Leveraging Corn Genetics Through Grid-Driven Agronomics

Joe Lauer
University of Wisconsin – Madison
GPS Dairy Consulting Leaders Forum
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Overview

- Corn genetics and progress
- To describe the realities of precision farming and grid management
  - Spatial variability
  - Temporal variability
- A real world situation:
  - To develop and classify site-specific management zones based on past grain yield
  - To determine if managed inputs (i.e. seeding rate) should be adjusted based upon management zone classification

Precision Agriculture Adoption
“Technology is available, agronomy is lacking.”

Corn grain and silage yield in Wisconsin since 1866
The yield march continues ...

For a copy of these slides, see http://corn.agronomy.wisc.edu
Desirable Forage Characteristics

- What makes a good forage? (Carter et al., 1991)
  - High yield
  - High energy (high digestibility)
  - High intake potential (low fiber)
  - High protein
  - Proper moisture at harvest for storage

- Ultimate test is animal performance
  - Milk2006 is our best predictor for performance (Schwab - Shaver equation)

Feed and Forage Use on 4,000 Cow Dairy

- Assumptions
  - 4000 milking cows (Lactating Cows); 800 dry cows (DC); no growing heifers
  - 80 lb. Milk/cow/day
  - Total DMI: LC 50 lb./d; DC 30 lb/d
  - Dietary Forage Content (% of DM) LC 50%; DC 80%; Total 53%
  - Forage DMI: LC 25 lb/d; DC 24 lb/d

<table>
<thead>
<tr>
<th></th>
<th>TMR Fed, tons DM</th>
<th>Refusals @ 3%, tons DM</th>
<th>Acres Needed @ 6%</th>
<th>Approximate Cost</th>
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<tr>
<td>Daily</td>
<td>115</td>
<td>3</td>
<td>72</td>
<td>+450 $2.5M</td>
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<tr>
<td>Weekly</td>
<td>808</td>
<td>24</td>
<td>506</td>
<td>+1,019 $5.0M</td>
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<tr>
<td>Monthly</td>
<td>3,233</td>
<td>97</td>
<td>2,024</td>
<td>+1,577 $7.5M</td>
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<tr>
<td>Annually</td>
<td>38,796</td>
<td>1,164</td>
<td>24,288</td>
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Forage value: ~ $9,000,000
Milk value: ~ $18,000,000
What is an Average Corn Silage Hybrid?

<table>
<thead>
<tr>
<th>Trait(s)</th>
<th>GxE</th>
<th>Forage yield</th>
<th>NDF</th>
<th>NDFD</th>
<th>Starch</th>
<th>Milk2006</th>
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<tr>
<td>Normal</td>
<td></td>
<td>N 7 DM/A 7%</td>
<td>59</td>
<td>30</td>
<td>3100</td>
<td>25000</td>
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<tr>
<td>Bmr</td>
<td>126</td>
<td>6.4 48</td>
<td>67</td>
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<td>21000</td>
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<td>Leafy</td>
<td>240</td>
<td>8.1 48</td>
<td>59</td>
<td>27</td>
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<td>25000</td>
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<tr>
<td>CB</td>
<td>736</td>
<td>8.1 46</td>
<td>59</td>
<td>31</td>
<td>3100</td>
<td>26000</td>
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<tr>
<td>RR</td>
<td>339</td>
<td>7.8 47</td>
<td>58</td>
<td>30</td>
<td>3100</td>
<td>24000</td>
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<tr>
<td>CB,LL</td>
<td>331</td>
<td>8.2 47</td>
<td>59</td>
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<td>26000</td>
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<tr>
<td>CB,RR</td>
<td>395</td>
<td>8.0 46</td>
<td>59</td>
<td>32</td>
<td>3100</td>
<td>25000</td>
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<tr>
<td>CB,RW,RR</td>
<td>891</td>
<td>7.9 46</td>
<td>58</td>
<td>32</td>
<td>3100</td>
<td>25000</td>
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<tr>
<td>LSD(0.05)</td>
<td>0.6</td>
<td>2 1 4 100</td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Average</td>
<td>7403</td>
<td>8.0 47</td>
<td>58</td>
<td>30</td>
<td>3100</td>
<td>25000</td>
</tr>
</tbody>
</table>

Selecting Corn Hybrids in the Transgenic Era
Increasingly Hybrid Selection Dictates Management

- **Principles for Selection**
  - Use independent yield trial data of multi-location averages.
  - Evaluate consistency of performance.
  - Pay attention to seed costs.
  - Every hybrid must stand on its own for performance; it must pull its own weight.
  - Buy the traits you need.

