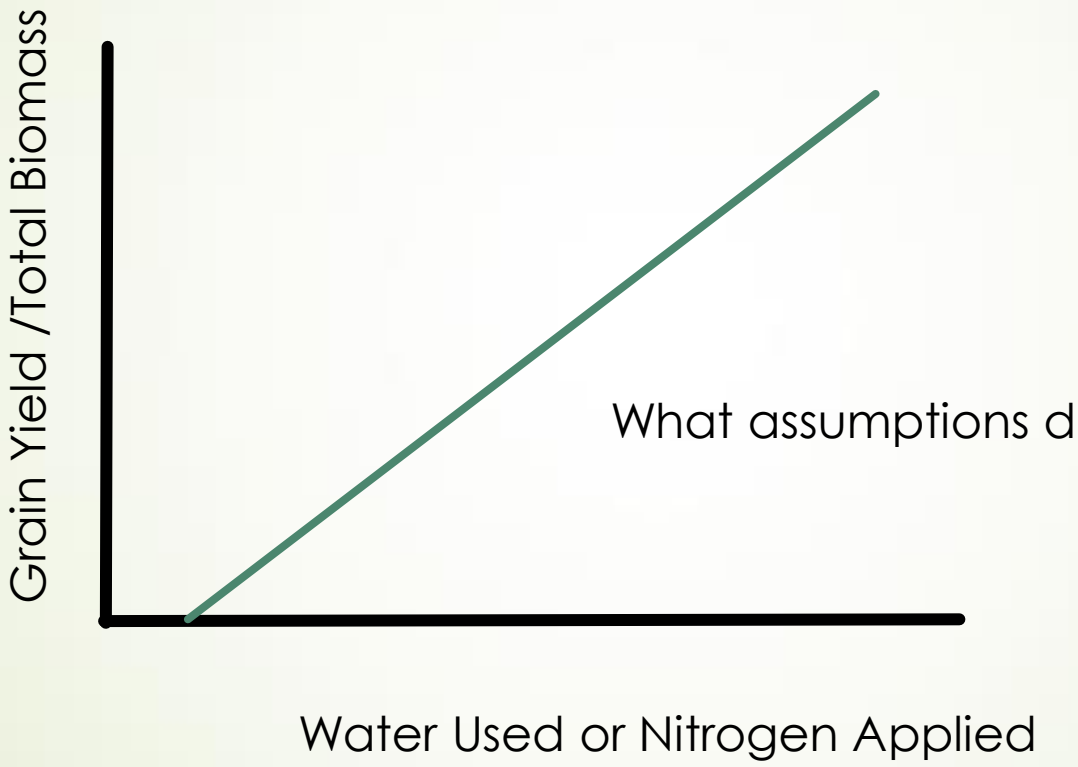
Why is Untangling Water and N Stresses so Difficult

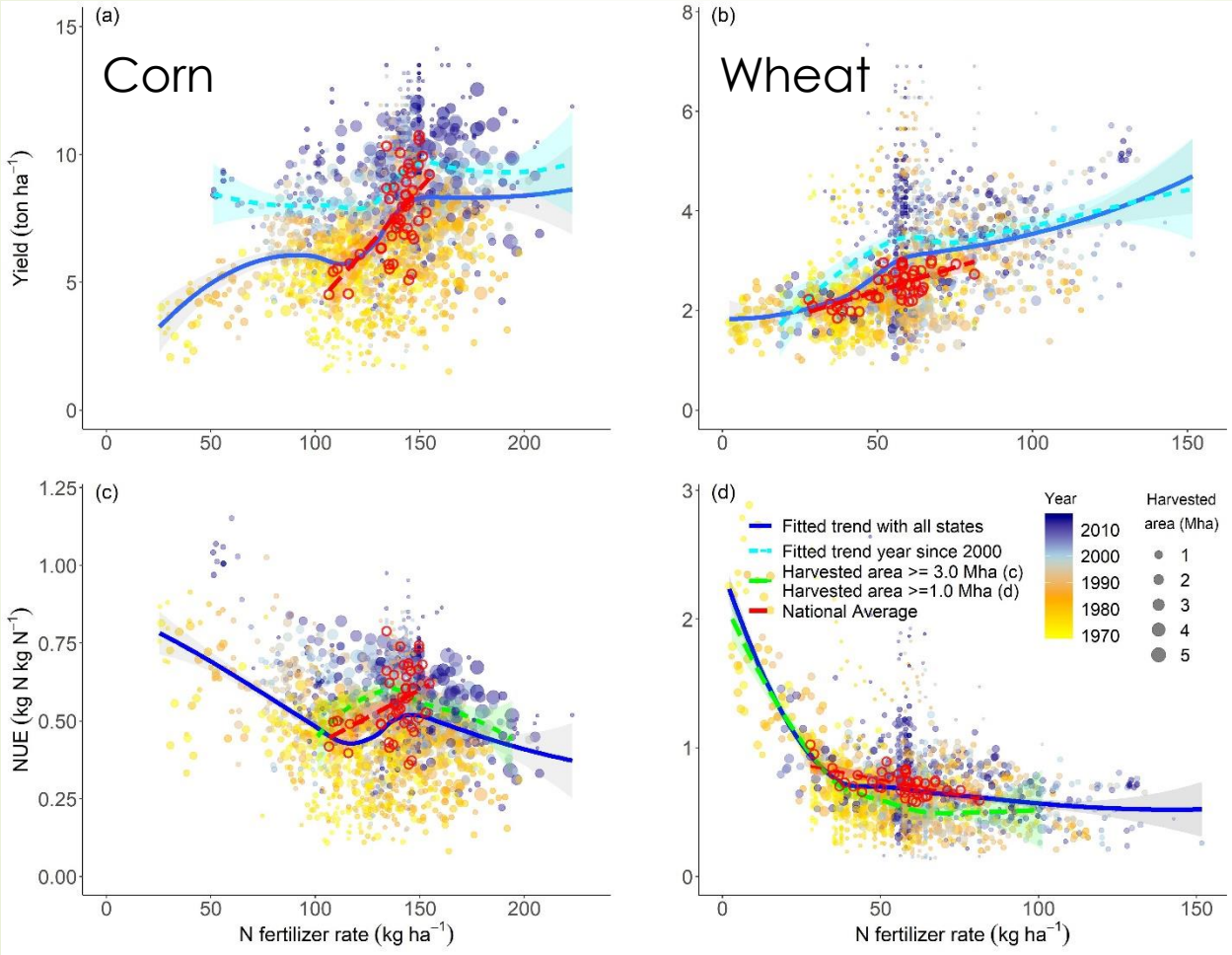
Life is complicated!

