-farm research. "Without access to yield monitors," says Bob Nielsen, extension corn specialist and professor of agronomy at Purdue University, "we simply wouldn't be able to conduct the kind of research we've been doing for the past 15 years" through the Purdue On-Farm Research Network.

Among a variety of studies underway, the NU team currently has on-farm research experiments comparing yield from growers' standard sidedress N approach (both flat and variable rate) and new model-based approaches such as Granular and Adapt-N. They're exploring N use efficiency and profitability between the approaches. They're including some small areas of lower rates than producers might be comfortable having in multiple whole-field strips in order to determine the economic optimum N rate (Figure 3).

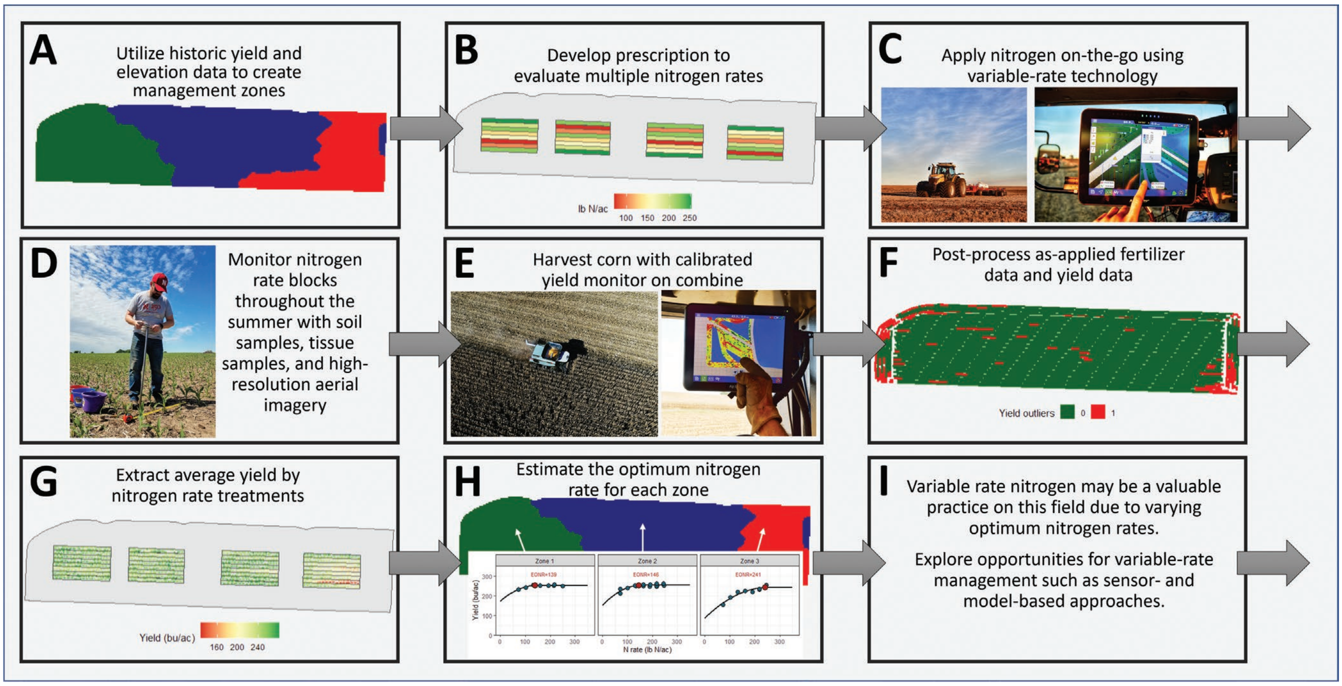

Figure 3. The process of using variable-rate fertilization capabilities and yield monitoring to estimate the economic optimum nitrogen rate by zone in a field. Image courtesy of Laura Thompson, University of Nebraska Extension.

"I just really encourage farmers to do some of their own research on-farm," Batie says. "You look at any major corporation, and they always invest some money every year into research. I think farmers need to be doing this on their own farms just so that we can get better. Every year, we need to keep getting better to stay in the game."

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Precision Conservation

Yield data can also help growers identify areas of their fields that might be more profitably placed in conservation.

