Precision Nitrogen Management:

Strategies to Increase Profitability and Sustainability of Irrigated Cropping Systems

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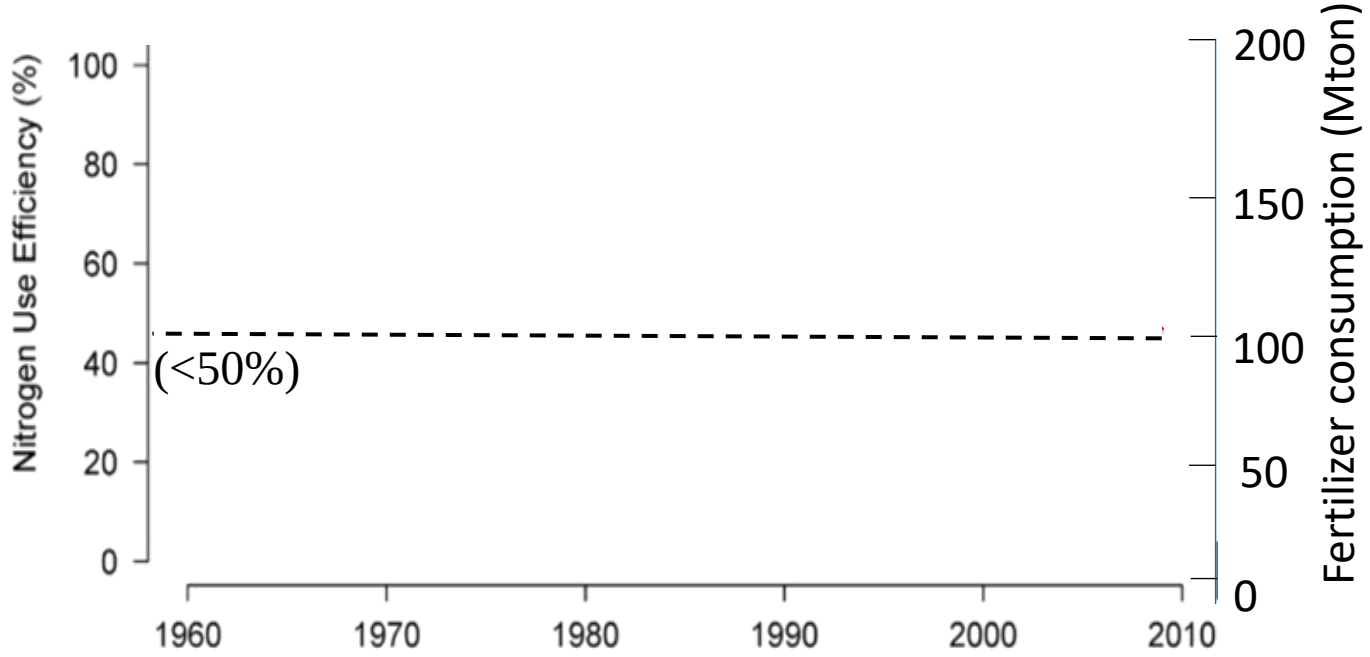
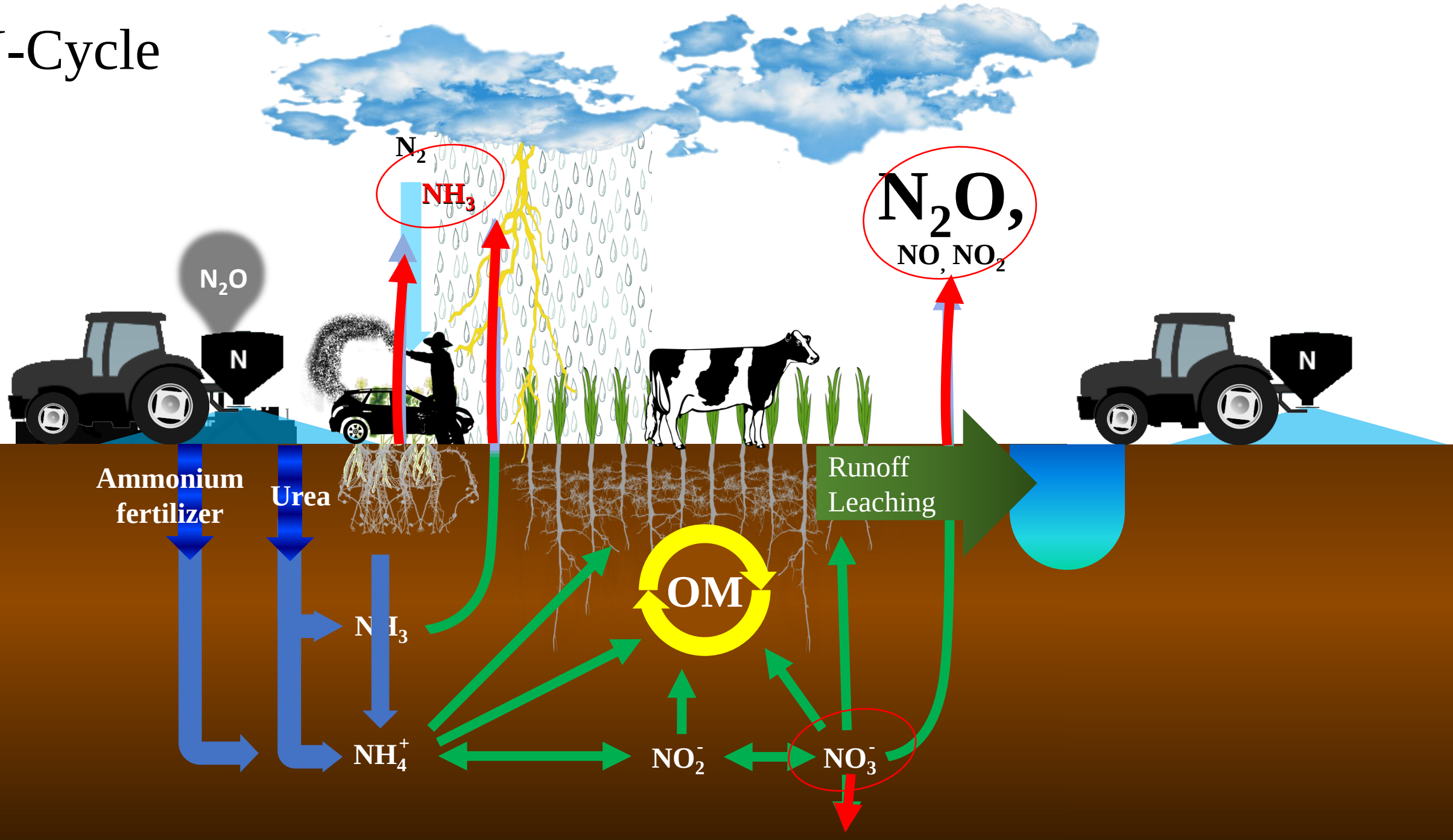
Nitrogen Use Efficiency