Water or Nitrogen Use Efficiency



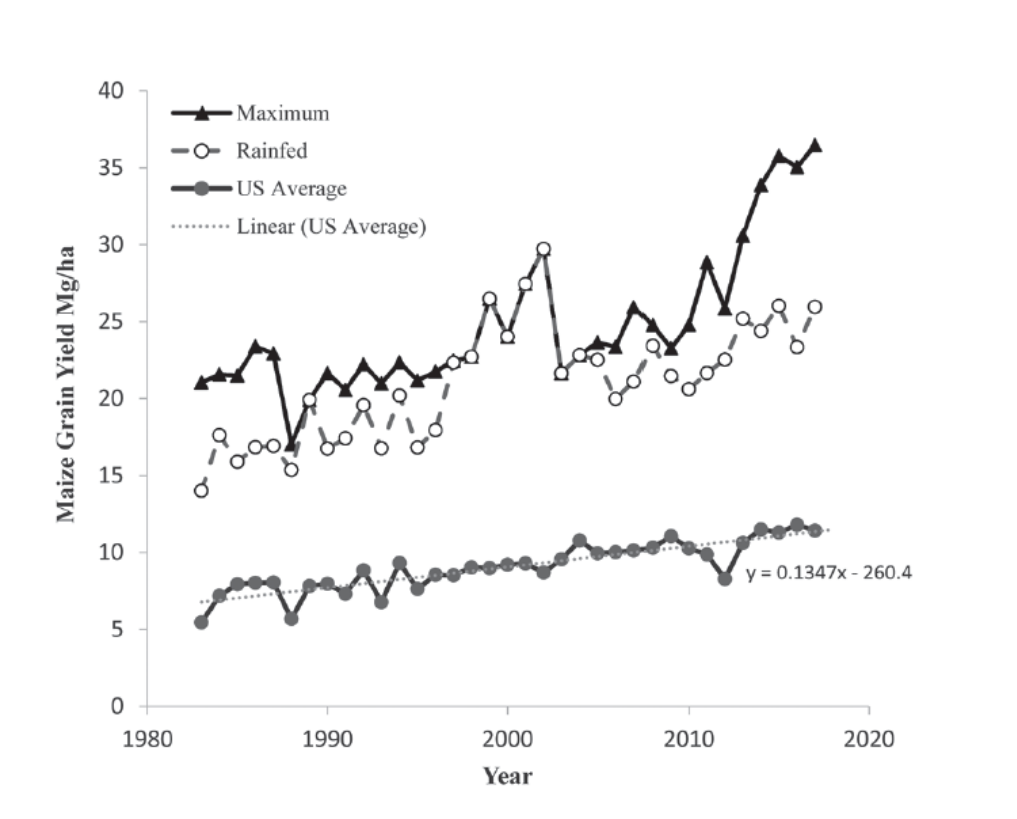
What assumptions do we make about efficiency?

Reality on NUE



Chaoqun Lu, Jien Zhang, Peiyu Cao , and Jerry L. Hatfield, 2019 J GeoPhysical Res.

Reality on WUE



Reality is that yield has been increasing but water use has not changed as much as yield

Limitations on productivity

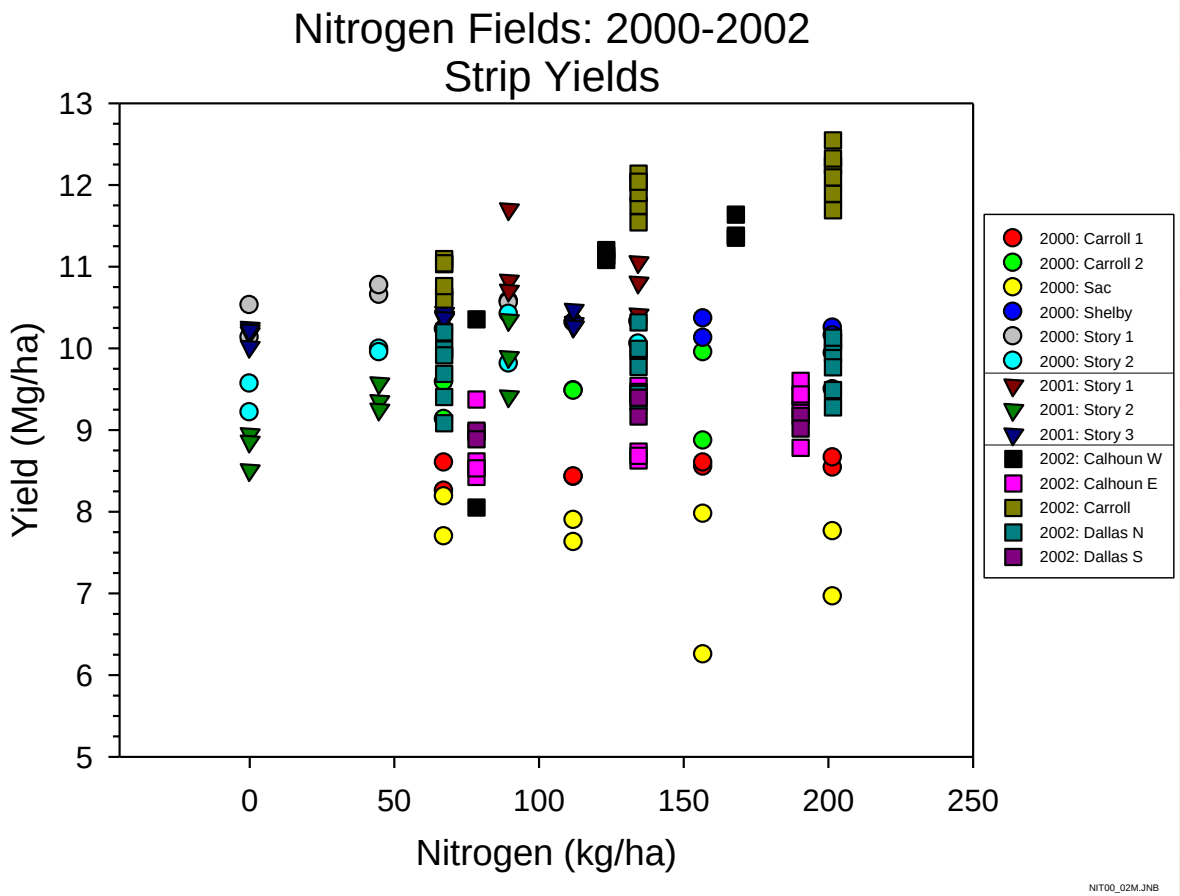
- Inadequate water or nitrogen supply to the plant
- Yield is negatively correlated to April and May rainfall and positively correlated to July and August rainfall
- Yield response to N is more complex

What do we want to know?

