Nitrogen Diagnostic Tools in Corn Production

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Evaluating Plant-Available N

- Soil N mineralization / Soil supply
  - Indirect procedures (crop rotation)
  - Plant vegetation
    - Yield, N uptake, tissue N, plant sensing
  - Laboratory microbial incubation
  - Total soil N analysis
  - Chemical extraction
    - Water, strong acids or bases, neutral salts
      - Analyze for C, N, distillable NH_3, UV adsorption
  - Soil inorganic NO_3-N (PPNT/PSNT)

Sidedress Soil Nitrate Test
In-Season Test

- Presidedress Nitrate Test (PSNT)
  Late Spring Nitrate Test (LSNT)
  - Take a 0- to 12-inch soil sample when corn is 6 to 12 inches tall
  - Analyze for nitrate-N
  - Determine sidedress N rate

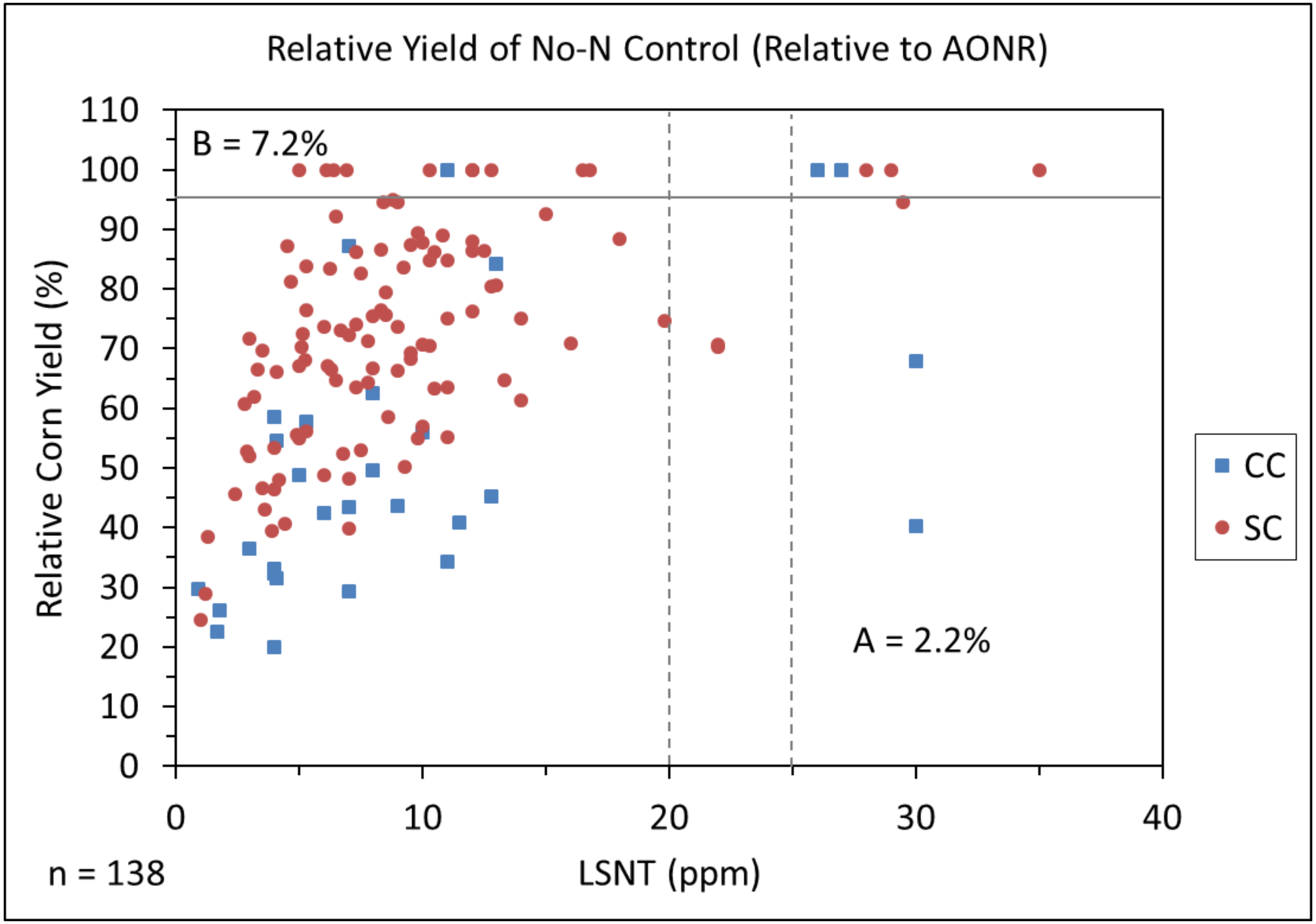
Sidedress Soil Nitrate Test

- Measures
  - Residual soil nitrate
  - Spring mineralized nitrate
    - Soil organic matter or manure organic N
  - Applied nitrate or nitrified ammonium (LSNT)
  - Nitrate present (top foot) at sampling
  - Not ammonium-N
- Sampling banded N difficult (LSNT)
- Best at indicating excess N situations

ISU Soil Test-Based N Recommendations For CC and SC

- Set soil nitrate-N critical value
  - 25 ppm NO_3-N
- If rainfall > 20% above normal between April 1 and sampling time
  - 3 to 5 ppm lower
- (Critical level minus soil test) x 8 = lb N/acre needed