Nathan Mueller is co-owner of a small farm in southeast Nebraska. He helped teach precision ag data management workshops for NU extension. He has used SMS Advanced software from Ag Leader to generate profitability maps (Figure 4) based on yield maps for his farm. Yield multiplied by the corn price equals gross revenue, and you'd subtract production costs to create a profitability map, which is especially helpful if it's based on a multiyear yield map. Profitability maps allow the user to run scenarios, such as changing the price of corn or inputs, to see the effect on profitability.

Once unprofitable areas are identified, the farmer can consider options. "There are always different ways to approach yield-limiting factors," Mueller says. He has used two approaches on his farm.

He put 1.2 ac of highly erodible field edge along a river bluff into USDA's Conservation Reserve Program (CRP), "where you're getting a payment to subsidize not having that in production," he says. It's planted with native grasses and pollinator habitat. So he's turned a money-losing area into a money maker.

Pheasants Forever/Quail Forever has a team of precision ag and

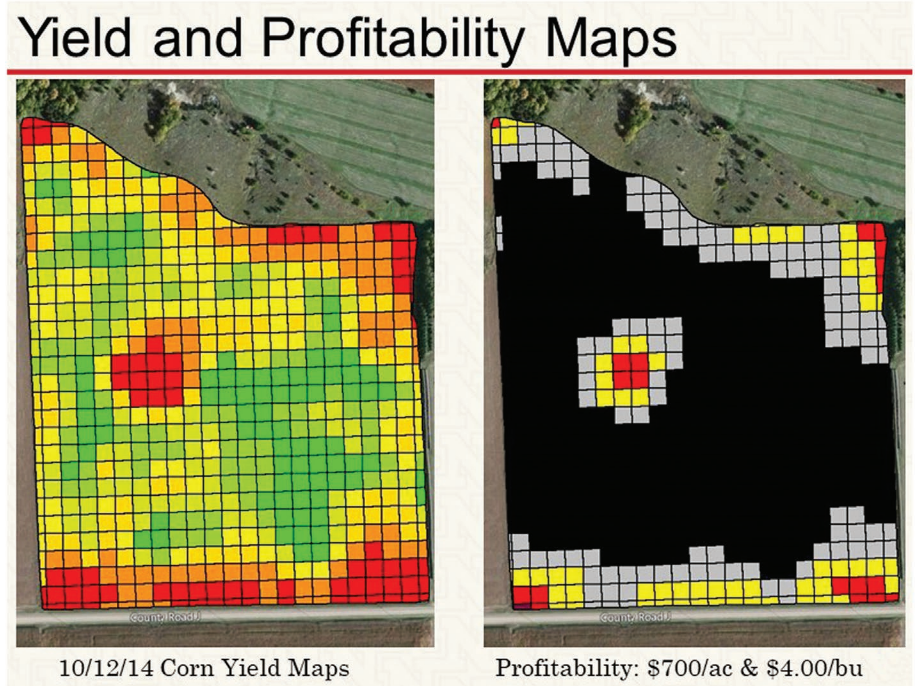

Figure 4. The relationship between yield and profitability maps. (a) Multi-year (2010, 2012, 2014) average corn yield map. (b) Profitability assuming $700/ac cost and corn price of $4/bu. Black is highly profitable, gray is profitable to break even, yellow is unprofitable, and red is highly unprofitable. Image courtesy of Nathan Mueller, University of Nebraska–Lincoln Extension.

conservation specialists who work with farmers using the data they've collected to analyze profitability on a subfield level, says Rachel Bush, conservation programs manager in North Dakota. The team presents a suite of options for the farmer to choose from, including CRP, EQIP, state cost-share programs, or converting the land to forage. Their goal is the old adage: Farm the best, conserve the rest.

Mueller had another 1.5-ac low-yielding, poorly drained flat area in the middle of a field that he approached differently. He switched from a corn–soybean rotation to corn–corn–soybean with cover crops each year to increase infiltration rates in and around the wet area on the west side of the field. On the east side of the field where the risk of soil erosion was higher, he switched to a corn–soybean–wheat rotation with cover crops. He has since seen less crop loss and standing water there.

Yield Monitor Calibration

It can be tempting at the start of the harvest season, when there's so much work to do, to skip calibration. It takes about an hour if the technology has been calibrated previously. It might take two hours the first time a machine is calibrated.

"In the heat of harvest, an hour is a long time for a farmer when they've got hundreds or thousands of acres to harvest," Nielsen says. "But I would argue if you're actually going to use the data, it's time well spent to ensure that you're going to have accurate yield data later on."

