Comprehensive Guide to Grain Yield Monitoring Systems

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Grain yield monitoring systems

Yield data generated by yield monitoring systems in today's agricultural production provides essential information to optimize input applications, improving environmental quality and farm profit. Yield data information allows farmers to make informed decisions in their operation (planting, irrigation, fertilization, pest control, harvest, etc.), leading to more efficient resource allocation based on collected yield data. This process can reduce waste and environmental deterioration while increasing crop quality and quantity. Accurate yield records are important for crop insurance claims and documenting farm performance. Yield monitors simplify record-keeping, making it easier for farmers to comply with regulatory requirements. These systems are invaluable tools in modern agriculture (Fig. 1). This fact sheet delves into the common errors and problems encountered with these systems and provides insights into calibration techniques to enhance their accuracy and reliability.

Components of a grain yield monitoring system

Sensors

Several sensors are mounted on a harvester to measure the grain harvested, including grain flow, grain moisture, ground speed, and header height sensors (Fig. 2). These sensors are to collect data on crop flow rates, moisture content, and other relevant parameters.

Figure 1. Grain Yield Monitoring Systems

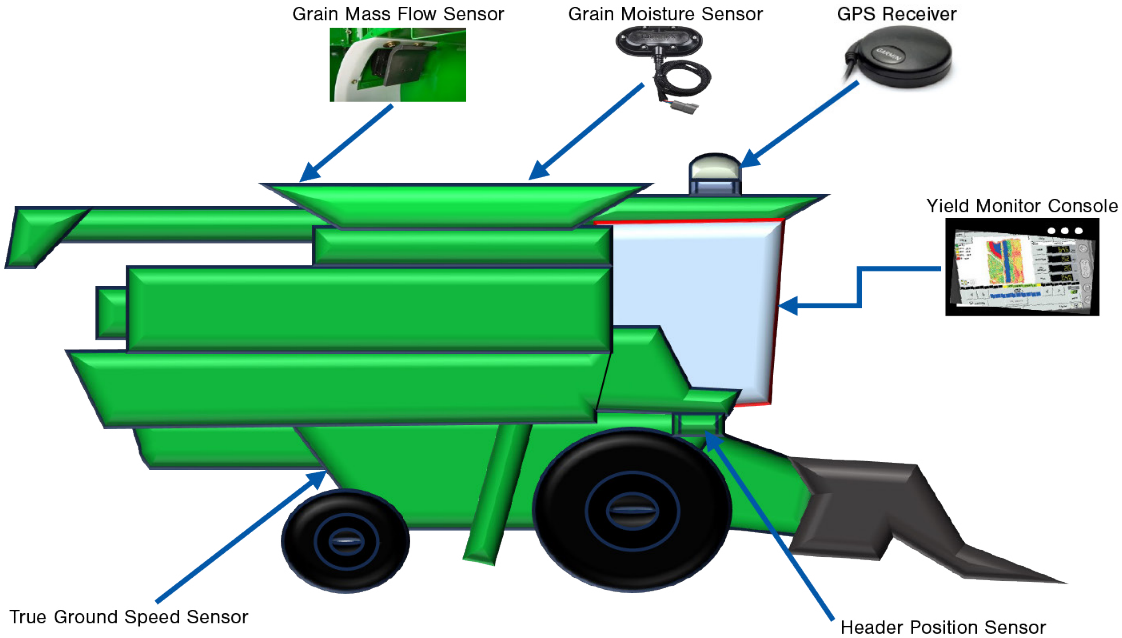

Figure 2. Grain Yield Monitoring System Components

The accuracy of recorded yield data depends on the calibration of the yield monitors.

Mass flow impact sensor

The impact plate is strategically positioned at the upper section of the grain elevator (Fig. 3). The harvested grain is directed into contact with the impact plate, generating an output voltage signal. This signal transforms into a usable numerical format using a specific scaling factor through an electronic unit. This converted data can be displayed and stored directly on the combine's monitor.