Samples From Corn Zero-N Plots



Sawyer and Barker, 1999-2015

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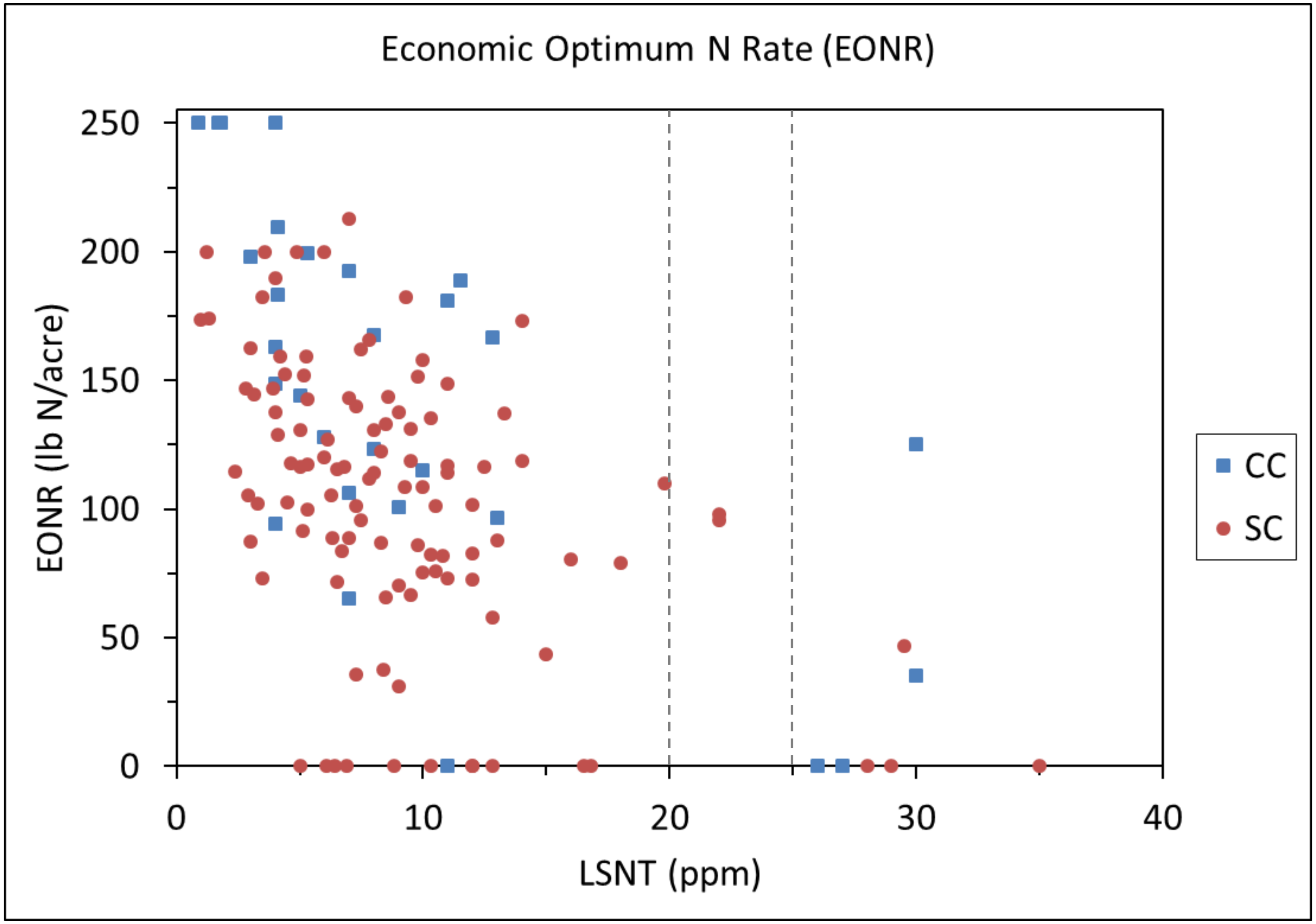
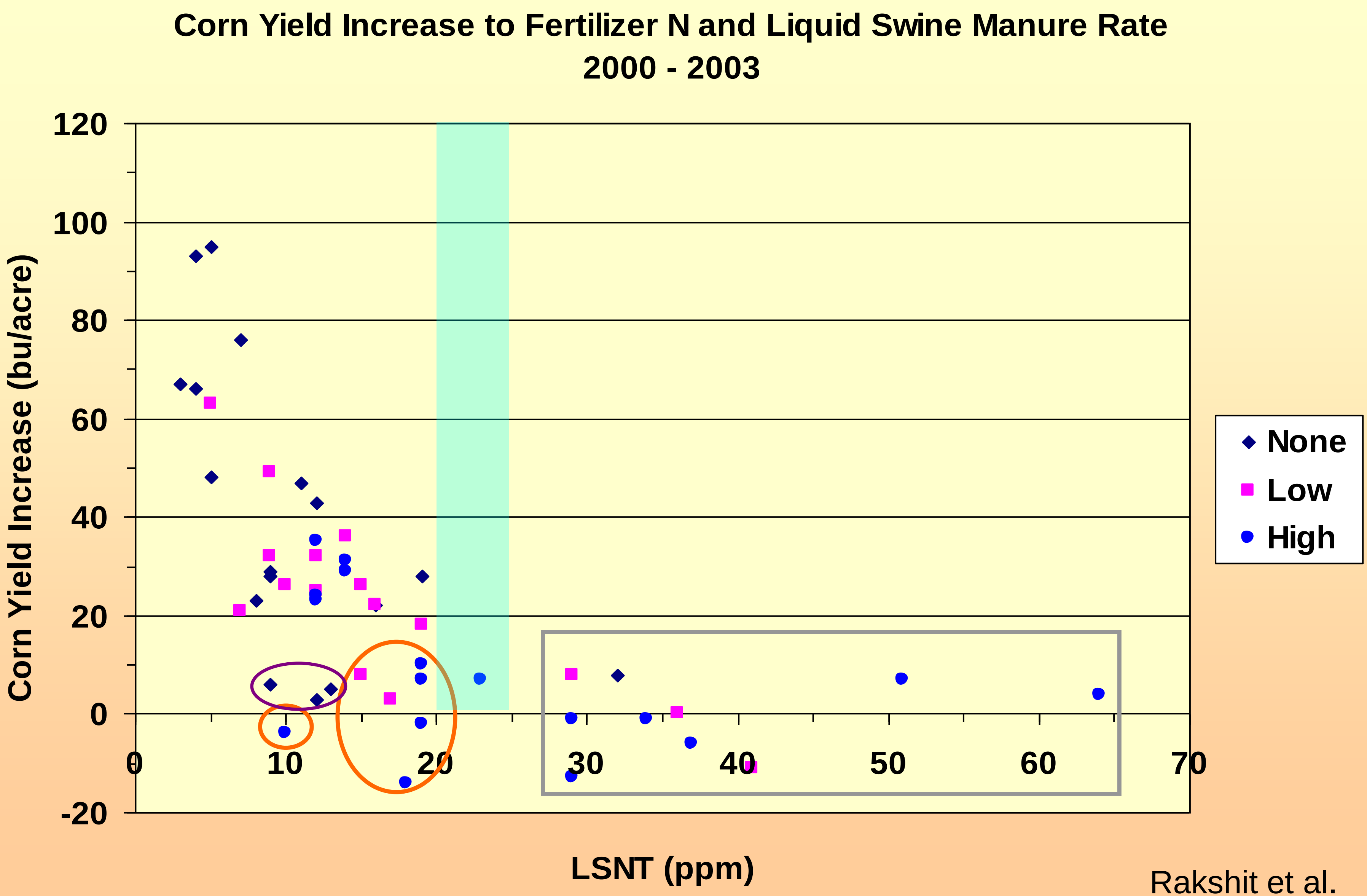
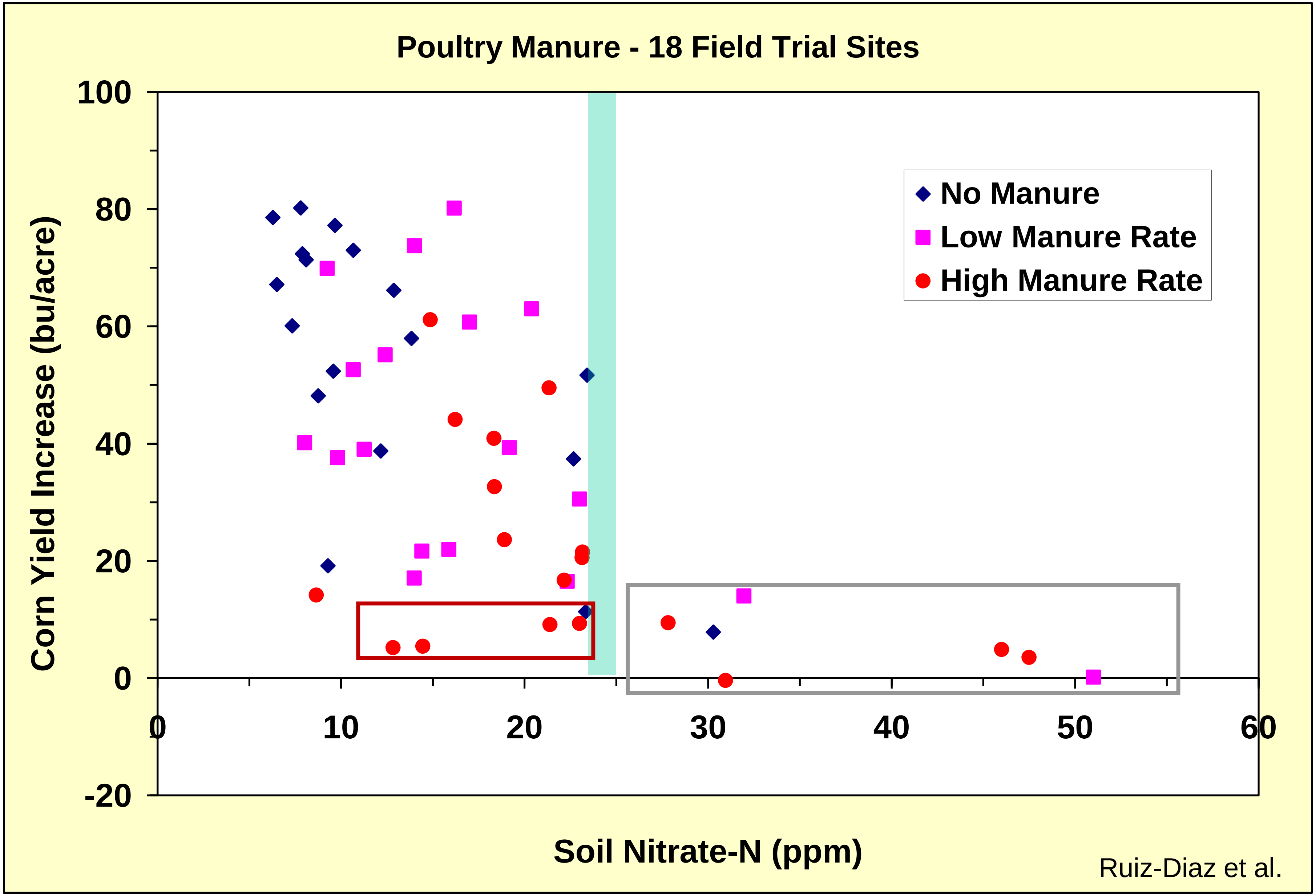


Sawyer and Barker, 1999-2015

Mean 10.7 lb N/acre per LSNT ppm increase



Rakshit et al.


Poultry Manure - 18 Field Trial Sites
100
80
60
40
20
0
-20
0
10
20
30
40
50
60
Corn Yield Increase (bu/acre)
Soil Nitrate-N (ppm)
No Manure
Low Manure Rate
High Manure Rate
Ruiz-Diaz et al.

Corn Stalk Nitrate Test
End-Of-Season Test

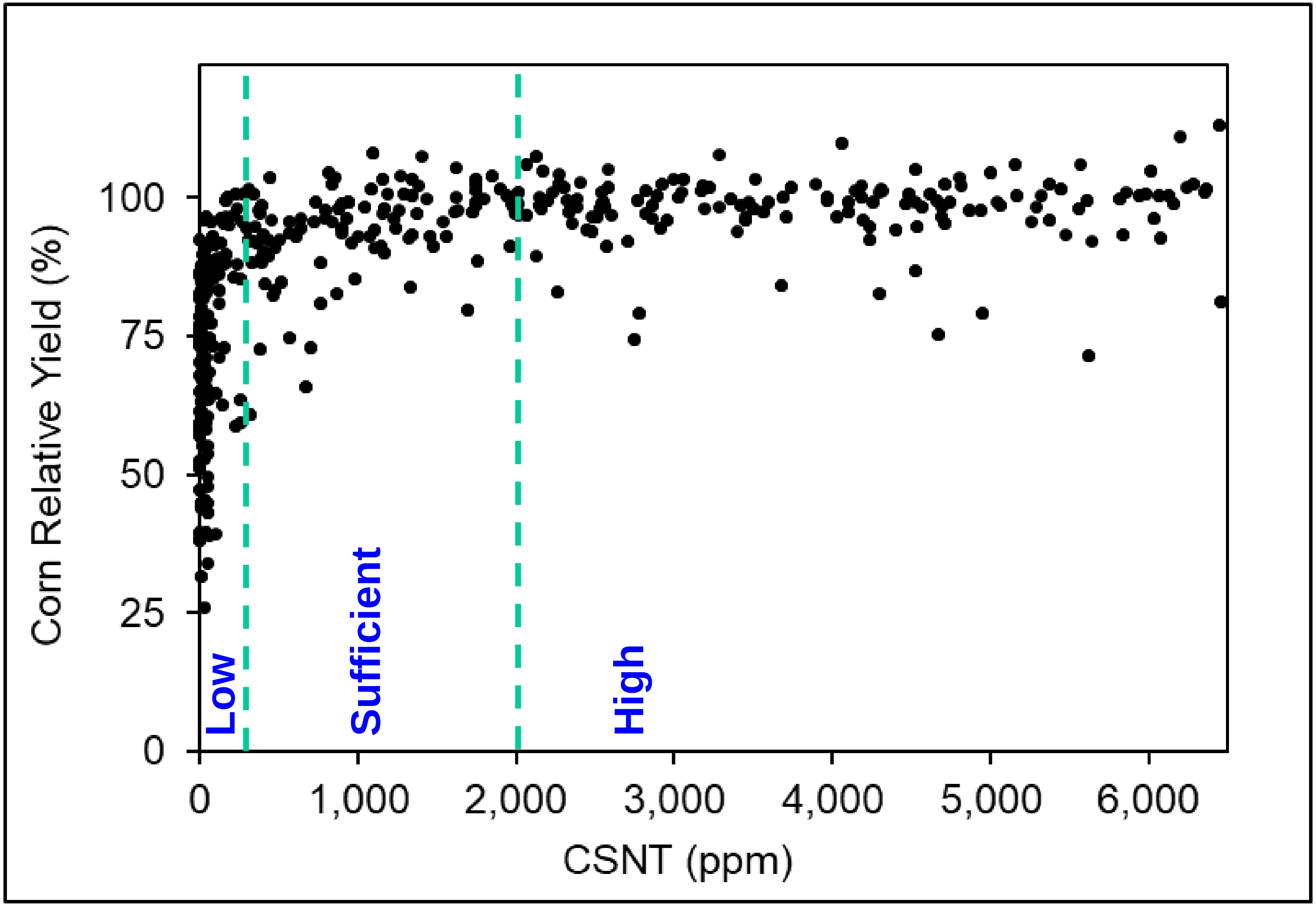
- Weather conditions can impact stalk nitrate concentration
  - Drought – result in high concentration
    - Poor ear development (small N sink)
  - High rainfall (N losses) – result in low concentration
- Insect/disease damage
- Stalk nitrate concentrations will vary from low to high between years in relation to late-season corn N use, corn productivity, optimal need, and soil N supply