  - “Traits do not add to yield … Traits protect yield.”
Precision farming – “Success is proving elusive”
Technology is available, but the agronomy is lacking.

Farmer frustrations because so far little economic benefit seen with yield maps ...

**Materials and Methods**

- Data used was 26 years from a corn-soybean rotation x tillage experiment at Arlington
  - Conventional tillage
  - Continuous corn
- Cells measured 30 x35 feet.
  - Three to four measurements (pixels) in cell per year
  - Same site every year
    - Cells: 6, 28, 32, and 53

**Equipment and Data**

- The technology is available, but the agronomy is lacking.
- Cost of precision agricultural equipment
- Sensitive equipment
  - Requires frequent calibration ("GIGO")
  - Requires both yield monitor AND GPS data.
- Computer resources
  - Data management
  - Software for analysis is sophisticated and complicated

**People**

- Lack of training and time required for producers and industry to learn, operate and maintain equipment and software
- Lack of local technical assistance for management decisions. Uncertainty with using analyzed data to influence decision making and future recommendations
  - Is the pressure put on growers and consultants to use PF justified?
  - Ads: "Place the right _____ in the right field at the right time."
  - "We will help you make your decisions regarding precision farming."
- Most benefit is to people in the field rather than absentee owners.
  - Data requires interpretation (notes)
Spatial and Temporal Variation of Corn Yield (bu/A) of Four Subfields (6, 28, 32, and 53)

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<tbody>
<tr>
<td>6</td>
<td>176</td>
<td>175</td>
<td>215</td>
<td>220</td>
<td>239</td>
<td>232</td>
<td>255</td>
<td>216</td>
<td>201</td>
<td>203</td>
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<tr>
<td>28</td>
<td>159</td>
<td>191</td>
<td>235</td>
<td>210</td>
<td>---</td>
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<td>---</td>
<td>----</td>
<td>----</td>
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</tr>
<tr>
<td>32</td>
<td>122</td>
<td>160</td>
<td>204</td>
<td>216</td>
<td>224</td>
<td>191</td>
<td>268</td>
<td>168</td>
<td>169</td>
<td>161</td>
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<tr>
<td>53</td>
<td>134</td>
<td>163</td>
<td>207</td>
<td>204</td>
<td>244</td>
<td>232</td>
<td>268</td>
<td>193</td>
<td>172</td>
<td>176</td>
</tr>
</tbody>
</table>

Temporal variability (1987-2012)

Subfield       Mean   Range   StD
6              176     97     49
28             159     109    42
32             122     64     43
53             134     120    43

Spatial variability (4 Sites)

- Mean 148
- Range 109
- StD 24

Materials and Methods

Randomized Complete Block Design with four seeding rates applied to plots within each subfield: 54 400, 74 100, 93 900, and 114 000 seeds ha⁻¹

Fields selected due to availability of past yield maps

- Field 1: 10 strips, 12 years of data previous field management 2001-2012 included strip treatments
  - 20 subfields (0.33 ha)
  - Plot size: 18 by 46 m
Management Zone Creation Process

Materials and Methods - Planted Map

Partial Budget Analysis
Grower Return = (Commodity Price * Grain Yield) – Costs
2013 Commodity Price = $159.06 Mg⁻¹

Costs

<table>
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<tr>
<th>Item</th>
<th>Price</th>
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<tbody>
<tr>
<td>Seed</td>
<td>$3.73 per 1000 kernels (Dairyland 95-01)</td>
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<tr>
<td>Handling</td>
<td>$0.78 Mg⁻¹</td>
</tr>
<tr>
<td>Hauling</td>
<td>$1.57 Mg⁻¹</td>
</tr>
<tr>
<td>Trucking</td>
<td>$4.33 Mg⁻¹</td>
</tr>
<tr>
<td>Storage</td>
<td>$0.78 Mg⁻¹</td>
</tr>
<tr>
<td>Grain drying</td>
<td>$0.03 per point of moisture</td>
</tr>
</tbody>
</table>