Grain moisture sensor

Grain moisture levels in a single field can vary significantly due to factors like soil type, growing conditions, ear size, and test weight, potentially resulting in fluctuations of around ten percent (NDSU Agriculture Communication, 2013). Additionally, the moisture content of crops in the field naturally decreases during the harvest season. To accurately assess field performance and standardize grain mass for commercial purposes, precise moisture sensor is essential (Fig. 4). This sensor employs capacitive technology to create an electric field by measuring voltage potential between two strategically positioned

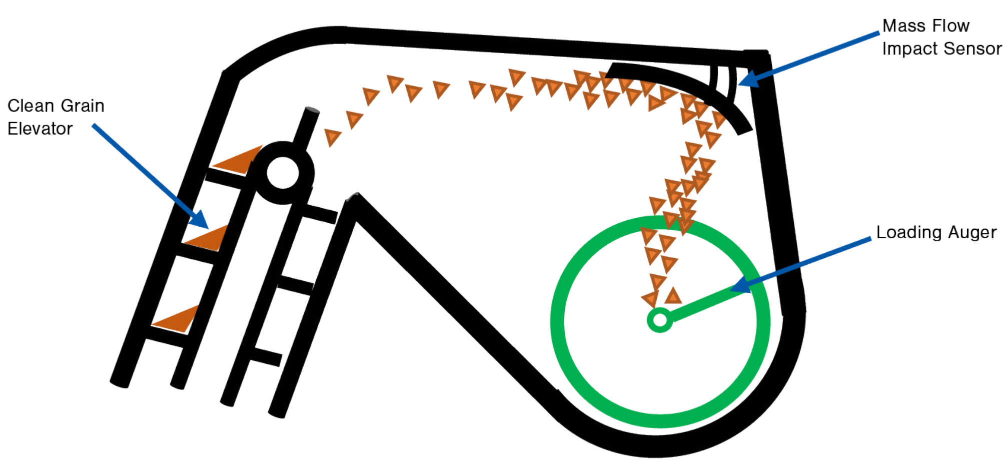

Figure 3. Schematic diagram of Mass flow impact sensor

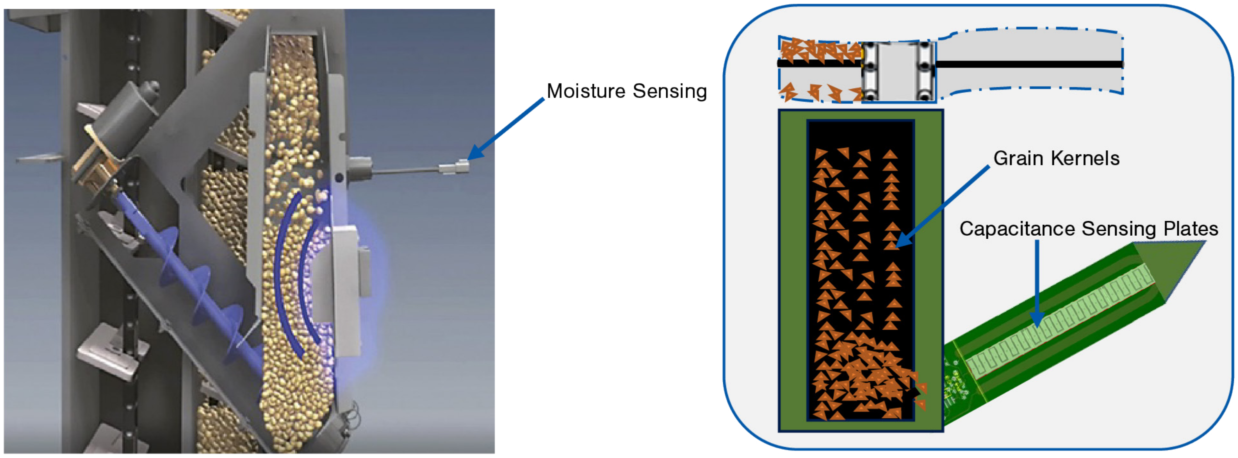

Figure 4. Schematic diagram of Grain moisture sensor

conductive plates set at a fixed distance, allowing for accurate grain moisture content measurement.

Global positioning system (GPS)

Accurate spatial information is essential for understanding variations in yield across a field. GPS technology is integrated into the system to record the precise location of yield data. This allows farmers to create yield maps, which visually represent yield variations.

Console

Inside the combine cab, there is a critical component that acts as the central control unit. Its primary purpose is to coordinate, manage, and optimize the interaction of all key components within the system to accurately monitor and record grain yield during the harvesting process. It provides real-time data and insights to farmers and operators, allowing them to optimize crop management decisions, improve harvesting efficiency, and maximize total yields.

Data storage unit

The data storage unit of a grain yield monitoring system is a critical component responsible for the secure and effective storing of data acquired throughout the harvesting process. This unit stores a variety of information, such as yield data, moisture content readings, GPS locations, and maybe other pertinent data points. It ensures security for data, accessibility, and usefulness to optimize farming operations and decision-making processes.

Problems faced by grain yield monitoring systems

Spatial variability

Spatial variability is an essential issue for grain yield monitoring systems. This issue arises because within a single field, there can be significant differences in soil properties, growing conditions, and other environmental factors. As a result, the yield of crops can vary considerably across the field.

