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BEST MANAGEMENT PRACTICES

CHAPTER 50

Calibrating Yield Monitors

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To create a yield map, the location, ground speed, swath width, and rate that the grain is collected must be known. This paper discusses strategies to improve yield monitor data. Yield monitor data are used for many purposes, some of these are provided in Table 50.1.

Table 50.1 The importance of yield monitors:

1. Comparing corn hybrids.
2. Developing tile-drainage maps.
3. Negotiating rents.
4. Developing production plans.
5. Conducting on-farm research.
6. Developing management zones.
7. Developing profitability maps.
8. Documenting the impacts of adverse climatic conditions on yield.

Yield Monitor Basics

Most current yield monitors use an impact plate to estimate the flow rate of grain at the point where the clean grain elevator discharges grain (Fig. 50.1). The grain mass is thrown from the top of the clean grain elevator toward the base of the fountain auger. The impact plate is mounted in this space and intercepts the grain. A strain gage bridge, which measures weight much like an electric bathroom scale, measures the force of the grain on this plate. More grain mass means more force on the sensor plate. While the concept is simple, the actual device is not so simple. Anything that changes the impact force will be detected as a change in grain flow rate. While combining uphill, gravity can force the grain harder against the sensor plate to indicate more flow. While combining downhill, gravity can reduce the indicated flow because the grain is being thrown upward. Vibrations will also affect the sensor's signal level, and a combine has lots of vibrations. The heightened sensitivity of this type of system is one reason it requires careful and regular calibration. The mass flow rate of the grain in pounds/second is determined using the sensor's calibration equation. To convert the force on the plate into bushel/acre, precise ground speed, swath width, location, temperature, speed of clean grain elevator, and crop moisture content are needed.

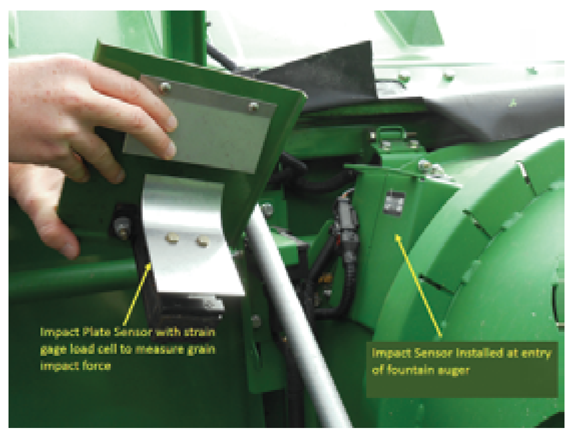

Figure 50.1 An impact-style flow-rate sensor using a curved plate and strain gage load cell to measure impact force of grain. The sensor is installed at the base of the fountain auger where grain leaving the clean grain elevator impacts. (Courtesy of authors)

A moisture sensor located on the clean grain elevator or fountain auger is used to measure grain moisture (Fig. 50.2), whereas the differentially corrected global positioning systems (GPS) can be used to determine the location of the GPS receiver. The location is determined by calculating the distance between the satellites and the GPS receiver. The intersection of these distances is the location of the GPS receiver. These satellites can be located almost anywhere, and the accuracy of the GPS location is dependent on their distribution. The highest accuracy occurs when they are distributed across the sky. Ground speed and swath width multiply together to determine the area being harvested.

Figure 50.2 Moisture sensor sampling system on the side of the clean grain elevator. The small auger periodically empties the chamber, which refills from the clean grain elevator to take another sample. (Courtesy of authors)

Preparing a Yield Monitor

While the flow rate sensor is the most important component of the yield monitoring system, it is actually the last part of the system that should be calibrated. Other sensors that should be routinely checked include the vibration, temperature, ground speed, and crop moisture sensors. To calibrate these sensors follow the manufacturer recommendation.

Vibration Calibration

Some yield monitor systems perform vibration calibration without user intervention, whereas others require this calibration. This calibration provides a baseline signal for the moisture and mass flow sensor. The calibration is conducted with an empty grain hopper prior to harvesting grain. Calibration is conducted by: 1) throttling up the combine; 2) engaging the thresher; and 3) lowering the header. Repairs or upgrades, such as replacing a drive chain, removing a drive chain link, or replacing an auger and flighting, may change the vibration in the system.

Temperature Calibration

Temperature information is needed to accurately calculate grain mass flow and moisture content. Temperature calibration should be done prior to starting the combine. The calibration might require the operator to enter the known outdoor temperature. The temperature output should be checked periodically during the season. Some systems do this automatically.

Ground Speed Sensor Calibration

Ground speed can be determined using the GPS or the combine speedometer. Systems using DGPS as the speed sensor typically don't require calibration, whereas wheel-rotation based sensors (speedometers) may require calibration. Speedometers may not be accurate for many different factors, including if there is a change in the wheel configuration. Ground speed can be checked when the sensor is operating by determining the amount of time that is required to drive a known distance. Calibration is conducted by entering the actual distance traveled into the yield monitor display. The known distance should be measured with a tape measure from the beginning location of a nondriven wheel to its final position.