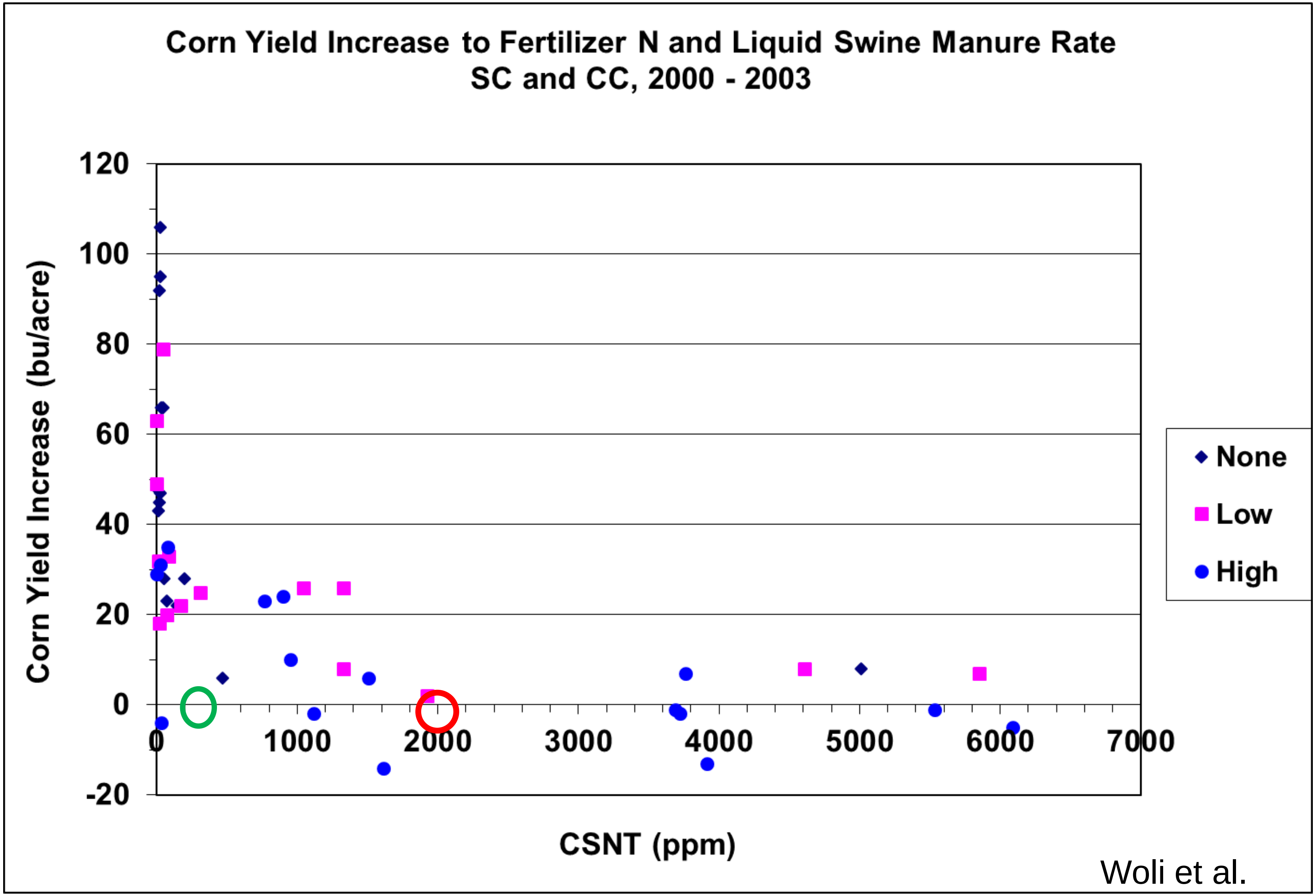
Corn Stalk Nitrate Test

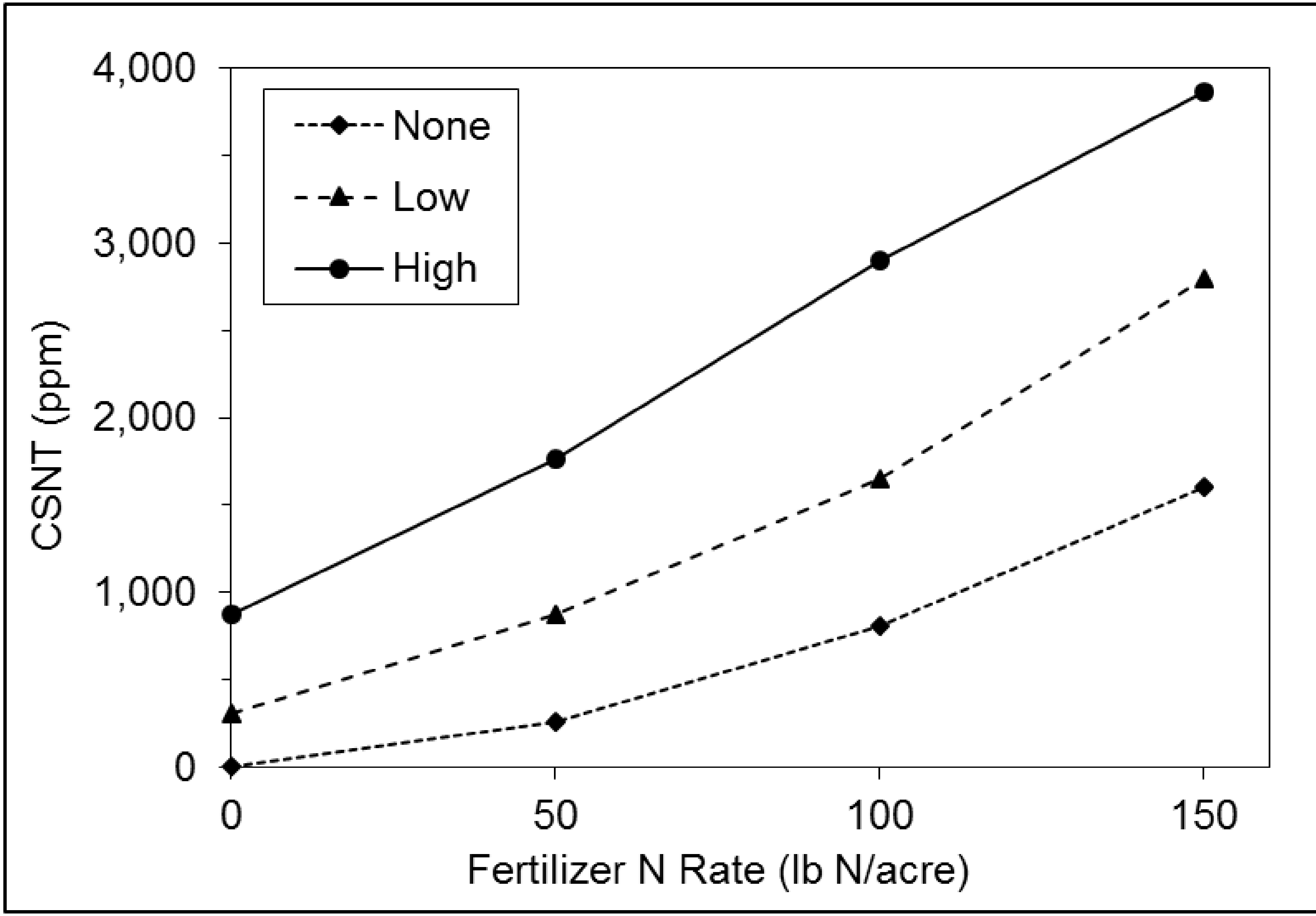
- Consistently low or high? Evaluate for several years
  - Usually in low range:
    - Increase N rate
  - Usually in excess range:
    - Decrease N rate
- Best at indicating excess N situations
- Does not indicate optimal N rate
- Does not indicate how much to change N rate

Corn Stalk Nitrate Test
CROP 3154

Sample stalk: 6 to 14 inch segment above ground
1 to 3 weeks after black layer
Fifteen 8-inch segments per sample