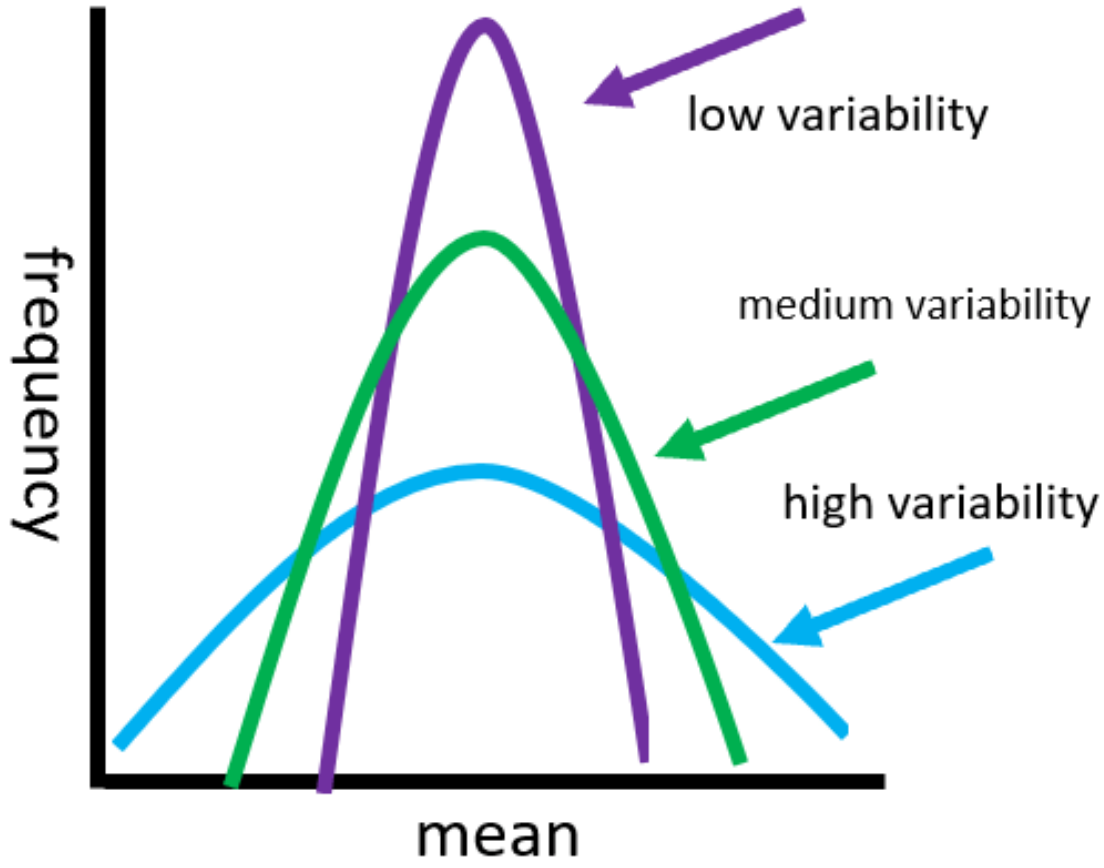


Adapted from: Lassaletta et al. 2014 *Environmental Research Letters*

N-Cycle


N_2
NH_3
N_2O
N_2O,
NO, NO_2
N
N
Ammonium fertilizer
Urea
Runoff
Leaching
OM
NH_3
NH_4^+
NO_2^-
NO_3^-

Variability happens!