ANCOVA of MYPD and EOPD using SAS PROC MIXED
- Utilized spatial exponential covariance structure
- Model Fitting Procedure
  1. H₀: all slopes were equal to zero
  2. H₀: covariant slope is equal to zero
  3. Fit data to a common slope model of significant coefficient terms where
    \[ y = a + bx + cx² \]

2013 Grain Yield Data: Mean and Standard Deviation

Maximum Yield Plant Density at Harvest

A maximum yield plant density in 22% of the subfields and 25% of the management zones
An economically optimum plant density in 41% of the subfields and 0% of the management zones

\[ y (Grain Yield) = a + 0.13x + -0.00077x^2 \quad R^2 = 0.26 \]

Field 1: 86,000 plants ha⁻¹ (35,000 plants/A)

H/L MZ \[ a = 7.5 \pm 0.14 \]
L/L MZ \[ a = 6.7 \pm 0.13 \]
HL/H MZ \[ a = 7.6 \pm 0.10 \]
**Economically Optimum Plant Density at Harvest**

Field 1: 65,400 plants ha\(^{-1}\)
(27,000 plants/A)

\[ y (\text{Grower Return}) = a + 13.40x - 0.10x^2 \quad R^2 = 0.59 \]

- H/L MZ  \( a = 1084.2 \pm 19.2 \)
- L/L MZ  \( a = 1003.1 \pm 19.1 \)
- HL/H MZ  \( a = 1073.0 \pm 13.5 \)

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**How much do corn silage hybrids vary across fields and farms?**

- Dairymen desire a uniform forage product for rations
- Field uniformity
  - Field knobs versus swales
  - Soil type
- Forage is mixed during:
  - Chopping, hauling and handling
  - Piling and compacting
  - Fermentation and ensiling
- Objective: Describe forage quality variability
  - Within a field
  - Between fields on a farm

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**Materials and Methods**

- Example: Pioneer 33F88
  - Arlington, Lancaster, Galesville, Fond du Lac
- Variability (standard deviation)
  - Field: reps (n=3)
  - Farm: locs (n=6)
  - Year: years (GxE > 12)
- UW Corn Silage Program
  - 1995-2012
  - 10 Locations
  - 8295 hybrids in 276 trials using 25,515 plots

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Photo by Mike Rankin
Forage yield (T/A) variability across fields and farms for Pioneer 33F88

<table>
<thead>
<tr>
<th>Year</th>
<th>Field</th>
<th>Farm</th>
<th>Rep 1</th>
<th>Rep 2</th>
<th>Rep 3</th>
<th>Field average</th>
<th>Field variability</th>
<th>Farm average</th>
<th>Farm variability</th>
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<tr>
<td>2009</td>
<td>ARL</td>
<td>9.8</td>
<td>11.0</td>
<td>11.0</td>
<td>10.6</td>
<td>10.6</td>
<td>+ 0.7</td>
<td>9.1</td>
<td>+ 1.6</td>
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<tr>
<td></td>
<td>FON</td>
<td>7.2</td>
<td>7.3</td>
<td>6.5</td>
<td>7.0</td>
<td>7.0</td>
<td>+ 0.4</td>
<td>7.0</td>
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<tr>
<td></td>
<td>GAL</td>
<td>9.9</td>
<td>9.7</td>
<td>9.9</td>
<td>9.8</td>
<td>9.8</td>
<td>+ 0.1</td>
<td>9.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LAN</td>
<td>8.4</td>
<td>7.8</td>
<td>10.6</td>
<td>8.9</td>
<td>9.1</td>
<td>+ 1.5</td>
<td>9.1</td>
<td>+ 1.6</td>
</tr>
<tr>
<td>2010</td>
<td>ARL</td>
<td>9.9</td>
<td>10.6</td>
<td>9.6</td>
<td>10.6</td>
<td>10.6</td>
<td>+ 0.6</td>
<td>10.6</td>
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<tr>
<td></td>
<td>FON</td>
<td>8.0</td>
<td>8.3</td>
<td>9.8</td>
<td>8.6</td>
<td>8.8</td>
<td>+ 0.8</td>
<td>8.8</td>
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<td></td>
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<td>8.8</td>
<td>11.1</td>
<td>8.1</td>
<td>10.0</td>
<td>9.7</td>
<td>+ 1.3</td>
<td>9.7</td>
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<td>8.8</td>
<td>9.6</td>
<td>11.1</td>
<td>9.7</td>
<td>10.0</td>
<td>+ 1.6</td>
<td>10.0</td>
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<td>2011</td>
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<td>9.2</td>
<td>10.7</td>
<td>10.2</td>
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<td>+ 0.1</td>
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<td>10.1</td>
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<td>9.1</td>
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<td>9.6</td>
<td>+ 0.6</td>
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<td>10.4</td>
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<td>+ 0.2</td>
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<td>8.4</td>
<td>8.0</td>
<td>8.7</td>
<td>9.2</td>
<td>9.0</td>
<td>+ 0.2</td>
<td>9.0</td>
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Forage yield and quality variability across fields, farms and years for Pioneer 33F88