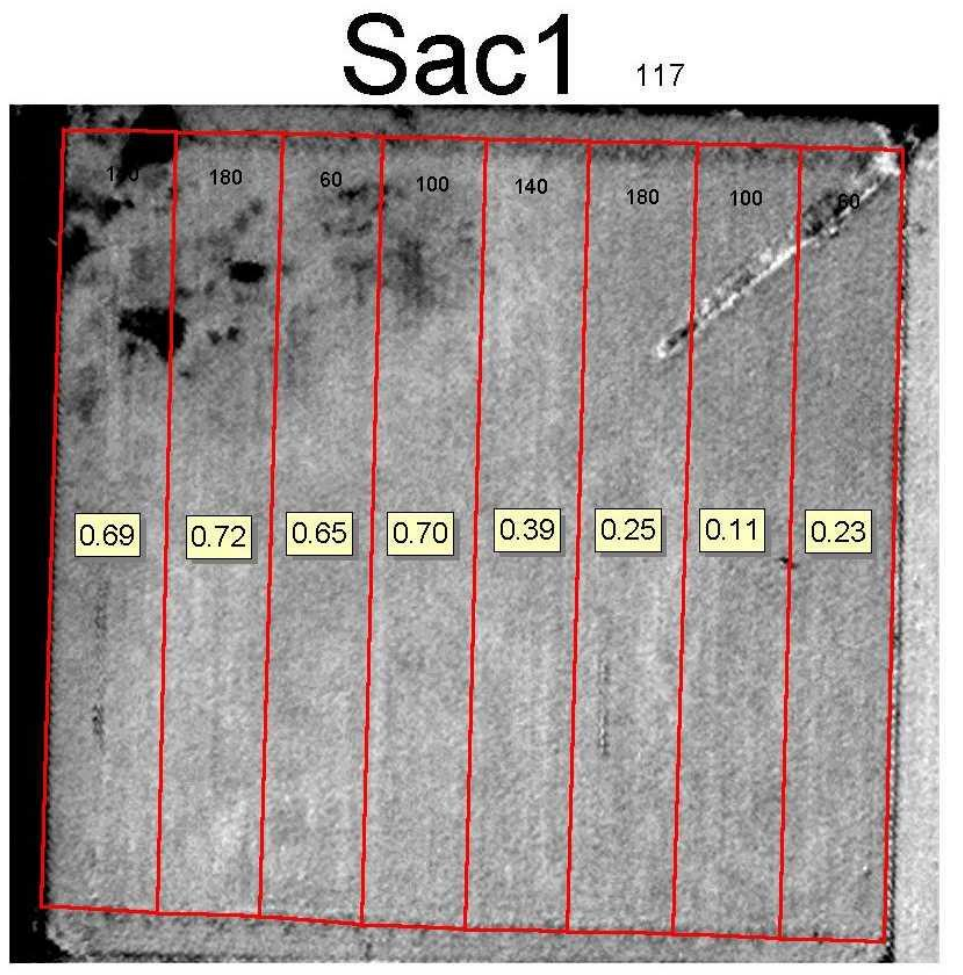
- How much is the stress impacting productivity?
- What can be done to correct the problem and is it worth the cost?

What we know!