Evan Delk, CCA and vice-president of sales and marketing for Integrated Ag Services, Inc., in Ohio, agrees: "We're constantly talking about calibrating yield monitors and junk in, junk out. You've got to have accurate data to make good decisions."

"Yield itself is not measured" by yield monitors, says John Fulton, professor and extension specialist at Ohio State University. "Yield is a calculated variable in the yield monitor." It's based on several variables that are measured and some other values entered by the operator.

Yield monitor calibration takes about an hour if the technology has been calibrated previously. It might take two hours the first time a machine is calibrated. Screenshot from a video from the Precision Ag Basics series on the YouTube channel of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America (www.youtube.com/user/ScienceSocieties).

The number of farmers gathering high quality yield monitor data and using it to inform on-farm decisions is growing, and many of them hire a CCA or another consultant to help them put yield data to work. Screenshot from a video from the Precision Ag Basics series on the YouTube channel of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America (www.youtube.com/user/ScienceSocieties).

As the clean grain is augered into the hopper by the clean grain elevator, the grain pushes against an impact sensor. The more grain flowing through the system, the harder it pushes against this sensor. The impact generates an electrical signal, which is used to estimate the mass flow (lb/second) of grain. So if there's only slight pressure on the sensor, where the harvest is light, it's a low electrical signal. More grain flowing through the clean grain elevator increases the mass flow sensor reading, so there's a higher electrical signal, which translates into a higher calculated yield value.

"So you have to emulate different yield levels when you're calibrating, and that translates into different grain flow rates," says Nielsen, "and by grain flow, I mean how many pounds of grain per second are flowing past that sensor."

Calibration mimics different percentages of the normal harvest load because the yield is not identical across the field. We calibrate at different harvest speeds to "teach" the yield monitor about the range of conditions it will encounter.

It's best to use uniform similar-yielding strips for calibration and to avoid areas influenced by excess traffic, shade, or animal damage.

Complete calibration also involves "moisture sensor operation, lag time settings, header position settings, distance traveled measurements, and header cut width settings" (see "More Information" below).

How to Calibrate

Complete how-to details can be found in combine and yield monitor operating manuals, but here are the basic steps.

- **Harvest a full grain tank (at least 3,000 lb) at a consistent speed.**
- **Weigh the harvested grain.**
- **Input the weight to the yield monitor display.**
- **Repeat the above four or five times at different harvesting speeds, ranging from about half of normal speed to slightly faster than normal (for example, 2, 3, 4, 5, and 6 mph). This allows the yield monitor display in the combine's cab to build a calibration response curve between the amount of grain the combine's sensors estimate and the true weight.**

Calibration Accuracy Standards

Failing to complete calibration as indicated in the equipment operating manual introduces error into the yield estimates (Figure 5), which can make a real difference in determining cost-effective courses of action.

"The error in accuracy can be as much as 100% if the yield monitor is taken 'off the shelf' and put into service without any calibration," Nielsen writes in a 2020 Purdue Extension article. Calibration inaccuracy error can also come from, among other things:

- **not accounting for the entire anticipated range of harvested grain flow rates**
- **not accounting for changes in grain moisture as the harvest season progresses by calibrating only at the beginning of the season (7–10% error)**
- **combine operator behavior, such as changing speed frequently, which throws off the calculation of area harvested**

Fulton says that the industry standard is 2 to 3% error on calibration. He recommends calibrating and then running one