Crop Moisture Sensor Calibration

Crop moisture sensors provide information needed to measure the yield at 15.5% moisture, or determine whether additional drying is required. To calibrate the moisture sensor, 4 to 6 samples of grain are collected from the hopper. This can be done when calibrating the flow sensor, as described below. The moisture content samples can be added together into a container such a five-quart pail, or large coffee can. The moisture content of these samples should be determined using a calibrated sensor, such as the moisture sensor at a grain terminal or elevator. Enter the average of this moisture content value into the yield monitor display prior to entering the load weight for the calibration load, below.

Mass Flow Sensor Calibration

Mass flow sensor calibration is the last step in the overall yield monitor system calibration and is the most critical. To avoid harvesting delays, mass flow sensor calibration should be conducted during harvest preparation. Different crops require different mass flow calibrations and the predicted yields are only as good as the calibration. For this process select a relatively uniform and level area of the field. Calibration loads should be collected sequentially in the most uniform portion of a field. Each load should be loaded into a weigh-wagon or instrumented grain cart, with the true weight of the load entered into the yield monitor mass flow calibration screen.

The rule of thumb for a good calibration is to control what you can control while maintaining as much uniformity in the noncontrollable variables as is possible. The ground speed, header width utilization, and load size are the three variables that are easiest for the operator to control, while the instantaneous yield and field slope are out of the operator's control. To maintain the desired uniformity, it is best to collect calibration loads in flat areas with relative uniform high yield. Each load should contain at least 3,000 pounds of grain. In 150 bu/acre corn, this requires about 800 feet of travel with an 8-row head, or 520 feet with a 12-row head. There are a variety of methods that could be used to collect calibration loads that span the full range, including loads collected from high-yield areas and low-yield areas. This method is less desirable than varying speeds in constant-yield areas and should be avoided.

The recommended number of calibration loads varies by manufacturer, but more calibration loads are generally better if they span the range of yields. The loads should be collected during the same day and with weather conditions as uniform as possible. Avoid splitting calibration load collections between two separate days, as the crop conditions might change. In corn, varieties with higher or lower test weight require new calibration curves.

Method 1

Collect samples where the combine is traveling at 110%, 100%, 75%, and 50% of the expected harvest speed. For example, if the typical harvest speed in a high-yield area is 4 mph, speeds of 2, 3, 4, and 4.5 mph could be used to span the range of expected grain flow rates. For each of the harvest speeds, the amount of grain harvested should be weighed. If one load were collected at each of these four speeds with full header utilization, the resulting calibration would have four points. While this is fewer than would be optimal, it will produce a calibration that spans expected flows.

Method 2

To generate further calibration points, it is possible to collect calibration loads at the same 3 to 4 ground speeds while utilizing only a fraction of the header (75%, for example). If 4 speeds were used with two possible header utilization settings, the resulting calibration would have eight points. The harvested grain for measurement should be weighed.

Importance of Multiple Point Mass Flow Calibration

Imagine that a series of 12 different loads of grain were harvested in a perfectly uniform field. Each load was collected by selecting a swath width and combine speed that were held constant for that whole load. Each of those loads would have been acquired with a different, but constant flow rate of grain impacting the flow sensor. Each flow rate and an associated sensor signal are depicted in Figure 50.3. Note that they do not form a straight line. Most combine grain flow sensors are nonlinear. With lots of calibration points, it is easy to calculate an accurate mathematical model. If only three points were collected, the model could overestimate or underestimate the yields in high-yield areas of the field.

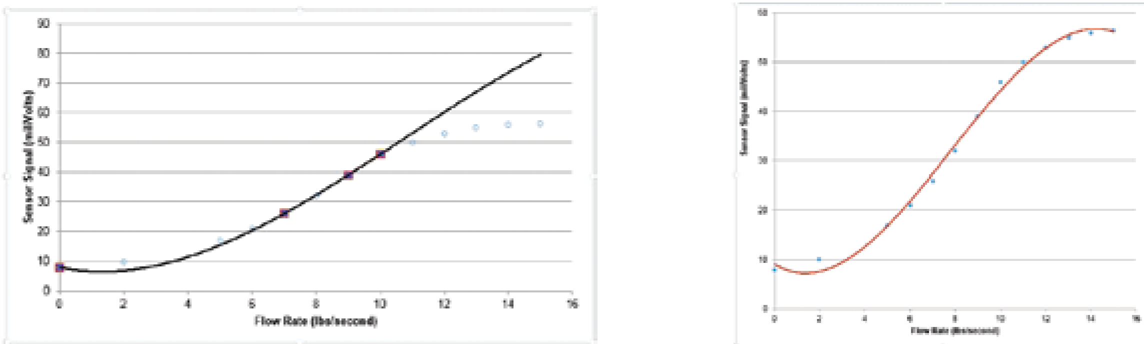

Figure 50.3 A set of calibration loads that represented a wide variety of flows impacting the combine flow sensor. Most sensors have a curved relationship between flow and signal voltage. The chart on the left has three loads and the resulting model provides poor estimates at high flow rates. (Courtesy of authors)

Potential Sources of Yield Monitor Error

Poor or Old Calibration Loads

Using old calibration data or poor calibration load collection procedures can create systematic error. Over time, the operating conditions of the yield sensor components or the combine itself can change due to machine wear or sensor output drift, while poor calibration technique should be evident due to differences in the indicated yield and the amount of grain delivered to the elevator. In either case, the best solution is to perform a new calibration of the entire system.

