Yield Monitoring Systems: Understanding how we Estimate Yield

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Discussion Topics

- Yield monitor components
- Calibrating the yield monitor
- Moisture sensing
- Yield monitor output
- Estimating crop yield
- Making yield maps
Basic Yield Monitor Components

- Mass Flow Sensor
- Moisture Sensor
- Header Sensor
- GPS System
- Field Computer

Yield Monitor Component Functions

Field Computer
- Monitors all sensors
- Displays harvest functions
- Logs data for storage and transfer

GPS System
- Provides field position

Header Status Sensor
- Logs data when down
- Stops logging when up
Yield Monitor Component Functions

Mass Flow Sensor
- Impact plate sensor (most popular)
- Mounted in clean grain elevator
- Grain impacts plate
- Force of impact deflects load cell
- Voltage output from load cell
- Voltage is proportional to mass flow

Calibrating the Yield Monitor

Why calibration is necessary:
- We only know the voltage output from the sensor
- We need to relate that to something real (lbs or bu)

Calibration procedure is specific to each yield monitor
- Collect mass of grain per time
- Computer records sensor output
- Enter grain mass into computer
- Computer develops equation to estimate mass flow from voltage output
Static Mass Flow Sensor Measurements

Sensor output at a constant mass flow rate:

Two-Point Calibration
Two-Point Calibration Errors

![Graph showing yield monitor error (%) against grain flow rate (bu/min)]

Multi-Point Calibration

![Graph showing grain mass flow rate (lb/sec) against mass flow sensor output (V)]
Multi-Point Calibration Errors

Calibration Notes

Mass Flow Sensor
- Accurate calibration is critical!
- Our goal is to calibrate mass flow rate
- Yield estimations come later
- Errors from 1 to 3% are expected (field average)
- Conduct at least one calibration per crop per year
- Test weights may affect accuracy…recalibrate
Moisture Sensing

Moisture is necessary for marketable yield

- Different sensor types:
  - Flow-through
  - Single-sample
- Electrical resistance of grain measured
- Indirectly proportional to MC
- Affected by temperature (measured), bulk density and surface moisture
- Manual entry not recommended

Output from the Yield Monitor Computer

Text file (.txt or .csv) format:
Output from the Yield Monitor Computer

What important data are in those columns:

- GPS location (latitude and longitude)
- Mass flow rate (lb/sec)
- Logging interval (sec)
- Distance traveled (in or ft)
- Header cut width (in or ft)
- Moisture content (%)

Estimating our Crop Yield

We need a little more information:

- Adjusting the crop moisture content to a marketable value
- What is the moisture content for that?
- We know our mass flow rate (lb/sec) but we want bushels…we need to estimate the density

<table>
<thead>
<tr>
<th>Grain</th>
<th>Moisture (%)</th>
<th>Grain Density (lb/bu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>15</td>
<td>56</td>
</tr>
<tr>
<td>Soybeans</td>
<td>13</td>
<td>60</td>
</tr>
<tr>
<td>Wheat</td>
<td>13.5</td>
<td>60</td>
</tr>
</tbody>
</table>
**Estimating our Crop Yield**

We use the general formula for yield (bu/ac):

\[
Yield \left( \frac{bu}{ac} \right) = (43,560) \left( \frac{m \times t}{d \times w \times \rho} \right) \left( \frac{100 - MC_{harvest}}{100 - MC_{market}} \right)
\]

Where:

- \( m \) = mass flow rate (lb/sec)
- \( MC_{harvest} \) = % moisture content at harvest
- \( MC_{market} \) = % marketable moisture content
- \( t \) = logging interval (sec)
- \( d \) = travel distance (ft)
- \( w \) = header cut width (ft)
- \( \rho \) = grain density (lb/bu)
- 43,560 = conversion from ft² to acres

**Estimating our Crop Yield-Example**

The yield data output shows a mass flow rate of 15.1 (lb/sec) of corn at a moisture content of 19.3% when traveling 54 inches in a one second logging interval. The header cut width of the combine was 240 inches (8 row header at 30 inches). What is the resulting yield in marketable bu/ac?

\[
Yield \left( \frac{bu}{ac} \right) = (43,560) \left( \frac{m \times t}{d \times w \times \rho} \right) \left( \frac{100 - MC_{harvest}}{100 - MC_{market}} \right)
\]
Estimating our Crop Yield - Example

Let's start by putting in the MC market & density
- $MC_{\text{market}} = 15\%$
- Density = 56 lb/bu

\[
Yield \left( \frac{bu}{ac} \right) = (43,560) \left( \frac{m \cdot t}{d \cdot w \cdot 56} \right) \left( \frac{100 - MC_{\text{harvest}}}{100 - 15} \right)
\]

Now the mass flow and logging interval
- Mass flow rate = 15.1 lb/sec
- Logging interval = 1 sec

\[
Yield \left( \frac{bu}{ac} \right) = (43,560) \left( \frac{15.1 \cdot 1}{d \cdot w \cdot 56} \right) \left( \frac{100 - MC_{\text{harvest}}}{100 - 15} \right)
\]

We can input our moisture content while harvesting:
- $MC_{\text{harvest}} = 19.3\%$

\[
Yield \left( \frac{bu}{ac} \right) = (43,560) \left( \frac{15.1 \cdot 1}{d \cdot w \cdot 56} \right) \left( \frac{100 - 19.3}{100 - 15} \right)
\]

Finally, we can input our travel distance and header cut width...can't we? What about the units?
- Travel distance = 54 inches = 4.5 feet
- Header cut width = 240 inches = 20 feet

\[
Yield \left( \frac{bu}{ac} \right) = (43,560) \left( \frac{15.1 \cdot 1}{4.5 \cdot 20 \cdot 56} \right) \left( \frac{100 - 19.3}{100 - 15} \right)
\]

Now we're ready! = 123 bu/ac
Creating the Yield Map

We really only need 3 pieces of information:

- Latitude
- Longitude
- Yield

But, we have to have software (GIS) like SMS

Summary

- Yield monitor components and their functions
- Importance of yield monitor calibration
- Estimating yield from the yield monitor output

- Moving forward…