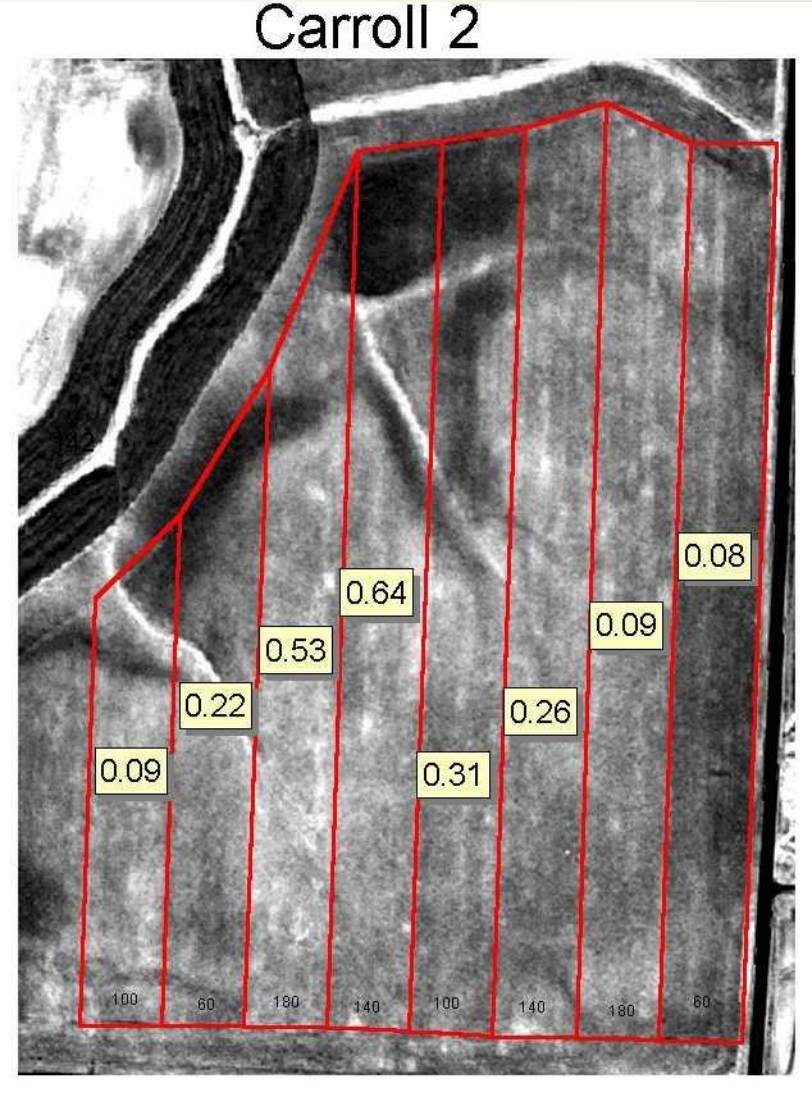
Nitrogen Response Across Fields



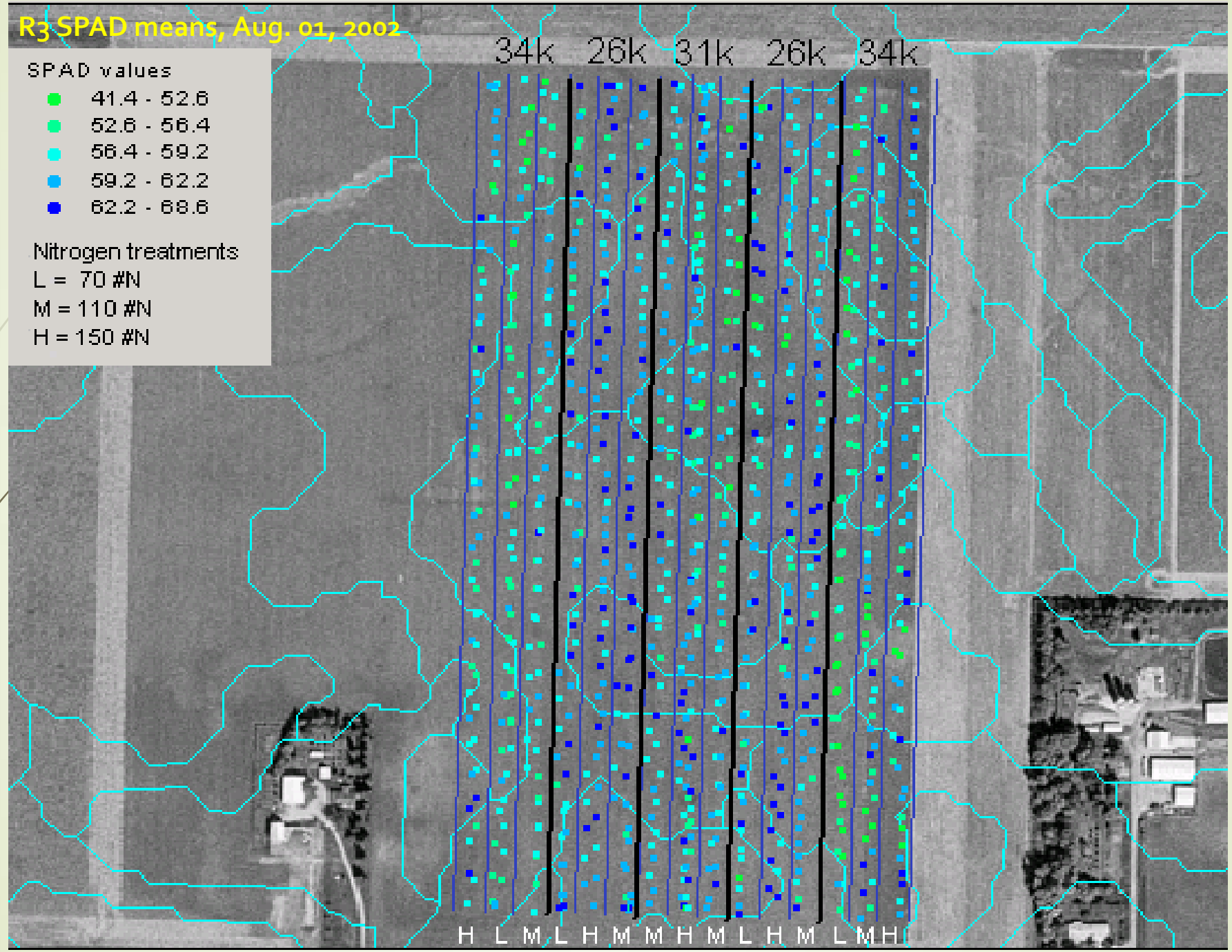
Yield Correlation with RS data



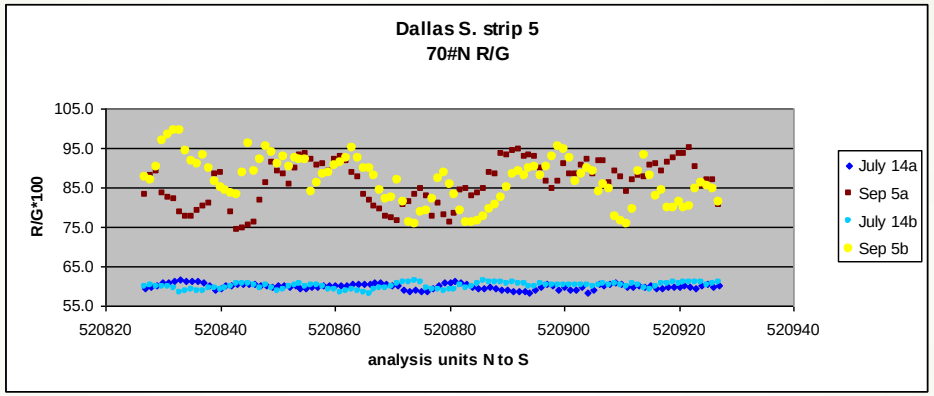
SAVI 3rd flight

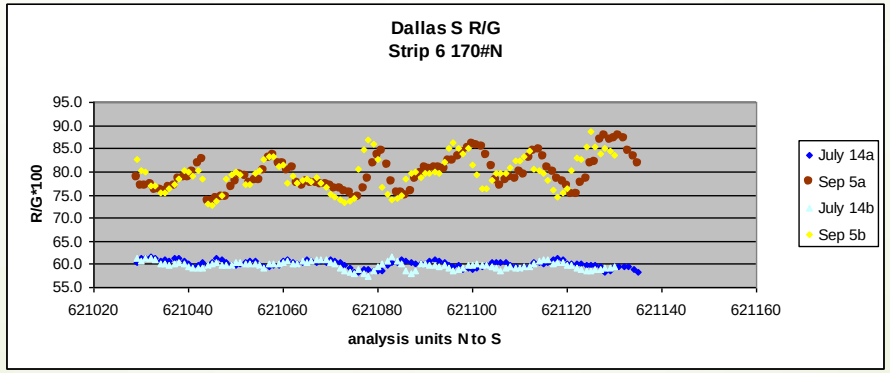


SAVI 4th flight


R3 SPAD means, Aug. 01, 2002
SPAD values
41.4 - 52.6
52.6 - 56.4
56.4 - 59.2
59.2 - 62.2
62.2 - 68.6
Nitrogen treatments
L = 70 #N
M = 110 #N
H = 150 #N
34k
26k
31k
26k
34k
H L M L H M M H M L H M L M H