<table>
<thead>
<tr>
<th>Year</th>
<th>Forage yield</th>
<th>Forage moisture</th>
<th>NDF</th>
<th>Starch</th>
<th>NDFD</th>
<th>Milk 2006</th>
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<tr>
<td>2006</td>
<td>9.3</td>
<td>66</td>
<td>48</td>
<td>30</td>
<td>57</td>
<td>13000</td>
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<tr>
<td>Mean</td>
<td>9.3</td>
<td>66</td>
<td>48</td>
<td>30</td>
<td>57</td>
<td>13000</td>
</tr>
</tbody>
</table>

Field variability ± 0.7
Farm variability ± 1.3
Year variability ± 1.5

Ratio (%) = Variability/Mean

Summary of field, farm and year variability (+ standard deviation) in the UW hybrid evaluation program

<table>
<thead>
<tr>
<th>Hybrids</th>
<th>Forage yield</th>
<th>Forage moisture</th>
<th>NDF</th>
<th>Starch</th>
<th>NDFD</th>
<th>Milk 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.2</td>
<td>64</td>
<td>47</td>
<td>31</td>
<td>59</td>
<td>3200</td>
</tr>
<tr>
<td>Field variability</td>
<td>8295 ± 0.8</td>
<td>± 2</td>
<td>± 3</td>
<td>± 2</td>
<td>± 100</td>
<td>± 2700</td>
</tr>
<tr>
<td>Farm variability</td>
<td>2899 ± 1.2</td>
<td>± 4</td>
<td>± 4</td>
<td>± 2</td>
<td>± 100</td>
<td>± 4200</td>
</tr>
<tr>
<td>Year variability</td>
<td>577 ± 1.5</td>
<td>± 6</td>
<td>± 4</td>
<td>± 5</td>
<td>± 200</td>
<td>± 4900</td>
</tr>
</tbody>
</table>

Ratio (%) = Variability/Mean

Conclusions

- Temporal variability is greater than spatial variability.
  - Hybrid performance
  - Plant density
- There is often an overall response to a management decision, but not by management zone.
- The maximum yield plant density was 86 000 plants ha⁻¹, while the economically optimum plant density was 65 400 plants ha⁻¹.
- Site-specific management of seeding rate was not more profitable than whole field management for grain yield classified management zones.
- Future directions:
  - To study variable seeding rate, use more plant density treatments and fewer reps.
  - What is the impact of legacy variability?
Future Directions

• What do we do with all these yield maps?
  ✓ Keep collecting them
  ✓ Associate GIS data with yield and moisture measurements
  ✓ Collect other agronomic notes
  ✓ Invest in storing and managing data until you have enough years

• Questions
  ✓ Should a field always get variable rates of inputs?
    ▶ Variance criteria? Spatial > Temporal
  ✓ If a management change is made, how long does it take for the management change to equilibrate? Do you start the clock over again?
  ✓ Could land value increase if you have a yield map history?

• Future crop yield gains will likely occur with agronomic management decisions.

Questions?

Website: http://corn.agronomy.wisc.edu
To subscribe (unsubscribe) to season updates
WiscCorn.blogspot.com
@WiscCorn
WiscCorn

Thanks for your attention!

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