Development of a New Procedure to Design In-Season Variable Rate Nitrogen Fertilizer Prescription Maps for Michigan Wheat Farmers

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Objectives

- To evaluate the **economic** and **environmental** benefits of implementing a spatially variable N fertilizer application in consideration of spatial variability in wheat fields.
Rationale

• Applying N in a spatially variable manner gives the grower the ability to customize their inputs to match the plant’s nutrient demand, which varies over space and years

• Decreasing excess fertilizer improves resources (N) efficiency and profitability

Basso Rx map visualized on applicator monitor
History of Basso Lab for MI Wheat Checkoff


- **2017 & 2018**: Strategic and Tactical Nitrogen Management Using Drone Images and Crop Modeling to Increase Protein Content and Grain Quality in Wheat

- **2019 & 2020**: Development of a New Procedure to Design In-Season Variable Rate Nitrogen Fertilizer Prescription Maps for Michigan Wheat Farmers
Crop simulation modeling, yield history, and remote sensing integrated to provide accurate yield forecasts with multiple N scenarios.

• **Working towards turn-key solution**

- Crop model simulations for different weather scenarios

- Basso lab drone collecting remotely sensed imagery
History of Basso Lab for MI Wheat Checkoff

• Trends of wheat yields related to yield stability zone in 145 field-years

• Includes multiple wheat varieties and N management strategies

Yield data at each yield stability zone for 145 site-years
2019-2020 Project Design and Implement Rx Maps in Wheat

- Scale-up Rx methodology
- 730 acres of Rx made in wheat for 2020
- Provided maps for N application for March-April-May applications
Methodology

UAV NDRE (left) and generalized grid Rx map (right) with rates adjusted to match model simulations.
2019-2020 Project
Design and Implement Rx Maps in Wheat

[Graph showing N Use Efficiency (%) with categories High & Stable, Medium & Stable, Low & Stable, Unstable Depression, Unstable Slopes, Unstable Hilltop, and two methods: Rx and Uniform]
2019-2020 Project
Design and Implement Rx Maps in Wheat

![Graph showing nitrogen supplied by soil (lb N/ac) for different soil conditions and methods.](#)
2019-2020 Project
Design and Implement Rx Maps in Wheat

- $0.45/lb of N
- $5/bu of wheat
- $300/acre for production

- **Profit maps** are adapted to adjust input/output costs depending on year

3 out of 8 fields where Rx maps were implemented
Conclusions

• This 2-year project developed a protocol/procedure for creating variable rate Rx maps in wheat.
• The Basso Rx method showed a benefit to increase NUE (from 75% to 120%) which also leads to a reduction of nitrate losses. **(Environmental benefits)**
• The Rx optimizes the return on investment by showing positive return in stable areas. **(Economic benefits)**
High-Intensity Management of Nitrogen in Wheat: How Soil Water Forecast Modeling Improves Fertilizer Efficiency

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Rationale

- Managing N would be a lot easier if fields were consistent and uniform.

- High-Intensity Management Trials incorporate additional N with PGRs, fungicides to encourage greater production and quality.

<table>
<thead>
<tr>
<th>Additional Nitrogen</th>
<th>Plant Growth Regulator Example</th>
<th>Fungicide Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 10-30 lb N/ac</td>
<td>Palisade, Manipulator</td>
<td>Priaxor, Caramba</td>
</tr>
</tbody>
</table>

Mid-season N application with strip-trial in Springport field.
Rationale

• Reality is these fields have immense spatial variability

• This variability affects every management decision

• These patterns of variability are known and quantified!

Springport field visualized via RGB camera on drone at 400 ft.
Rationale

- Reality is these fields have immense spatial variability
- This variability affects every management decision
- These patterns of variability are known and quantified!

### Yield Stability

<table>
<thead>
<tr>
<th>Yield Stability Zone</th>
<th>2013 Yields (bu/ac)</th>
<th>2020 Yields (bu/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High &amp; Stable</td>
<td>106.0</td>
<td>86.8</td>
</tr>
<tr>
<td>Medium &amp; Stable</td>
<td>95.4</td>
<td>80.7</td>
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<tr>
<td>Low &amp; Stable</td>
<td>76.8</td>
<td>65.5</td>
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<tr>
<td>Unstable- Depression</td>
<td>92.1</td>
<td>69.0</td>
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<tr>
<td>Unstable- Slopes</td>
<td>89.1</td>
<td>74.0</td>
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<tr>
<td>Unstable- Hilltops</td>
<td>89.9</td>
<td>67.1</td>
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</tbody>
</table>

Springport field visualized with yield stability map from 13 years of data

Total area: 366.41 ac
13 years of yield data
Rationale & Methodology

Yield History

Crop Modeling

Remote Sensing
Objectives

• **The overall goal** of this two-year proposal is to effectively prescribe wheat N strategies for forecasted weather scenarios related to conventional or HIM for Michigan wheat farmers.

• In **year 1**, we aim to collect and **analyze best N practices** by Michigan Wheat Program Districts and relate trends with soil water availability.

• In **year 2**, we aim to **distribute these recommendations** through a web-based decision support tool that is available to every Michigan wheat grower.
Methodology

- Soil water drives N uptake

- Soil water content varies across field and within fields due to soil-landscape-weather interactions

- Ranges of soil water known for each field

Soil water in profile based on soil water capacity for every field in MI where wheat was grown between 2008-2018. (USDA NASS Cropland Data Layer, 2019).
Methodology

• Field survey to gain knowledge about management strategies in wheat

• Data powers better model calibration and simulation

• Carry out model runs based on regional information for enhanced understanding of soil water variability

Michigan Wheat Program Districts with locations of fields in the Basso Lab yield database.
Methodology

- Design and implement field experiment and trials
- Identify highly productive zones and implement HIM based on field’s variability
- Create Rx’s based on contour or generalized maps

Airborne NDVI (top) and contoured Rx map (bottom) with rates adjusted to match model simulations
Expected Results

- Trends of wheat yields related to yield stability zone for 145 field-years

<table>
<thead>
<tr>
<th>Yield Stability</th>
<th>Avg. Yield</th>
<th>Avg. NUE (Assuming 100 lb N/ac)</th>
<th>Adjusted Rx N Rate</th>
<th>Savings from Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>High &amp; Stable</td>
<td>94.9</td>
<td>1.42</td>
<td>100</td>
<td>n/a</td>
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<tr>
<td>Medium &amp; Stable</td>
<td>84.9</td>
<td>1.27</td>
<td>90</td>
<td>$4/acre</td>
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<tr>
<td>Low &amp; Stable</td>
<td>69.0</td>
<td>1.03</td>
<td>70</td>
<td>$12/acre</td>
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</tbody>
</table>
Many Thanks to the Michigan Wheat Program for Their Support

basso.ees.msu.edu