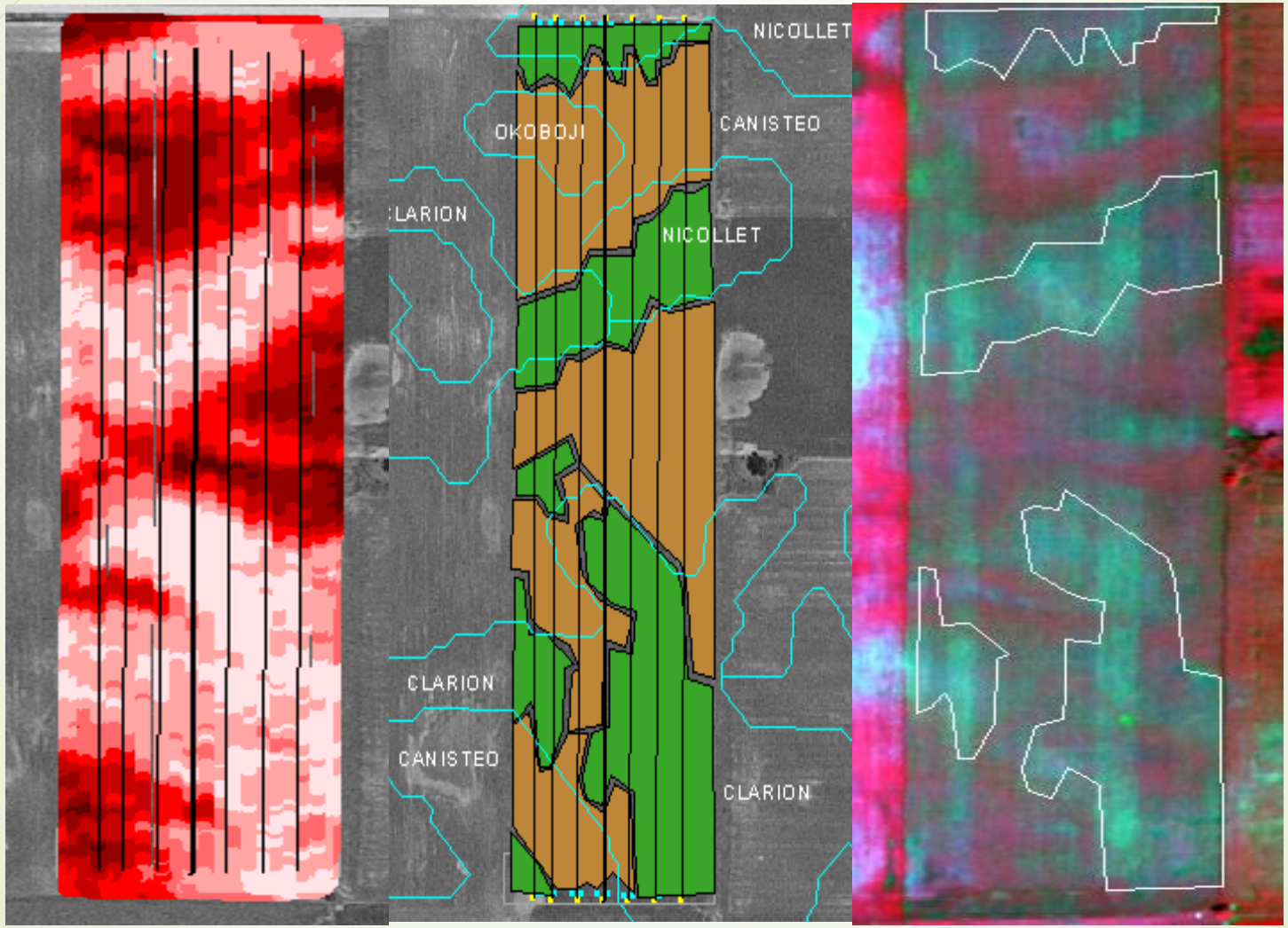
Field Scale Variation





Spatial Patterns within Fields

Dallas South



EM-38 Yield Reflectance

Water vs Nitrogen

- Dissect the growing season into phenological stages for the Midwest
- Spring conditions
- Excess water that limits plant root development and causes crusting, limiting oxygen. Result is yellow plants due to excess water not lack of N.

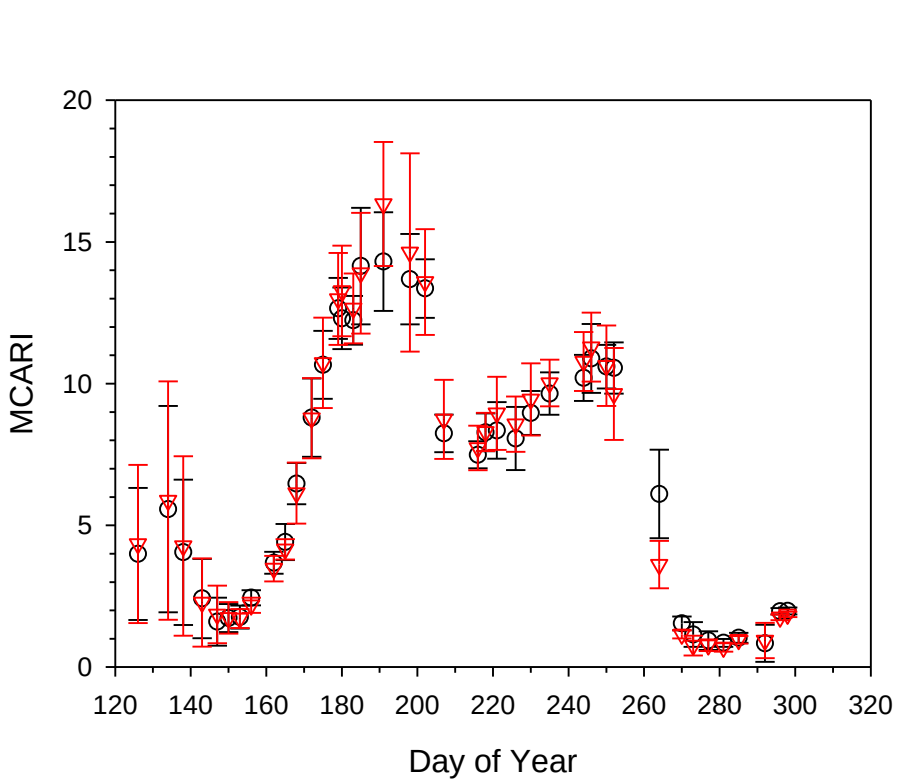
Water vs Nitrogen

- Reproductive stages
- Soil water is often the limitation rather than N because of rainfall patterns and soil water holding capacity.

Detection of Stress

- Nitrogen
  - Indices related to leaf or canopy chlorophyll content
    - MCARI
    - CI
- Water
  - Indices related to canopy temperature
  - CWSI