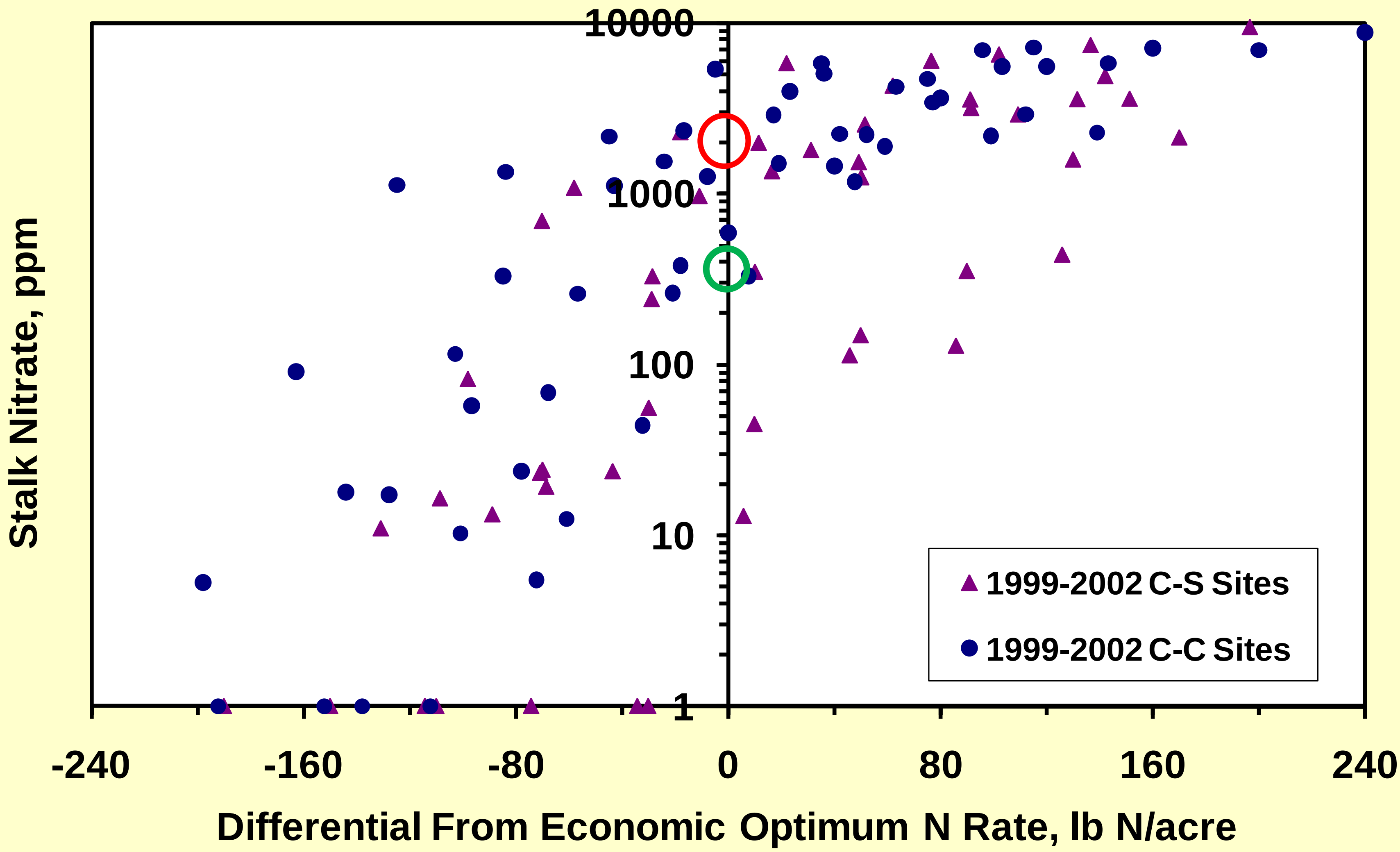



Corn Yield Increase to Fertilizer N and Liquid Swine Manure Rate
SC and CC, 2000 - 2003
Corn Yield Increase (bu/acre)
120
100
80
60
40
20
0
-20
0
1000
2000
3000
4000
5000
6000
7000
CSNT (ppm)
None
Low
High
Woli et al.



Ruiz-Diaz et al. (poultry manure)

Stalk Nitrate at Maturity vs. Applied N Rate Difference from Economic N Response



Sawyer and Barker, ISU

Corn Plant N Stress
In-Season Sensing

Aerial Photo

Aerial Sensed Image

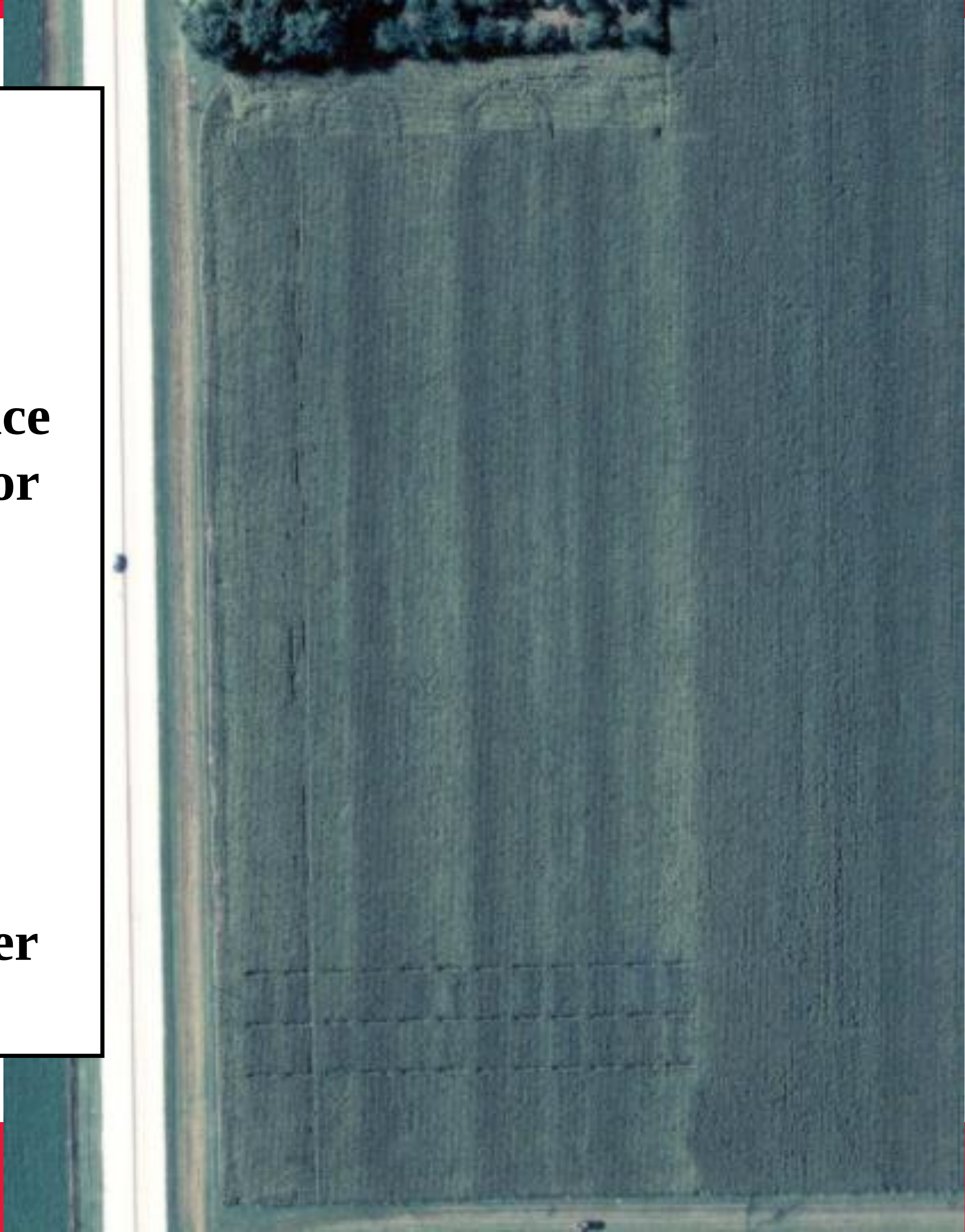
- **Multi-spectral reflectance**

Equipment Mounted Sensor

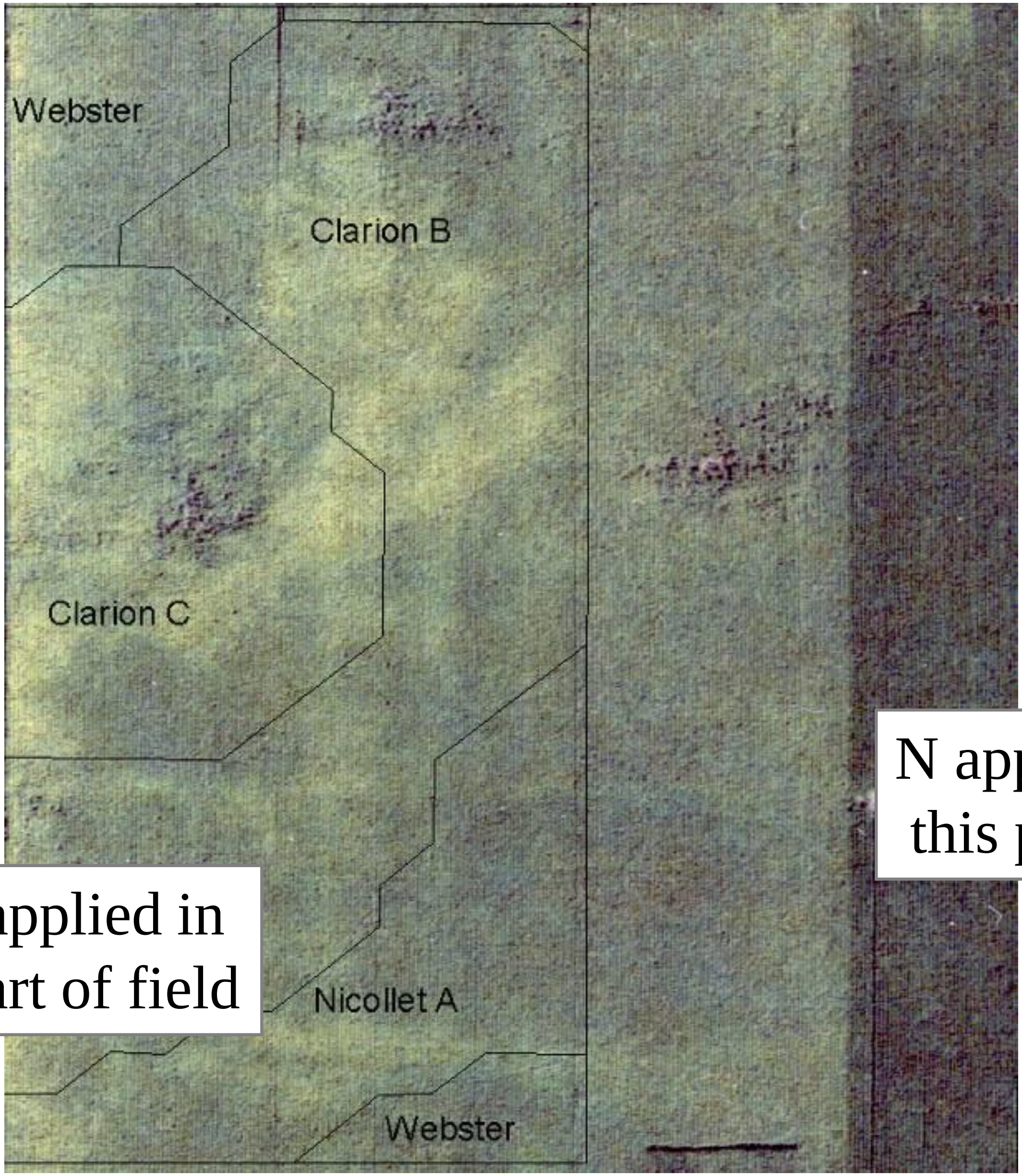
- **Active Canopy Sensors**
  - **GreenSeeker**
  - **Crop Circle**
  - **OptRx**
  - **CropSpec**