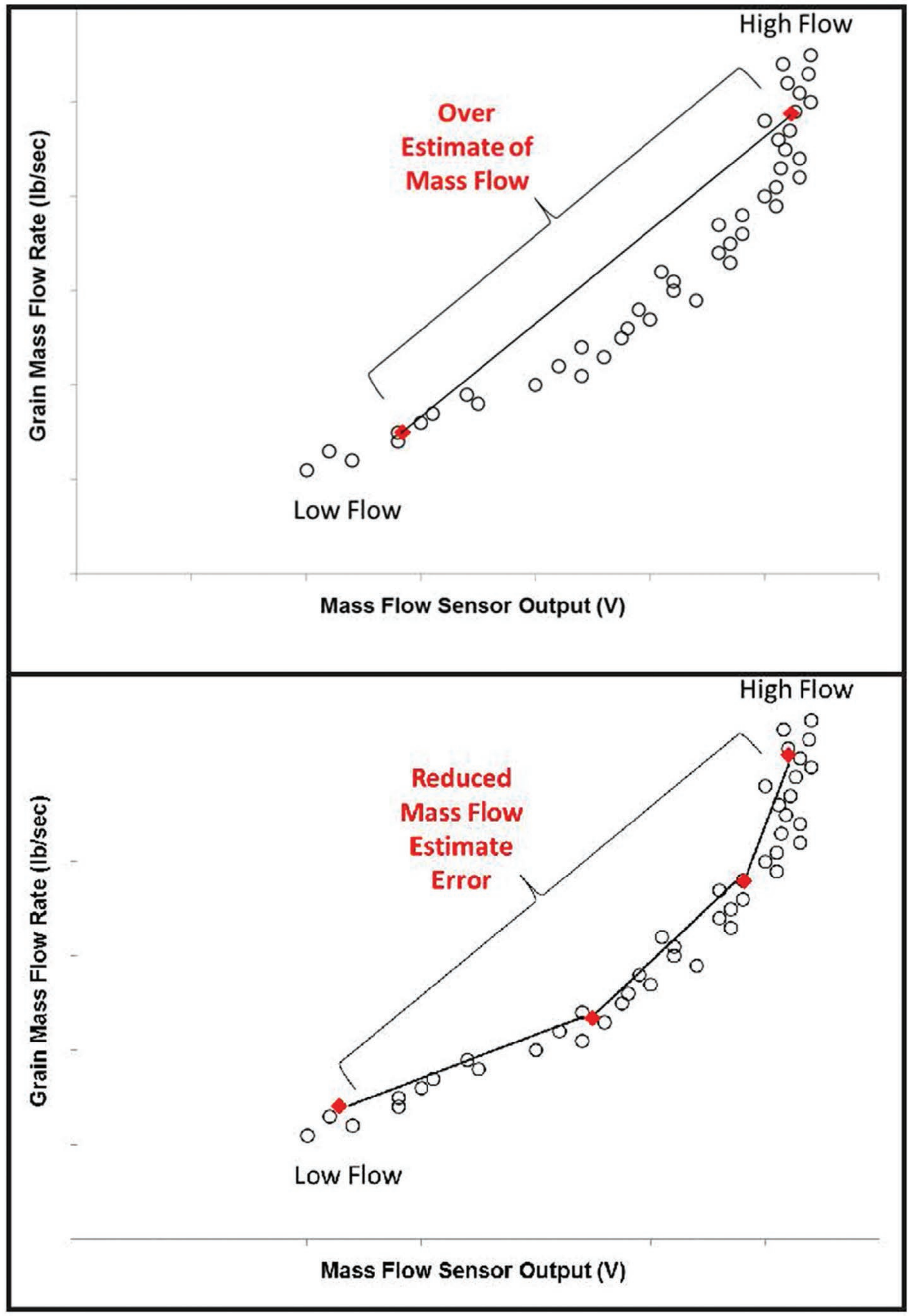

Figure 5. Potential error when using a two-point calibration (top) versus additional point (bottom). Calibration load points are shown in red. Image courtesy of the University of Nebraska–Lincoln Extension.

last test load as a double check at the ground speed to be used for harvesting to compare actual yield and estimated yield from the monitor.

"If we're trying to do site-specific management," says Fulton, "using that data in analyses, then it becomes very important for accurate yield data to be collected." For field-scale research, Nielsen's team typically works with no more than 1% error.

It's important to note that the calibration affects every single yield point collected, as opposed to different errors, which we'll discuss next, that affect only certain points within the field.

Data Cleaning

Yield monitor data should not be used for on-farm decision-making without first removing errors from the data, a process referred to as "data cleaning." Careful preharvest calibration reduces but does not eliminate the need for post-harvest data cleaning, which is typically done by a consultant as part of a service package.

Experts agree that data cleaning is an absolute necessity. University of Nebraska researchers found that using raw "uncleaned" yield data can throw off N recommendations by more than 15 lb/ac, high or low (Figure 6). That's a lot of money to waste or a lot of yield to sacrifice.

The Yield Editor software of USDA is often used for data cleaning. Sabourin estimates that he typically spends 15 to 20 minutes on data cleaning for each field. Often, it's just a matter of applying filters. For instance, if the average yield was 50 bu/ac in soybeans, he might use a filter to delete points over 70 bu and under 20 bu because equipment or operator error are likely there. Error can be introduced, for example, if the crop is thin and the combine travels faster, or if the crop is very thick for a stretch, and the combine travels more slowly.