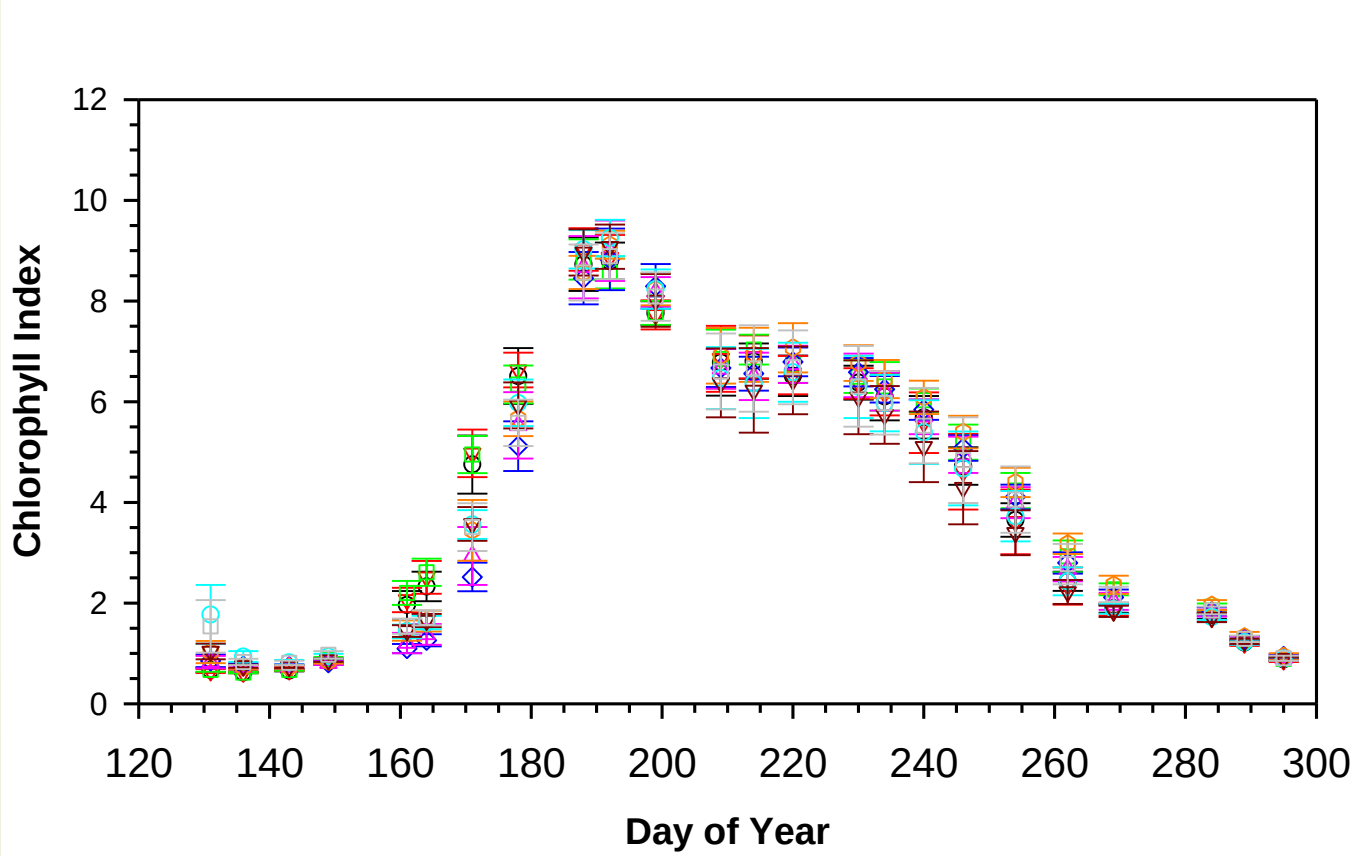
MCARI



MCARI over corn

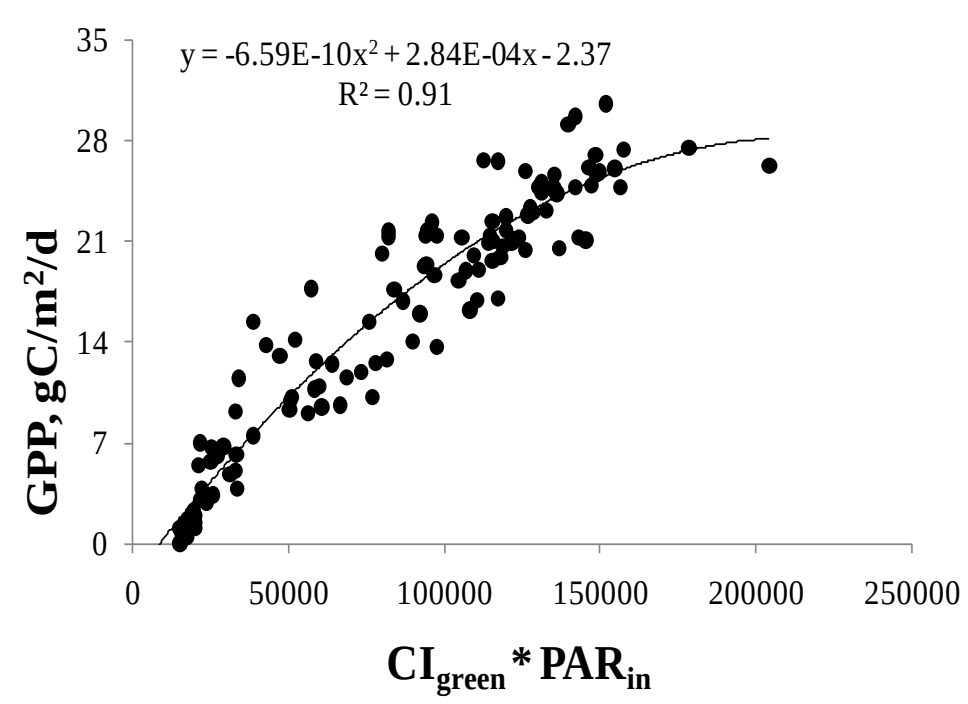
Tassels impact the reflectance patterns

Leaf Chlorophyll



GPP vs CI (Corn)