Calibration Loads Do not Span the Flow Rates

A yield monitor system is most accurate in yield regions that are similar to a calibration point. The group of calibration loads should represent the span of yields that will be observed in the field. If errors are in the field extremes, adding a few new calibration loads improves results. For example, if the calibration was conducted in a field averaging 170 bu/a and the current field is averaging 240 bu/a, adding calibration points at 100% and 110% of the harvest speed would likely resolve the issue.

Poor Calibration of the Moisture, Temperature, and Speed Sensors

If the moisture, temperature, or speed sensors are not properly calibrated, repeating the calibration procedures usually will improve measurements. Poor calibration of the moisture sensor results in incorrect predictions of dry-grain or marketable-grain totals from a field. Recalibration of this sensor can be done at any time and can also be used to correct previously collected yield data. The need for recalibration of this sensor system can be determined by comparing the moisture content indicated by the monitor for one or more loads with moisture content determined at the elevator.

The mass flow sensor and grain moisture sensor rely on a properly calibrated temperature sensor to provide correct results due to their reliance on temperature for output calculation. The temperature sensor can also be recalibrated at any time, but yield data results produced while the system was out of calibration are not easily correctable.

A poorly calibrated ground speed sensor results in area measurements that are erroneous. This will cause the yield calculation to also produce an error since yield is flow rate divided by the rate that area is being covered. The error can also show up as a mismatch of a known area of a field compared to the area displayed on the yield monitor. Data collected with a poorly calibrated speed sensor can be easily corrected by multiplying yield data by (D_New/D_Old), where D_New is the indicated distance traveled by a newly calibrated sensor and D_Old is the indicated distance traveled by the old calibration.

Inaccurate Setting on the Number of Rows (Swath Width Error)

When collecting yield data on a combine, it is the operator's responsibility to ensure that the yield monitor is aware of the harvesting operation at every point in the field. This includes adjusting the swath width in the monitor for cleanup passes and other areas where the full header is not being utilized. This type of error is usually easy to spot in post-processing. This will appear as a combine pass that has very low yields and it is too close to an adjacent full swath harvest area.

Sudden Speed Changes

Changes in combine speed can result in erroneous yield measurement because yield is the amount of grain in a given area and the combine measures average yield as opposed to instantaneous yield. For example, the combine measures 10 bu in 1/20th of an acre. The yield per acre for this measurement would be 200 bu/a (=10 bu/0.05 acres). As the combines slows from 4 mph to 3 mph, the area decreases from 0.05 to 0.0375 acres, which in turn results in a yield estimate of 267 bu/a (=10 bu/0.0375 acre). Increases in the combine speed have the opposite effect.

Wear of the Flighting in the Clean Grain Elevator

As a combine operates, there is expected wear on many of the moving parts. The clean grain elevator flighting is the combine part that has the most potential to impact yield monitor operation because of wear. As the flighting wears the ejection speed of the grain leaving the elevator begin to decline. This slippage of grain past the flights results in a gradual decrease in the force measured by the mass flow sensor impact plate. This wear and the resulting change in operating parameters require periodic recalibration of the mass flow sensor.

Changing to New Chain and Flighting

When the auger flighting wear becomes critical, it is often replaced. This creates an immediate, noticeable change in the amount of grain ejected per revolution and the ejection speed of the grain, and a subsequent jump in the output of the mass flow sensor. The mass flow sensor should be recalibrated when the chain or flighting of the clean grain auger are replaced.

Changing Speed Setting or Increment on the Clean Grain Elevator

Some combines have more than one sprocket driving the clean grain elevator to allow for speed changes with high- or low-volume crops. If changes are made to the speed or level sensor in the clean grain elevator, it is possible that the yield monitor output would show a sudden change as well. Recalibration of the mass flow sensor should be completed as soon as a new operating regime setting is implemented.

Buildup of Plant Residue or Debris on the Sensor Plate

After many hours of operation, there is a tendency for grain residue to build up on the impact plate of the yield monitor mass flow sensor, particularly when harvesting softer varieties or wet grain. This results in changes to the coefficient of friction on the surface of the impact plate, typically causing the sensor to indicate higher yield as the amount of residue builds. This effect is more common in soybeans than in corn, but it is still another reason that periodic calibration loads should be collected during the entire harvest season. If a combine is used to harvest multiple crops, the yield monitor should be calibrated, or at least checked, each time the type of crop is changed.

Summary

A well-calibrated yield monitor system is a “good” tool for understanding sources of spatial yield variation. Constant honing of production practices for the variability of individual fields is a result. A systematic calibration of the yield monitor system is essential if high-quality data are to be obtained. Producers are understandably reluctant to slow harvest by making the controlled passes required to collect calibration loads. Learning how your monitor system works can help to identify when recalibration is needed. For more information about yield monitor calibration contact your local dealer.

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