Hand-Held Sensors

- **Minolta 502 SPAD Meter**
- **Phone Apps**

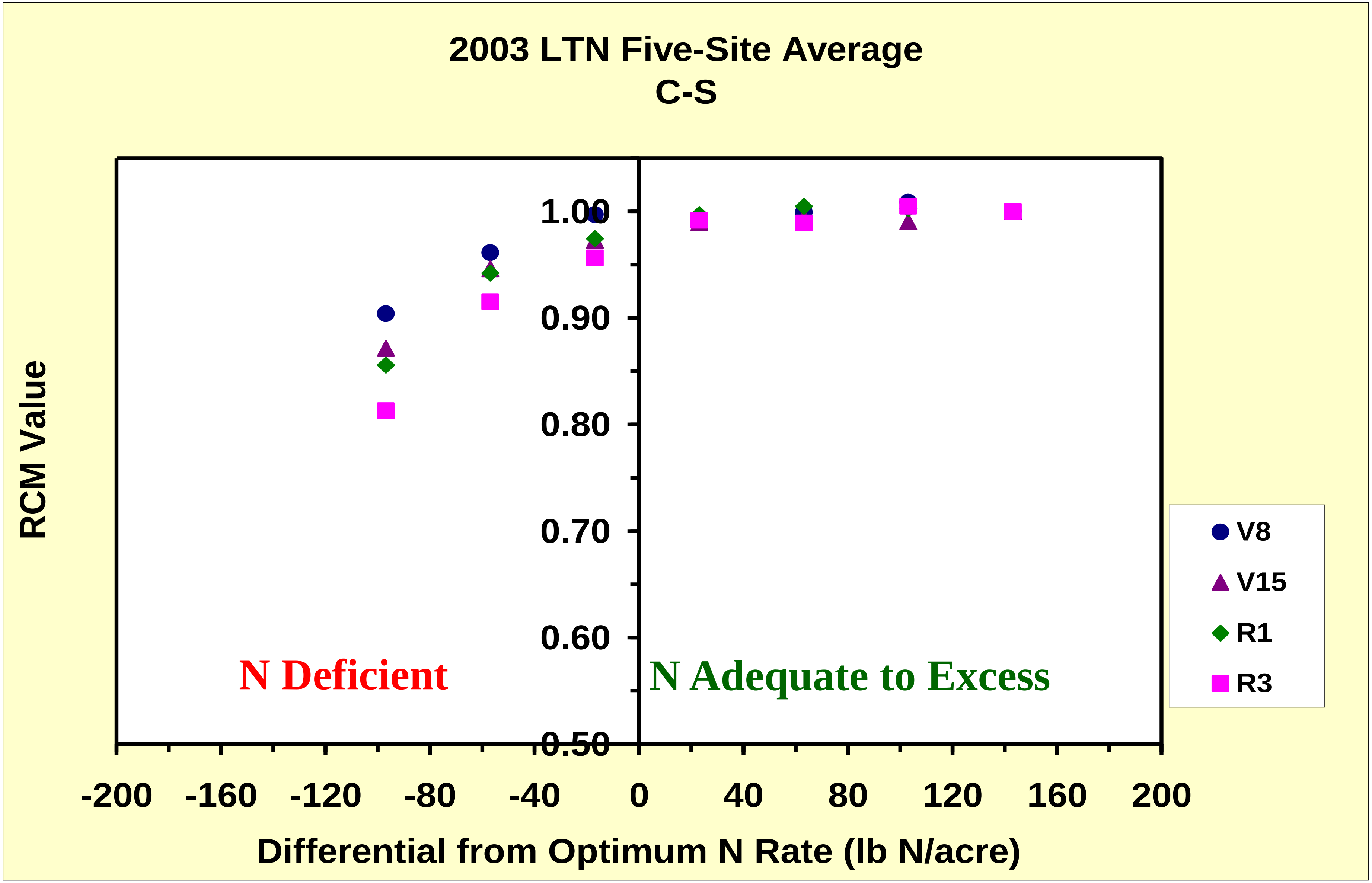


Seeing Field Variability in N Deficiency



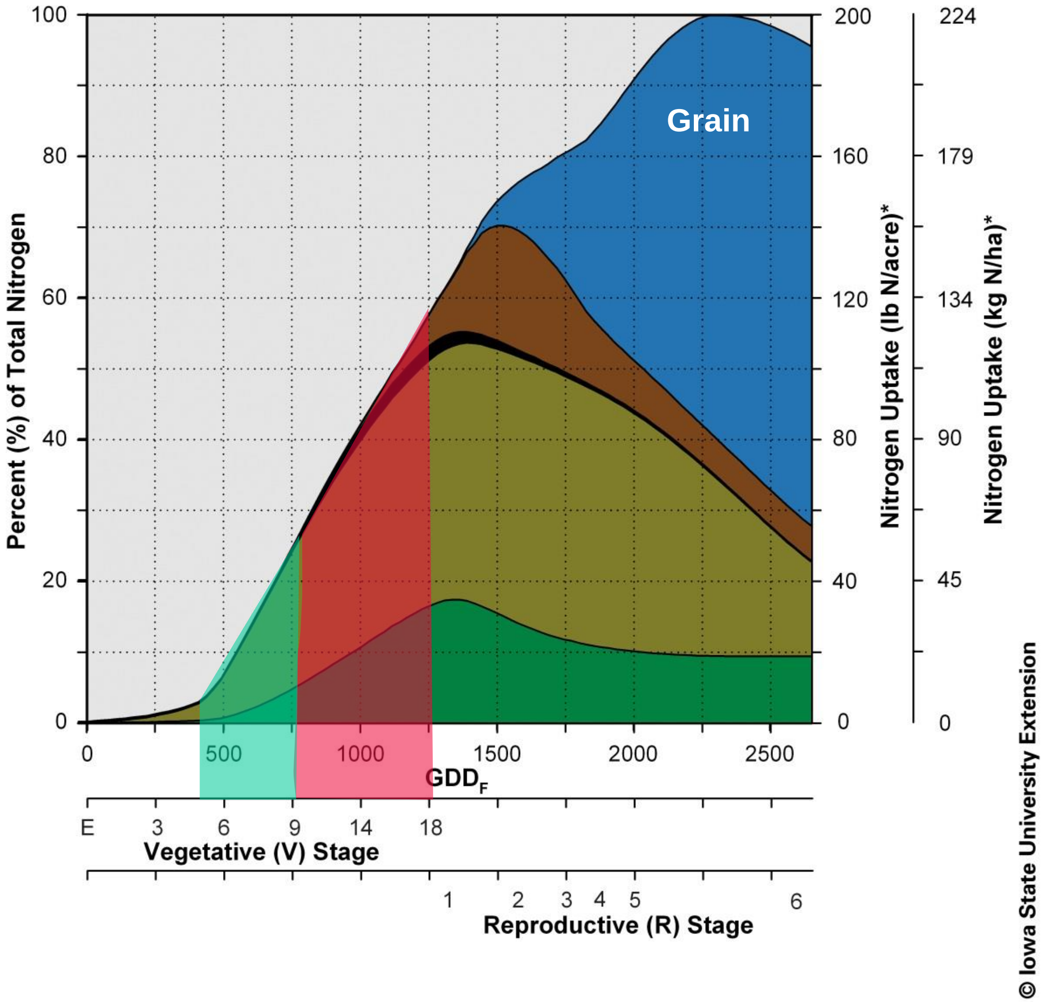
N applied in this part of field

No N applied in this part of field



Sawyer and Barker, ISU

Corn Nitrogen Uptake and Composition



PMR 1009; Abendroth et al., 2011

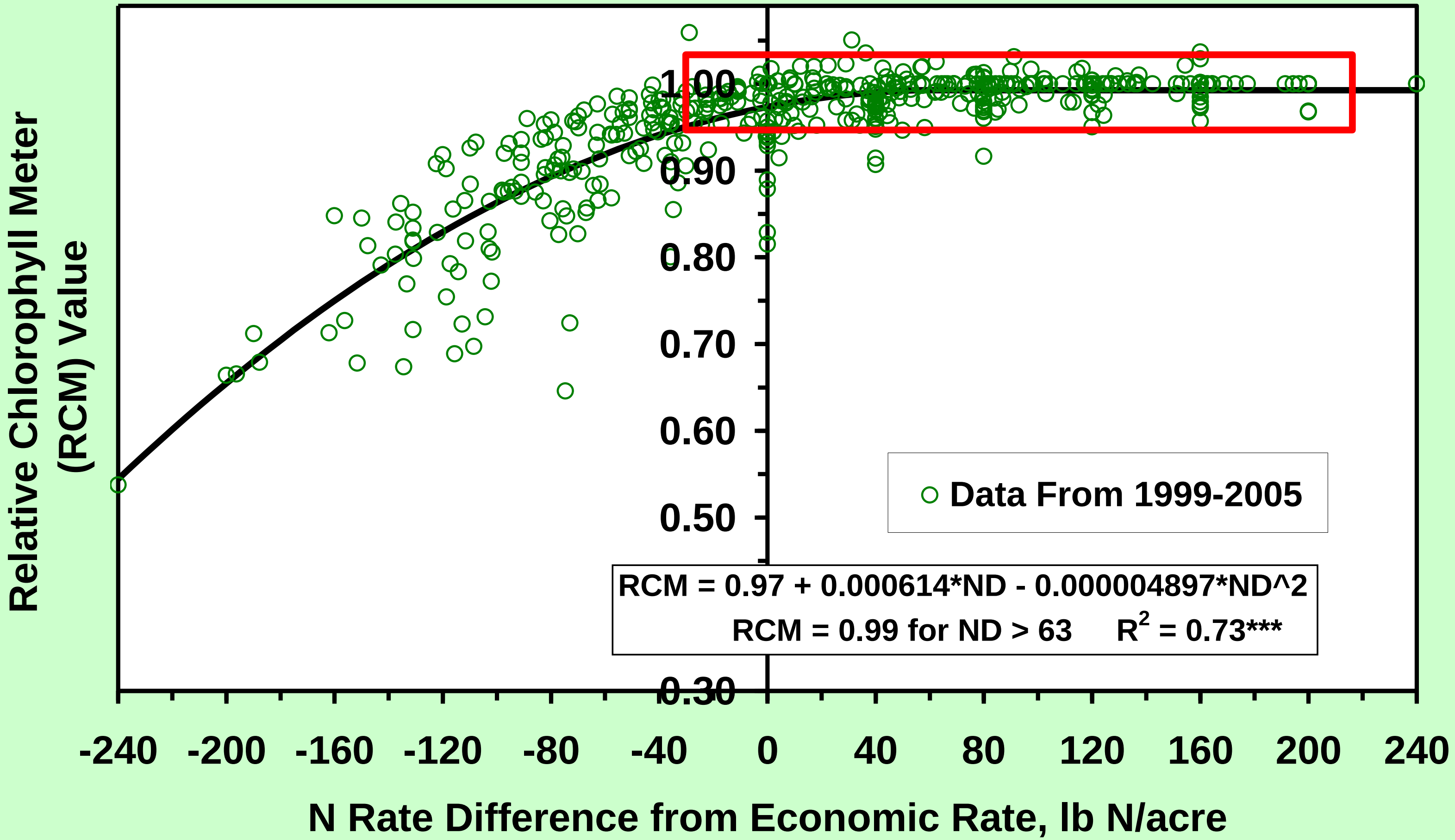
Leaf Greenness Chlorophyll Meter

- Minolta model SPAD 502
  - Read 30 plants per area
    - Prior to VT: sample most recently developed leaf with color exposed
    - After VT: sample ear leaf
    - Sample ½ distance from leaf tip to collar
    - Sample ½ distance between leaf edge and midrib
  - Read area of interest and well fertilized reference area
  - Calculate relative sufficiency index (relative greenness)

Leaf Greenness
Chlorophyll Meter

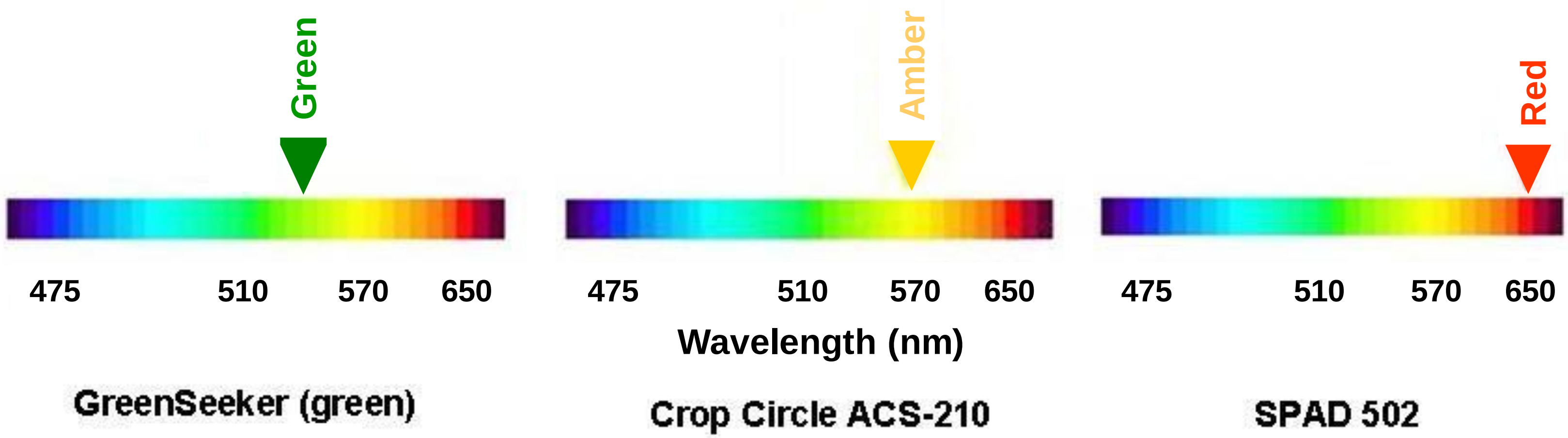
- Does indicate N deficiency
  - Relative index < 95% (Nebraska) or <97% (Iowa) indicates N deficiency
