Yield Monitoring and Mapping

Yield Monitoring

- Most popular precision agricultural operation
- Aids in quantifying spatial and temporal variability in soil and crop properties

Yield Monitoring and mapping

Yield monitors provide a way to quantify yield variations that producers know exist.

Definition of yield map

A yield map is a spatially referenced, graphical representation of crop yield for a defined area.

Yield mapping includes:

- Acquisition
- Analysis, and
- Summarization of crop yield data by location within a field.

Final product is usually a tonal or colored map displaying ranges of yield within a field.

Types of yield map

1. Inference maps
2. Prediction maps
3. Interpolation maps, and
4. Aggregation maps.
1. *Inference maps*:

Are developed by associating yield estimates with existing map delineations without changing the delineations on a base map.

For e.g. associating a yield goal with a soil map unit in a county soil survey.

<table>
<thead>
<tr>
<th>Type</th>
<th>Yield Goal (bu/ac)</th>
<th>1A</th>
<th>1B</th>
<th>25B</th>
<th>29B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bojac</td>
<td></td>
<td>104</td>
<td></td>
<td>100</td>
<td>175</td>
</tr>
<tr>
<td>Wickham</td>
<td></td>
<td>142</td>
<td></td>
<td>140</td>
<td>175</td>
</tr>
</tbody>
</table>

50 lb N/ac starter band applied on whole field

2. *Prediction maps*:

Yield component is not measured but predicted from other spatial data using a prediction function or model.

For e.g. Predicting crop yield as a function of soil/weather properties for a region or field

![Soil EM 38 readings](Image)

3. *Interpolation maps*:

- Yield measurements are made at specific locations and
- Yield values between data points are estimated using interpolation techniques.
- Measured data are obtained at a much coarser scale than the estimation scale (similar to grid sampling).

4. *Aggregation maps*:

Yield maps derived from measured data in which either the original data or some aggregation of the data are mapped.

Once yield measurements are determined, no estimation, prediction, or interpolation of point yield data is required for mapping because the intensity of data collection is on a very high scale.

E.g. Site-specific instantaneous (on-the-go) yield monitoring system.
Three major yield measuring approaches

1. **Collect and weight**: The most common and widely used method, weighing crop after being threshed, separated, and cleaned.

2. **Batch type**: It holds large volume of grain harvested from a total area.

3. **Instantaneous**: When combined with a GPS/DGPS system, produce site-specific grain yield maps.

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**An in-cab batch-type yield monitor**

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**8-row header**

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**Instantaneous yield monitor display location crop yield, area, moisture content, etc all in dynamic mode**

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**AgLeader InSight display does it all**

- planner and application control
- yield monitoring
- real-time data logging
- automated steering control, and much more
Calculating grain yield on-the-go...

To determine instantaneous crop yield need 3 pieces of information:

- Grain flow rate (lbs/sec)
- Combine’s travel speed (ft/sec)
- Cutting width of header (ft)

Example: Calculate the instantaneous grain yield of a combine with an 8-row corn header harvesting at a speed of 10 miles per hour. The corn row width is 30” and the grain flow sensor recorded a flow rate of 78 lbs/sec for the previous second.

Recall:
- 1 mile = 5280 ft
- 1 hr = 3600 sec
- 1 acre = 43560 ft

Moving at 10mi/hr = 14.67 ft/sec

Header width = 20 ft

Area harvested = 293 ft²/sec

Size of the area represented by a yield pixel

One yield pixel/second is collected

Calculating grain yield on-the-go...
**Various types of grain flow sensor**

- Impact Force Sensor
- Plate Displacement Sensor
- Radiometric Sensor/System
- Load Cell System
- Volume Measurement System

(i) **Impact Force Sensor:**

Grain flow is measured by quantifying the amount of force applied when the grain strikes on a spring-loaded impact plate. 

Force is measured by a load cell that converts load into electrical signal. A very light impact on the plate causes a measurable change in the resistance of the electrical current flow. Change in electrical flow is proportional to amount grain flow.

(ii) **Plate Displacement Sensor:**

Similar to impact force sensor. Measure displacement of plate and not force. Grain flow is measured by quantifying the displacement of the plate when the grain strikes on a spring-loaded impact plate.
(ii) Plate Displacement Sensor:
Similar to impact force sensor. Measure displacement of plate and not force.

(iii) Radiometric System:
Uses a radiation source (Americium 241). Measures the intensity of radiant energy.
- Intensity is inversely proportional to grain flow.
- It is max. when there is no obstruction (no grain flow).
- It decreases with grain flow.

(iv) Load Cell System:
The system actually weighs the grain as it passes through combine’s clean grain auger. Grain flow rate is proportional to the load cell electrical impulse.
Optical sensor detects the degree to which grain elevator is loaded. Measurement of light and dark period is used to estimate grain flow volume. Must know bulk density (mass/unit volume) to estimate grain yield.

\[
\text{Grain flow (mass)} = \text{volume} \times \frac{\text{mass}}{\text{volume}}
\]

Yield monitor components:

I. Grain Flow Sensor
II. Grain Moisture Sensor
III. Ground Speed Sensor
IV. Header Position Switch
V. Display Console

Various types of Grain Flow Sensor:
- Impact Force Sensor
- Plate Displacement Sensor
- Radiometric Sensor/System
- Load Cell System
- Volume Measurement System

Let’s have a look at Grain Moisture sensor.

Yield monitor components:

II. Grain Moisture Sensor:

Grain moisture content is of great practical importance. It affects:
- Timing of harvest
- Amount of grain damage during harvest
- Drying cost
- Storage issues (pest damage, etc)

Moisture sensor is located in combine’s clean grain conveying system near grain flow sensor. It is a Capacitance type sensor, works on the principle of measuring dielectric property of a substance (Grain).

Dielectric constant of:
- Water \( \approx 78 \)
- Soil \( \approx 4 \)
- Vacuum \( \approx 1 \)

A capacitance type grain moisture sensor
III. Ground Speed Sensor:

- An ultrasonic ground speed sensor
- In wet slippery conditions

IV. Header Switch:

- When header is in raised position area measurement is suspended even when combine is running
- Area measurement is resumed when header is at cutting height

V. Display Console:

- Operator supplied information:
  - Field name
  - Load name or number
  - Cutting width

- Sensed/Calculated information:
  - Crop moisture content
  - Instantaneous yield
  - Average yield
  - Area harvested
  - Travel speed
  - Quality of DGPS signal reception
YIELD MONITORING DEVELOPMENTS FOR NON-GRAIN CROPS

- Yield monitoring has been most widely applied to grain harvesting, but is certainly not limited to grains.
- Yield monitors are being, or have been, developed for several non-grain crops as listed in the table below. The list is expected to grow in the near future.

<table>
<thead>
<tr>
<th>Crop Method</th>
<th>Measurement Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>load cells</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>load cells</td>
</tr>
<tr>
<td>Sugar beets</td>
<td>load cells</td>
</tr>
<tr>
<td>Peanuts</td>
<td>load cells</td>
</tr>
<tr>
<td>Cotton</td>
<td>load cells</td>
</tr>
<tr>
<td>Forage Crops (baled)</td>
<td>load cells</td>
</tr>
<tr>
<td>Forage Crops (chopped)</td>
<td>shaft torque sensing</td>
</tr>
<tr>
<td>Forage Crops (chopped)</td>
<td>load cells</td>
</tr>
</tbody>
</table>