Irrigated and Rainfed Maize



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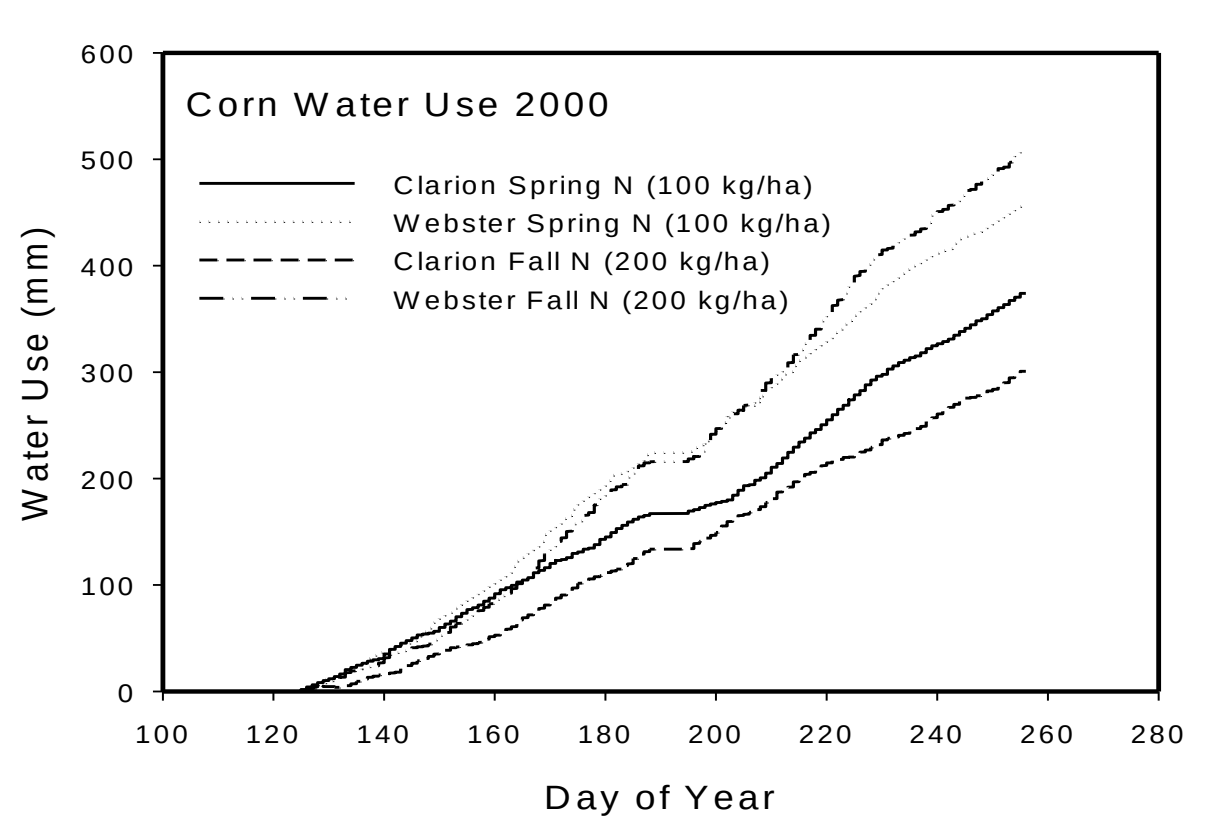
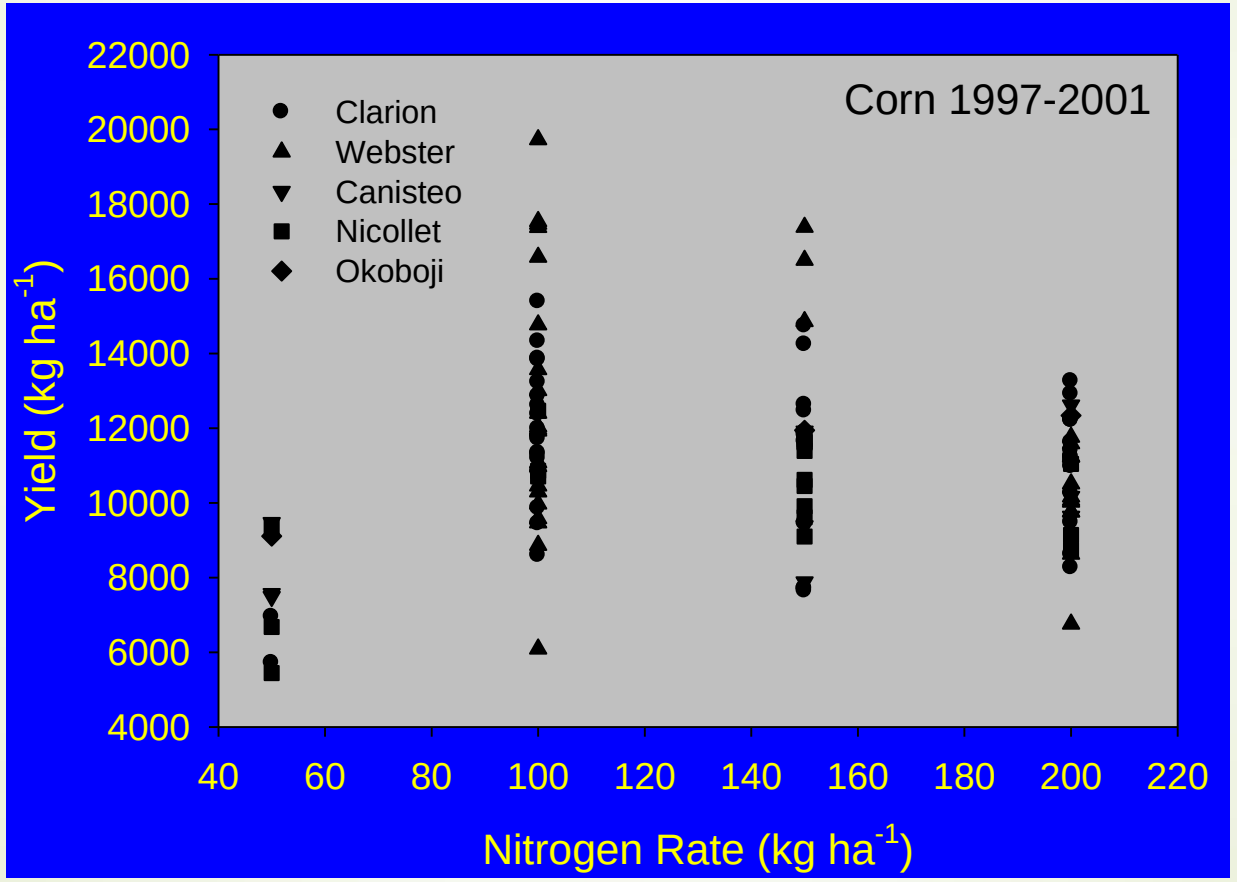
Soil Water Use Patterns