    - Need for comparative reference area that is well fertilized
- Does not indicate excess available N
  - Maximum leaf greenness not affected by luxury N consumption
- Can indicate rate of supplemental N required

Figure 1. Relative SPAD chlorophyll meter (RCM) value versus N rate difference from economic optimum rate, R1 corn growth stage.



ISU Publication PM-2026

Active Sensor Wavelengths



Sensor	Visible, nm	NIR, nm	Other, nm
Minolta SPAD Meter	650 (red)	940	
GreenSeeker 506	560 (green)	774	
GreenSeeker 505	656 (red)	774	
Crop Circle ACS-210	590 (amber)	880	
RapidScan CS-45	670 (red)	780	730 (red edge)
Crop Circle ACS-470	various	various	various
CropSpec		800-810	730-740 (red edge)

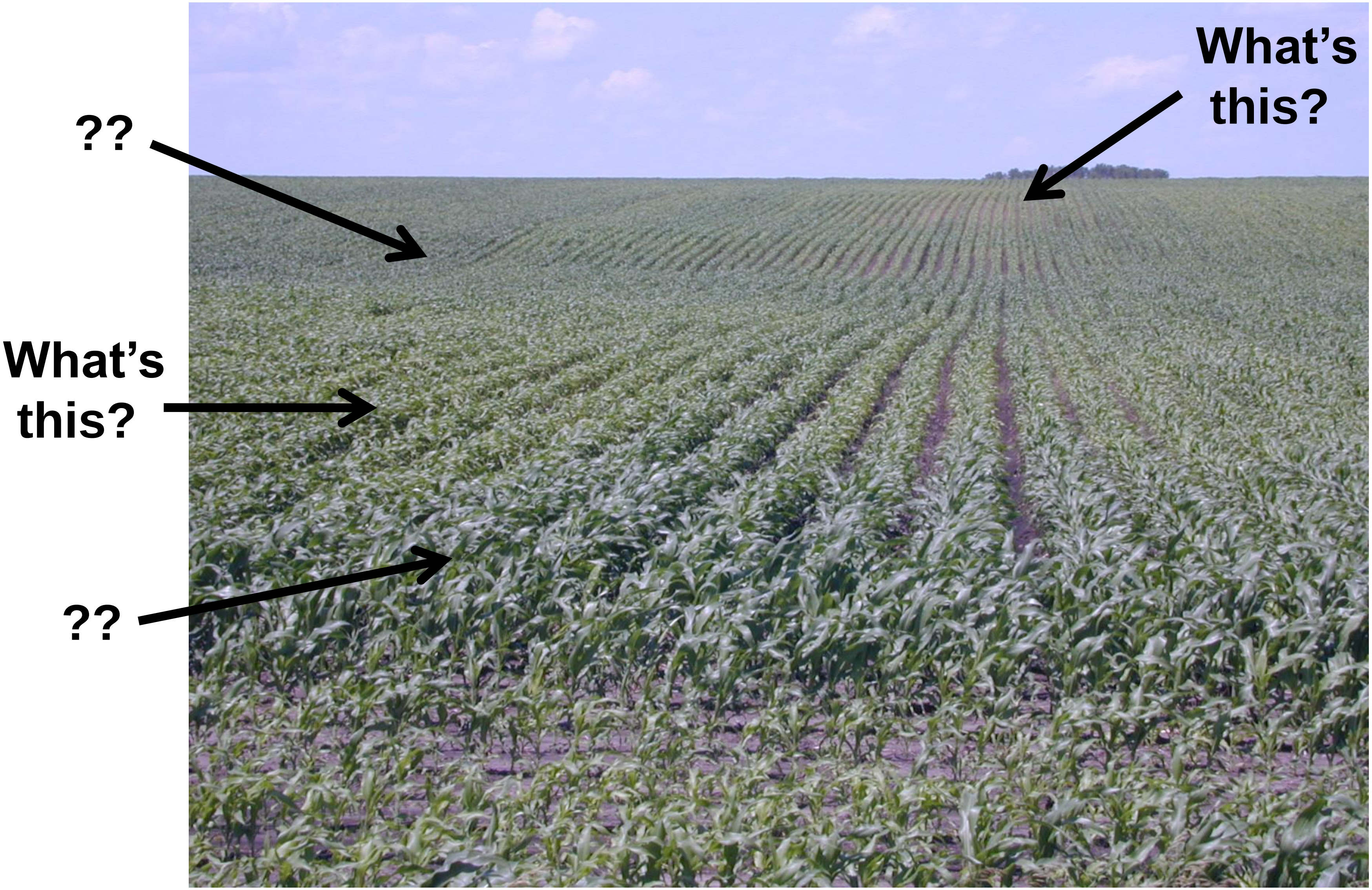
Sensor Index Calculations

- Most common active canopy sensor indices
  - Normalized Difference Vegetative Index (NDVI)
    - (NIR – VIS) ÷ (NIR + VIS)
  - Chlorophyll index (CHL)
    - (NIR ÷ VIS) – 1
- Relative values
  - Sensor reading normalized to highest N rate