Problems can also arise at the entrance and exit to fields. During the turn at the end of the rows, the header of the combine often isn't lifted high enough, so the machine is still collecting yield data. We don't want those data points included in analysis because they incorrectly influence our understanding of the yield in different parts of the fields.

Trimble Agriculture has a yield-cleaning tool built into its system. "I guess that would be one of the first times I've seen a company embed something like that in their software," says Joe Luck, NU associate professor and precision agriculture engineer.

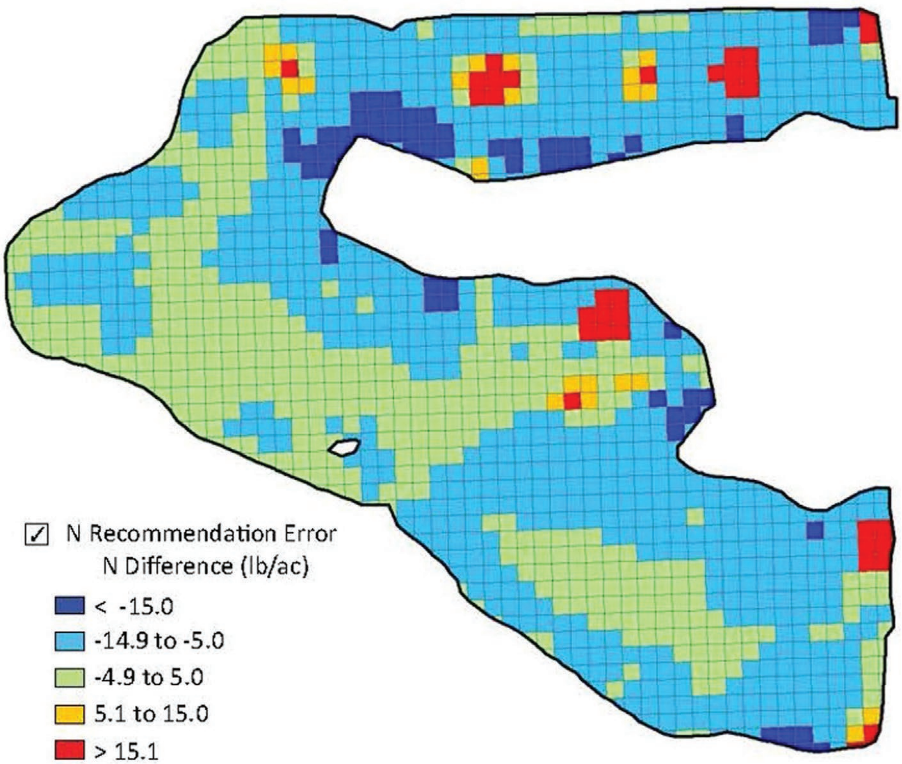

Figure 6. Map (50-ft grid) showing the potential differences in a N prescription map when using raw yield data vs. cleaned yield data. In many instances, predictions of N can exceed 15 lb/ac. Image courtesy of the University of Nebraska–Lincoln Extension.

Data Management and Standardization

Data compatibility across farm tools is "one of the biggest issues lots of farmers have," Luck says. "They don't like getting tied in to one specific set of equipment," so they often have mixed fleets. This complicates data management and standardization.

"Data standardization in precision ag has been a problem ever since precision ag came out," Delk says. The velocity of this data is also important, he says. So much data is generated during harvest season, and there's tremendous pressure to crunch numbers and get farmers seed recommendations before planting time.

Trimble Agriculture and Ag Leader SMS software are two platforms that can bring in data from most equipment types and manufacturers and standardize it for analysis.

With high fertilizer prices like we're seeing now, growers' interest in precision ag will likely increase. Luck says that on-farm research, for instance, "to test strategies to push nitrogen management as low as you possibly can," including the use of N model-based tools such as Granular or Adapt-N, will need as much background yield data as possible. "Having good quality yield data from the past few years is really going to be critical to help those tools work well," he says.