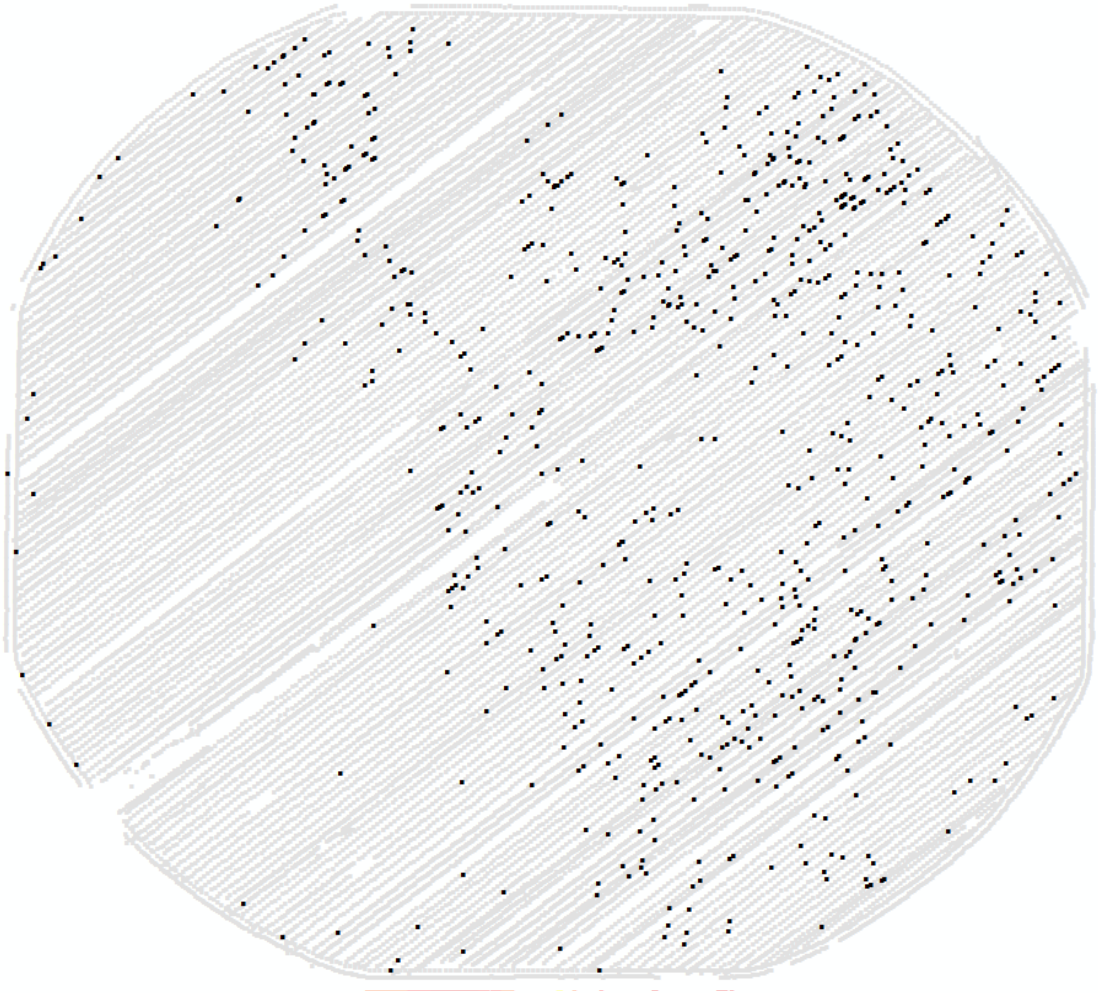


Spatial Variability

Mean: 180 bu/a