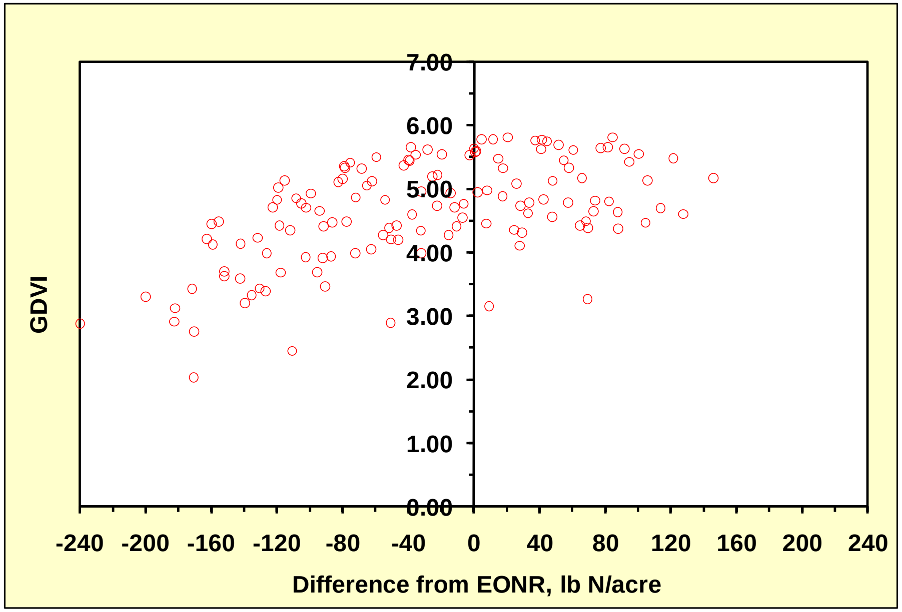
Why Use Relative Index Values?

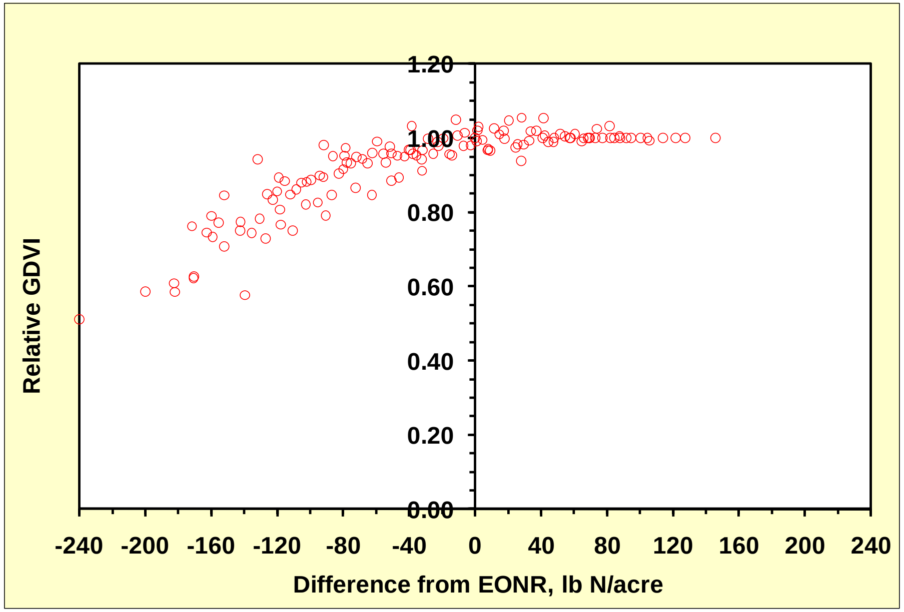
- Various canopy characteristics influence sensor readings and index values
  - Leaf chlorophyll
  - Whole plant biomass
  - Canopy temperature
  - Canopy moisture content
  - Hybrid
  - Plant density (population)
  - Other nutrient deficiencies

Reference Corn?



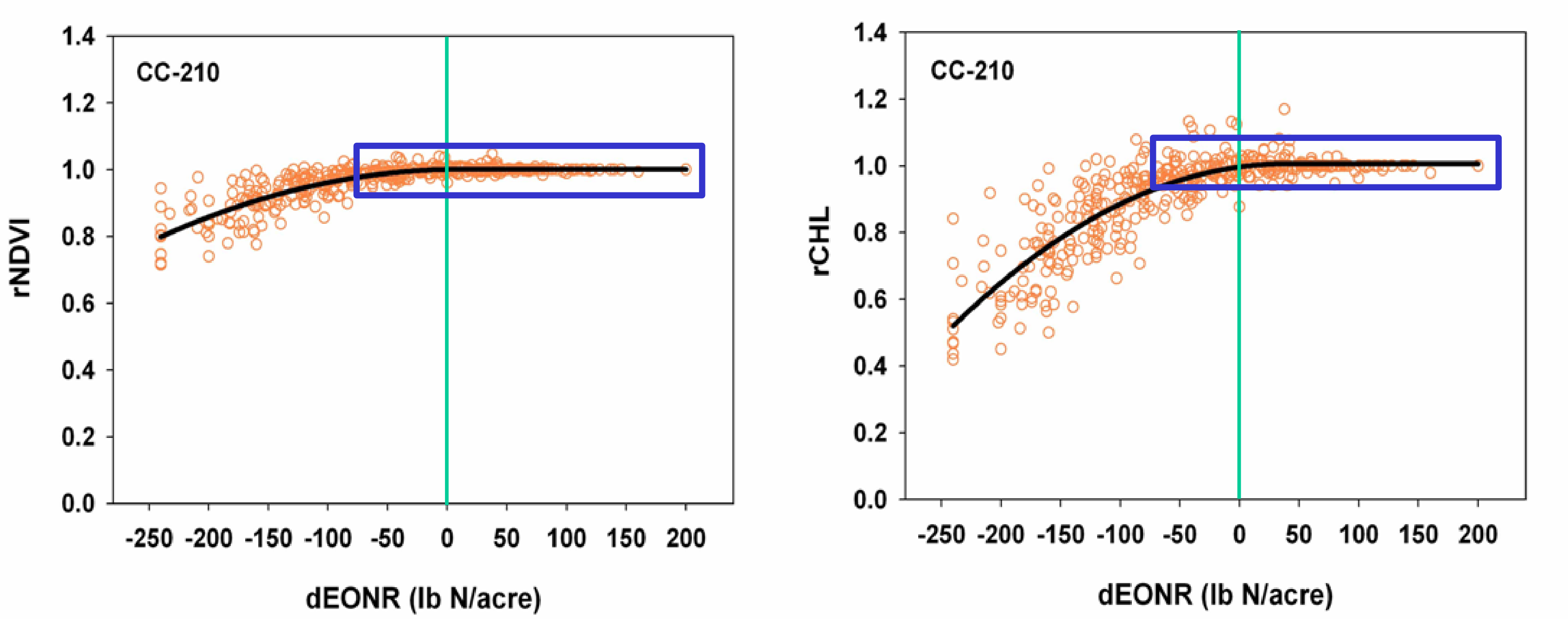
Why Use Relative Index Values?