Calibration drift/sensor related problem

Calibration drift and sensor-related problems pose significant challenges for grain yield monitoring systems. Calibration drift occurs as sensors age or are affected by environmental factors, leading to inaccuracies in data collection. These inaccuracies can result in misleading yield measurements, potentially leading to resource mismanagement and reduced confidence in the system's data. To address these issues, regular sensor calibration and maintenance, along with the adoption of advanced sensor technologies, are essential to ensure the accuracy and reliability of data collected by these systems.

Data integration challenges/operational problem

The process of integrating data from various systems or departments can be complex and time-consuming, leading to delays in decision-making and potential errors in data analysis. Additionally, ensuring data quality, consistency, and security throughout the integration process is a constant concern. Addressing these challenges effectively requires robust data integration strategies, tools, and governance to

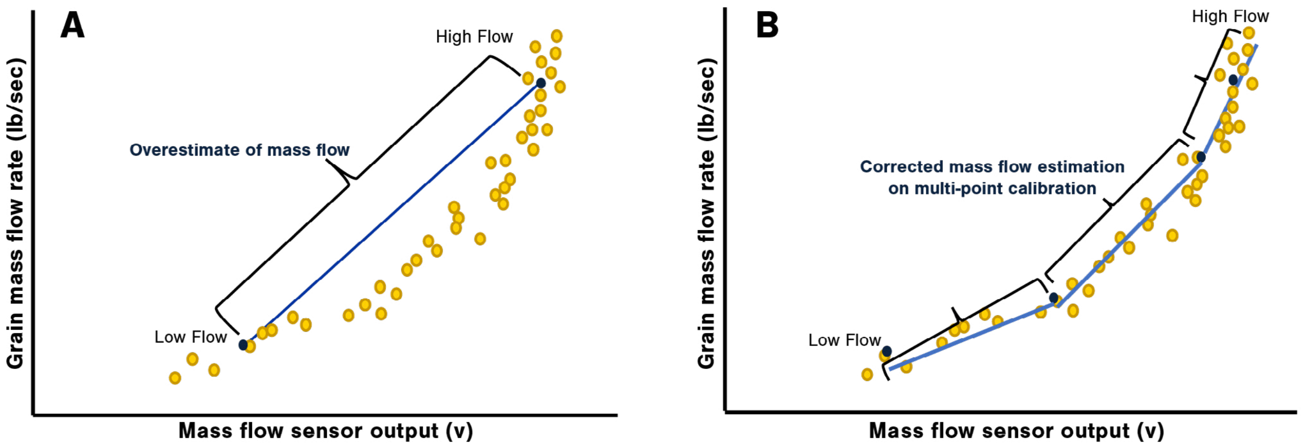

Fig 5. Single point calibration (A) vs. multi-point calibration (B) for a yield monitoring system Single-point calibration

streamline operations and maximize the value of data assets for informed decision-making. concise it.

Yield monitor accuracy and calibration procedure

Mass Flow Sensor Calibration

» The first step requires using calibration "loads" of grain to train the yield monitor's system. This enables precise conversion of electrical signals from sensors into grain flow rate estimations. Calibration typically involves harvesting specific "loads" of grain that mirror the anticipated range of grain flow rates. This accounts for variations in yield levels across the field. During the grain harvesting process, the yield monitor continuously estimates the weight of each "load" in real-time.

» The amount of grain needed for each calibration "load" varies, typically ranging from 3,000 to 6,000 pounds (50 to 100 bushels) based on the manufacturer's recommendations for the specific yield monitor model. Subsequently, each "load" is offloaded from the combine grain tank and weighed using calibrated or certified accurate weigh wagons or commercial scales. The actual weight of each "load" is then entered into the yield monitor console, and the yield monitor's firmware makes mathematical adjustments to fine-tune the calibration response curve.

» The calibration process involves establishing a response curve that relates grain flow rate (lb/sec) to flow sensor signal strength (v), enabling accurate estimations of low, medium, and high yields (Fig. 5). The nature of this calibration curve may vary among different yield monitor manufacturers. While some manufacturers suggest that a single grain load calibration is adequate, implying a near-linear relationship between grain flow rates and flow sensor signals.

» Multipoint calibration allows the system to provide accurate estimates through combining over a range, from low to high flow.

Single-point calibration

The calibration process for mass flow sensors follows a simple linear regression path from the sensor's zero-offset reading to a single calibration load. To improve accuracy, include an average of at least three calibration loads in this single-point calibration. This method contributes to the creation of a more representative data point while also mitigating any errors caused by faulty procedures or environmental variables during calibration. This extensive method is designed to increase the overall accuracy of the mass flow sensor, resulting in more accurate data for agricultural decision-making.