Water Use Between Soils

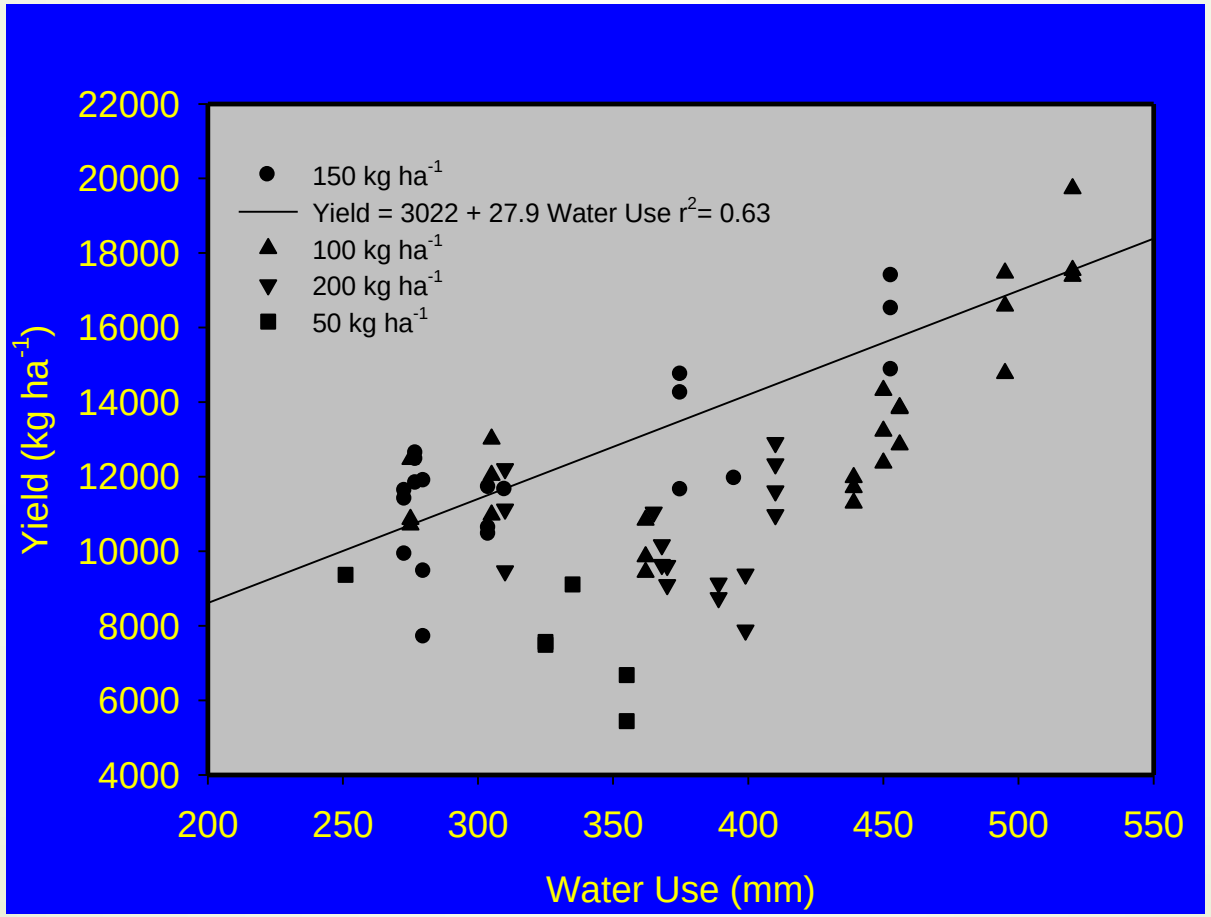


Soils within the field have different water use patterns depending upon soil water holding capacity and precipitation patterns

Nitrogen-Yield Response



Water Use Efficiency



WUE was limited by soil water availability, not nitrogen

Feedbacks between Water & N

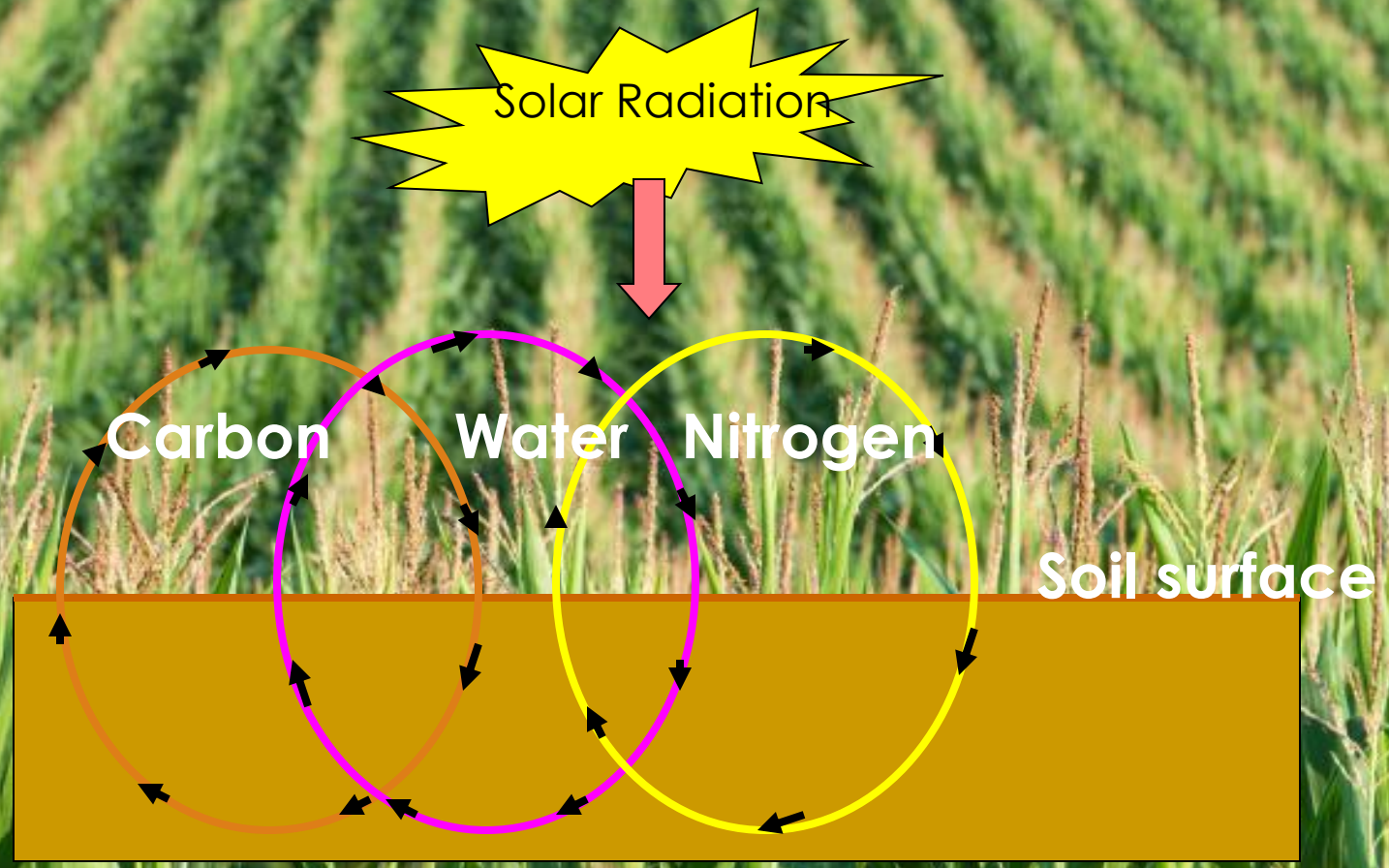
Inefficient water and nitrogen use

In water limited soils this creates a water deficit condition

Increased N leads to increased growth

Increased growth leads to increased water use

Cycles interact over time and space with different rates



Key Processes

Photosynthesis	Precipitation	N Fixation
Respiration	Evaporation	Mineralization
Org Matter decomp	Infiltration	Denitrification
Plant decomposition	Runoff	Plant ecomposition
	Percolation	

Challenges

- Understand the growth, water use, and nitrogen dynamics are closely related
- If we are going to improve NUE, need to realize that water use and availability may be the major limitation
- Need to start using the G x E x M framework to evaluate management practices to optimize genetic performance for the variable environment (soils and weather)