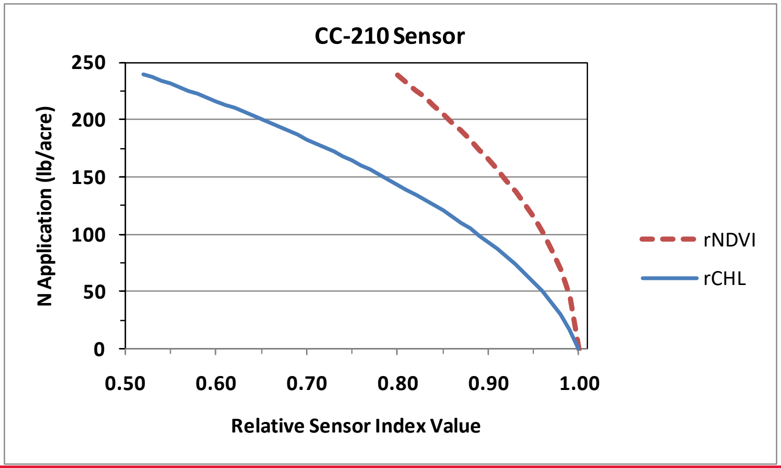




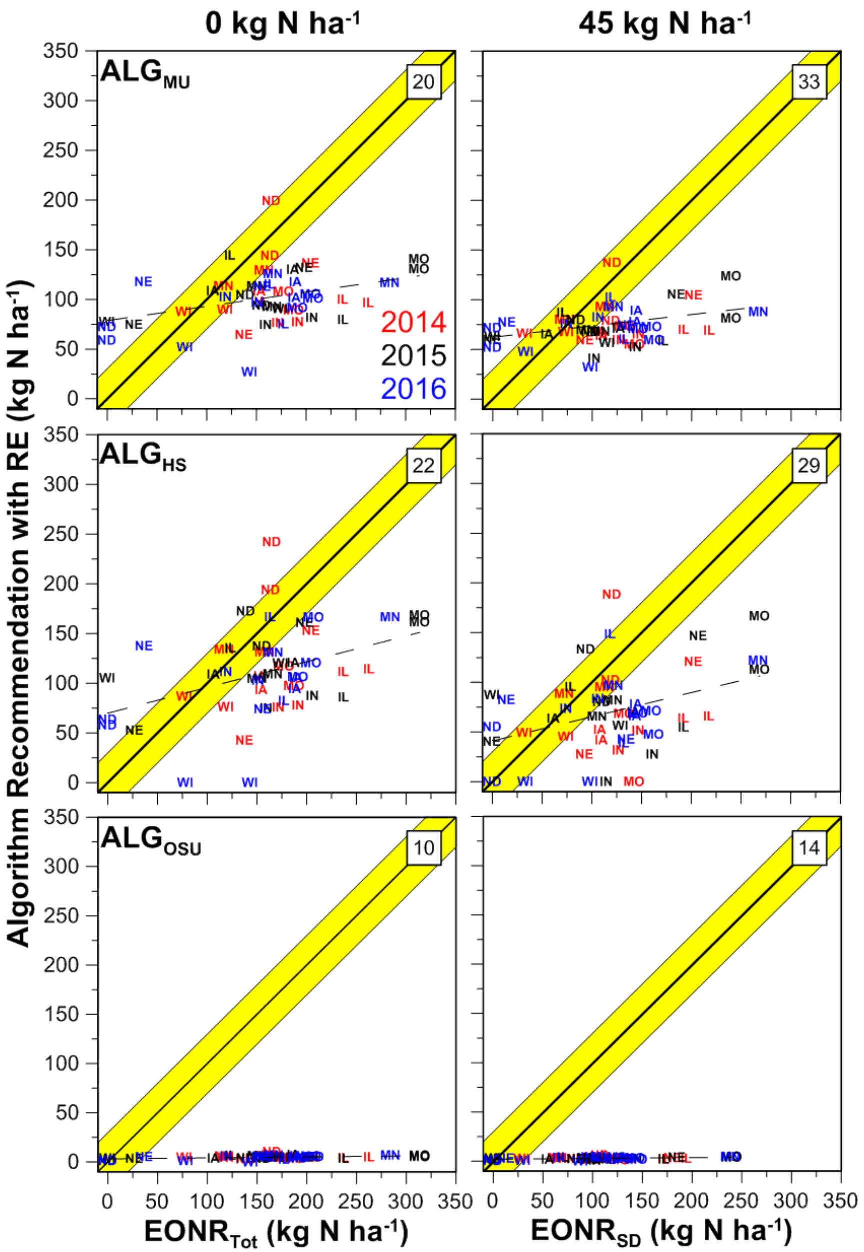
Barker and Sawyer, ISU

Active Sensor Calibration at Mid-Vegetative





Barker and Sawyer, ISU



Within 30 lb N/acre of EONR?

G.M Bean et al., Univ. Missouri

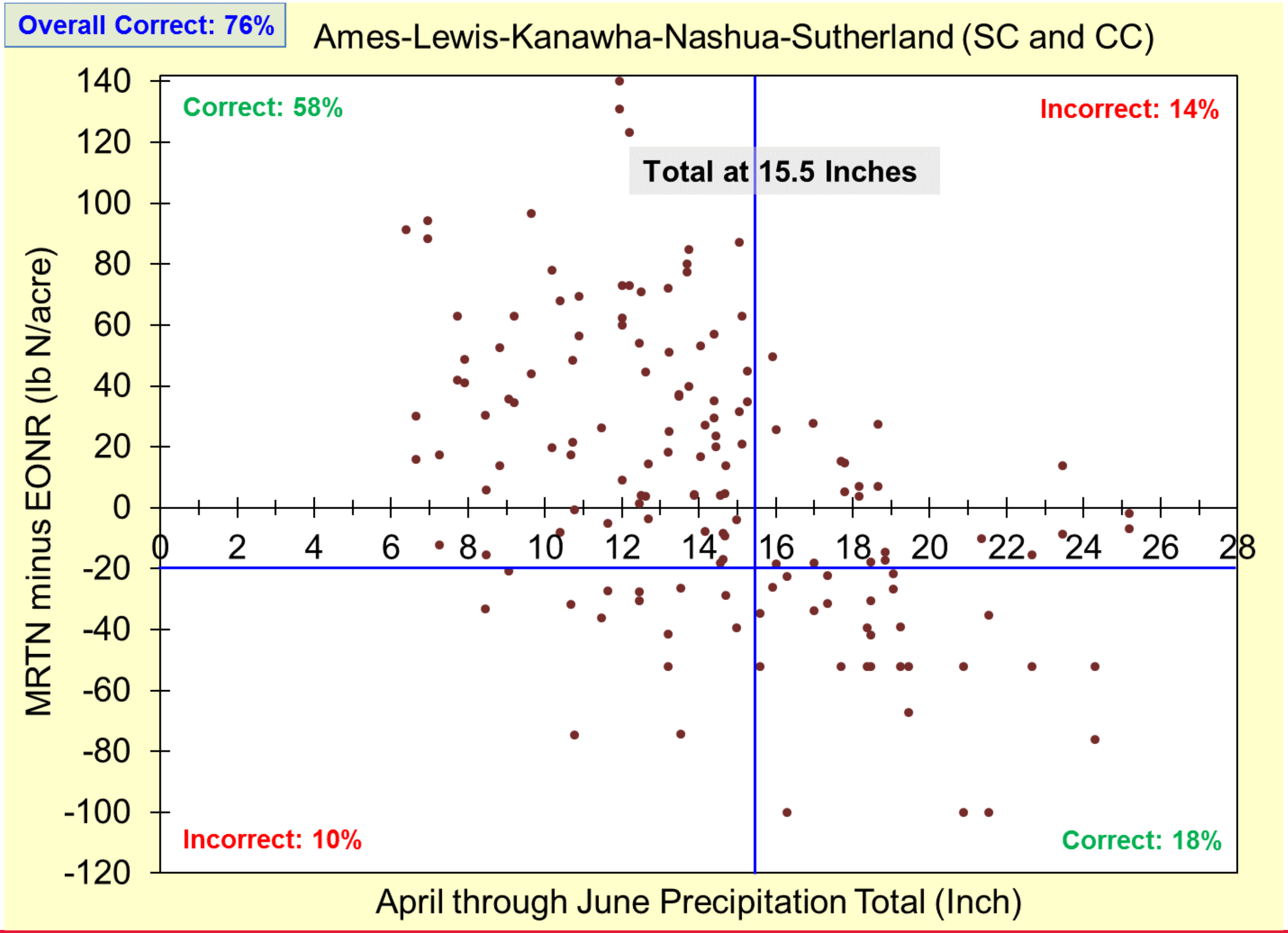
Corn Plant and Canopy Sensing

- Uses corn plant as indicator of N adequacy or deficiency
- Corn plant able to integrate across time
- Provides instantaneous feedback
- With active canopy sensors
  - Electronic integration of sensing and N rate application on-the-go
    - Requires recommended operation
  - Sub-field/continuous N rate adjustment

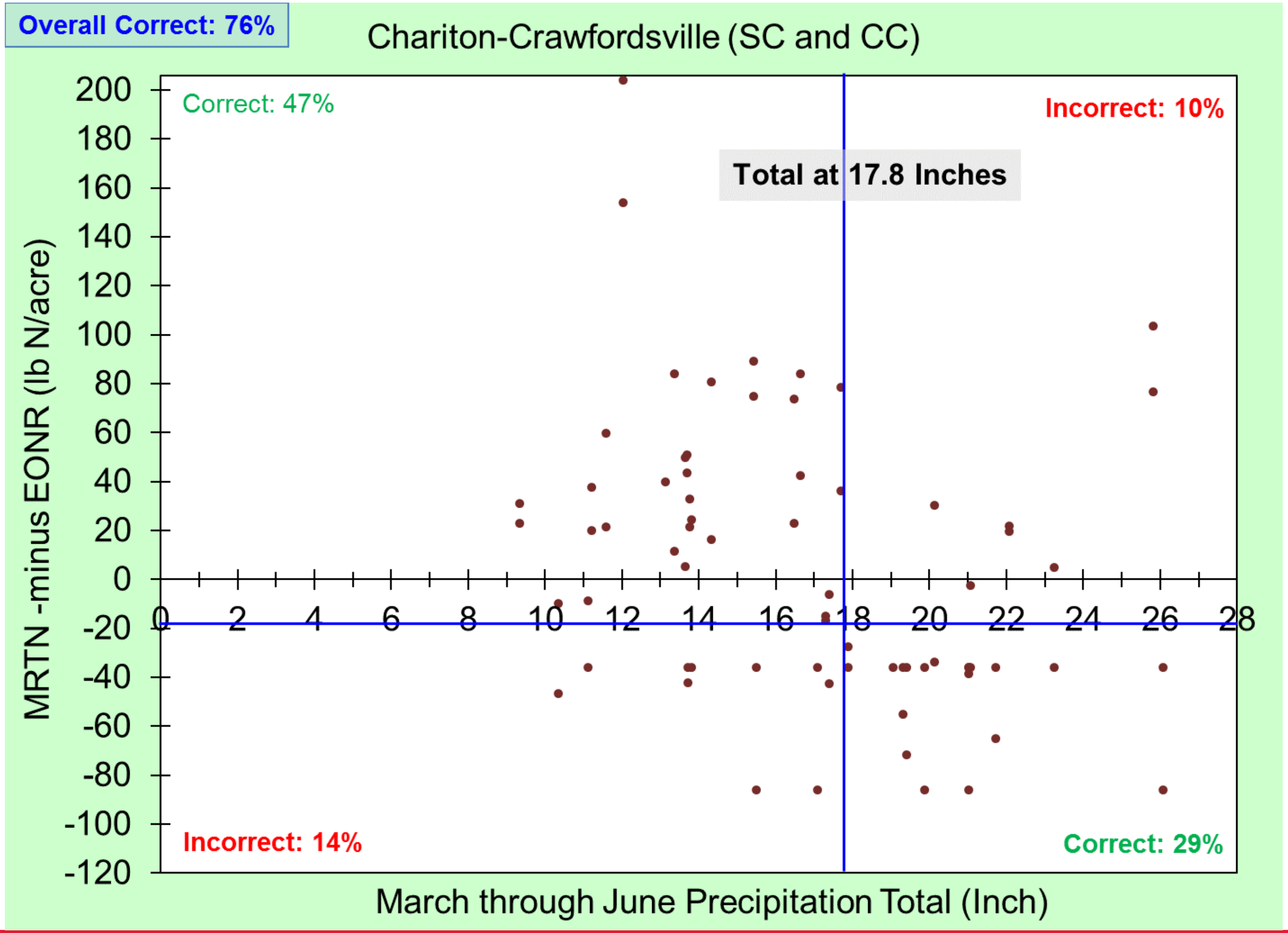
Corn Plant and Canopy Sensing

- Considerations
  - Sensors cannot detect excess N
  - Corn must be N deficient to express N stress
  - Detecting small N deficiency difficult
  - Must have an “adequate or N-Rich” in-field references (create relative N stress value)
    - Sensors “see” any plant stresses

Spring Precipitation as a Tool for Decisions About Additional Nitrogen Application (Main Iowa)



Spring Precipitation as Tool for Decisions About Additional Nitrogen Application (Southeast Iowa)



Questions?