More Information

- Ohio State University, Tips for Calibrating Grain Yield Monitors—Maximizing Value of Your Yield Data: https://ohioline.osu.edu/factsheet/anr-8
- Ohio State University, eFields On-Farm Research: https://digitalag.osu.edu/efields
- Purdue University, "Yield Monitor Calibration: Garbage In, Garbage Out": http://www.kingcorn.org/news/timeless/YldMonCalibr.html
- Purdue University, "Identify and Eliminate 'Gremlins' from Yield Monitor Data": http://www.kingcorn.org/news/timeless/CleaningYieldData.html
- University of Nebraska, "Best Management Practices for Collecting Accurate Yield Data and Avoiding Errors During Harvest," EC2004: https://extensionpublications.unl.edu/assets/pdf/ec2004.pdf
- University of Nebraska, "Improving Yield Map Quality by Reducing Errors through Yield Data File Post-Processing," EC2005: https://extensionpublications.unl.edu/assets/pdf/ec2005.pdf
- University of Nebraska On-Farm Research Network: https://on-farm-research.unl.edu/

SELF-STUDY CEU QUIZ

Earn 1.5 CEUs in Crop Management by taking the quiz for the article at https://web.sciencesocieties.org/Learning-Center/Courses. For your convenience, the quiz is printed below. The CEU can be purchased individually or you can access as part of your Online Classroom Subscription.

1. **According to a survey of large corn and soybean farmers cited by the authors, what percentage of respondants reported that their fertilizer decisions were "somewhat" or "highly" influenced by data?**
   a. 24%. **b.** 52%. **c.** 78%. **d.** 93%.

2. **Yield maps can help a farmer determine which parts of a field to invest more resources in and which might need to be used or managed differently.**
   a. True. **b.** False.

3. **What advantages does yield monitoring offer farmers, according to the article?**
   a. It can be used for on-farm research to assess how agronomic practices, products, or hybrids affect yield.
   b. It can help boost fertilizer efficiency.
   c. It can show which fields are more profitable than others.
   d. All of the above.

4. **When creating a yield map, it is recommended to collect data how often?**
   a. Twice a year, before planting and after harvest.
   b. Annually.
   c. Every two years.
   d. Every three years, assuming similar conditions.

5. **Yield maps can be used to generate profitability maps for farmers. To do this, multiply the yield by the crop price to get gross revenue. Then, divide that number by production costs to create a profitability map.**
   a. True. **b.** False.

6. **For land that profitability maps reveal to be unprofitable for farming, which of the following options is NOT recommended in the article?**
   a. Make some money off the land by converting it to conservation land.
   b. Continue to farm but with reduced fertilizer to minimize costs.
   c. Identify and attempt to remediate the issue causing the lower yield/profitability; for example, test different crop rotations.
   d. All of the above.

7. **Which of the following is NOT mentioned in the story as a factor driving interest in yield measurement and maps?**
   a. Thinner profit margins.
   b. Ease of use.
   c. Providing data for on-farm research.
   d. Rising fertilizer prices.

8. **When measuring yield, it is critical to calibrate the instrument first to ensure accuracy.**
   a. True. **b.** False.

9. **How long does it take to properly calibrate a yield monitor?**
   a. Half an hour. **c.** Half a day.
   b. One to two hours. **d.** Three to five days.

10. **Careful preharvest calibration eliminates the need for post-harvest data cleaning.**
    a. True. **b.** False.

11. **When measuring yield, which of the following mistakes can result in errors?**
    a. Not accounting for the entire anticipated range of harvested grain flow rates.
    b. Failing to recalibrate during harvest season to account for changes in grain moisture.
    c. Frequently changing the combine speed.
    d. All of the above.

12. **What, specifically, do yield measurement systems record?**
    a. How quickly the grain is harvested.
    b. How many pounds of grain are harvested per second (i.e., the mass flow).
    c. Weight of the grain.
    d. The quality of the grain.

13. **Even the most well-prepared yield measurements must be "cleaned" to remove errors. According to research cited in this article, "uncleaned" data can throw off N recommendations by how much?**
    a. 1 to 5 lb/ac. **c.** 10 to 15 lb/ac.
    b. 5 to 10 lb/ac. **d.** More than 15 lb/ac.

14. **There are several ways errors can be introduced into measurements. Which of the following is NOT mentioned in this article?**
    a. If the harvester speed remains constant throughout the field.
    b. If the harvester speed varies in lighter or heavier sections of the field.
    c. If the harvester continues to collect data during the turns between rows.
    d. If the harvester continues to collect data while entering or exiting a field.

15. **Yield data will help farmers get the most out of N model-based tools such as Granular or Adapt-N as they seek to reduce fertilizer costs.**
    a. True. **b.** False.