Multi-point calibration

It is a more comprehensive calibration process that aims to capture the non-linear response curve of the yield sensor across a range of grain flow rates. Unlike single-point calibration, which uses only one data point, multi-point calibration involves harvesting multiple calibration loads, typically between 3 and 6, at different flow rates of grain. There are two approaches to acquiring a calibration point at a specific grain flow rate. The more commonly used method involves harvesting uniform, representative crop sections at different speed settings to establish calibration points. In this method, one calibration load is harvested at the standard harvesting speed, followed by two additional loads obtained at incrementally higher and lower speeds relative to the standard speed.

Moisture sensor calibration

The yield monitor's moisture sensor should be calibrated using a precise portable or laboratory moisture tester.

» For moisture sensor calibration, collect 4 to 6 grain samples from the hopper. These samples can be stored in either a five-quart pail or a large coffee can.
» Use a calibrated moisture meter to measure the moisture content of these samples.
» Enter the average moisture content value into the yield monitor display as input value. This should be done before entering the load weight for the calibration load.
» Periodic inspections of the moisture sensor chamber or blade should be conducted to check for any buildup of soil and crop material. For chamber-type moisture sensors, adjustments should ensure they are full when readings are taken to maintain accuracy.

Ground speed sensor calibration

Calibration may require adjustments if the wheels have been altered, damaged, or modified. A simple test for the ground speed sensor involves accurately marking a known distance, such as a quarter mile of road.

» The combine should be driven at a constant speed over a marked distance, and the time taken from start to finish is used to calculate the actual ground speed.
» The formula for calculating speed is Distance traveled (in feet) divided by time (in seconds) to cover the distance, divided by 1.4666, yielding the speed in mph.

If the calculated speed significantly differs from the ground speed indicated by the monitor during the test, the sensor should be checked and serviced. Data from this sensor improves the material flow rate calculations and helps account for higher and lower volumes of material moving through the conveyance duct.

Header height determination

Three commonly used techniques for sensing header height to determine the start and ending points for data logging and area accumulation are:

» Using a magnetic sensor that triggers a contact when the header reaches a predefined position.
» Employing a rotary potentiometer to sense the angle or elevation of the header.
» Tracking the length of time, the header height control switch is in the "up" or "down" positions.

Mass flow time delay: "a source of error to consider."

The time delay in crop analysis is a critical factor to consider. Grain mass flow and moisture measurements are taken in the clean grain elevator after the harvested crop has undergone cleaning and aggregation. Since harvesting is a continuous process, there is a notable time gap between when the yield monitoring system analyzes the grain and its corresponding geographical location within the combine (Fig. 6). This delay in grain delivery can range from 13 to 14 seconds, as observed in previous studies (Chung, Sudduth, & Drummond,

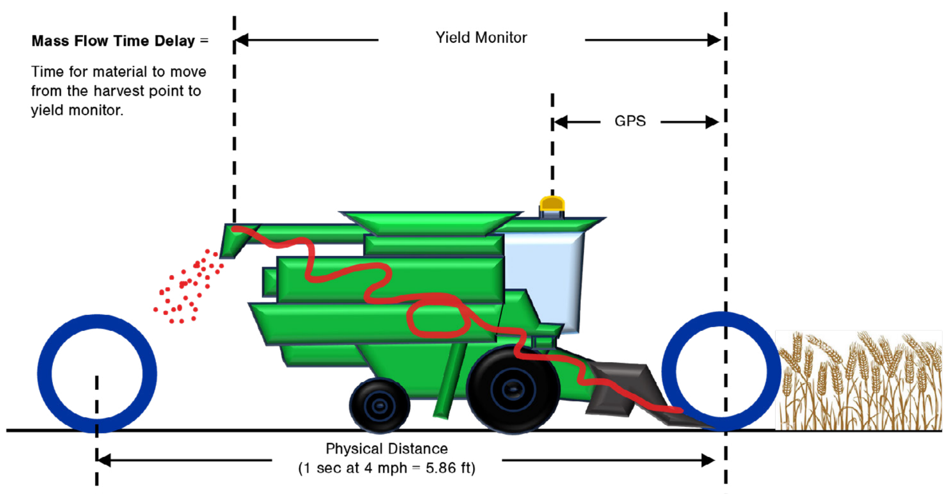

Figure 6. Mass flow delay repositions yield measurement.

2002). The significance of this time delay becomes increasingly pronounced when generating yield maps, a practice adopted by more than half of operators using a yield monitor (USDA Economic Research Service, 2015).

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