Range: 80 to 275 bu/a

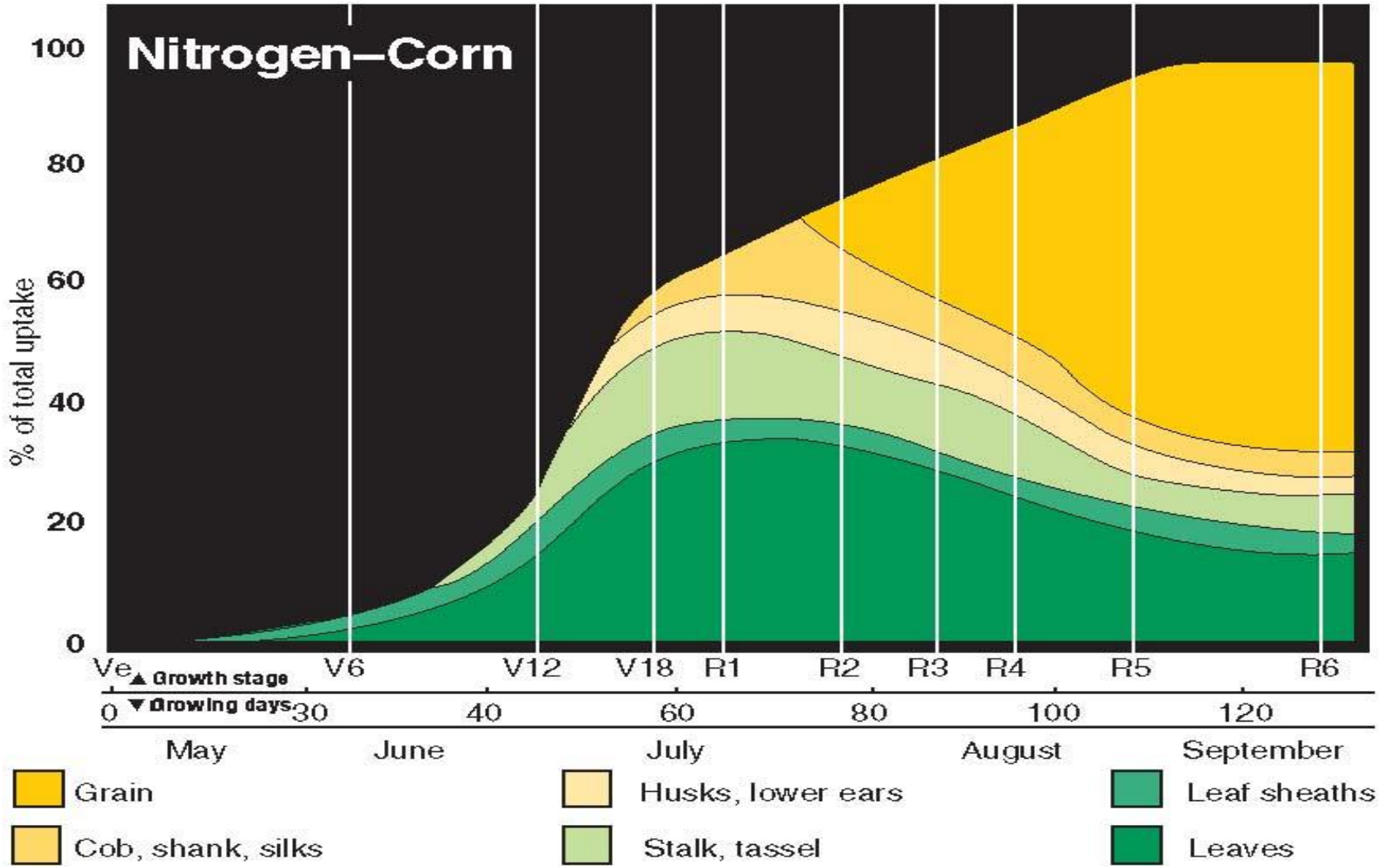
Pixels = Average?

2.3%



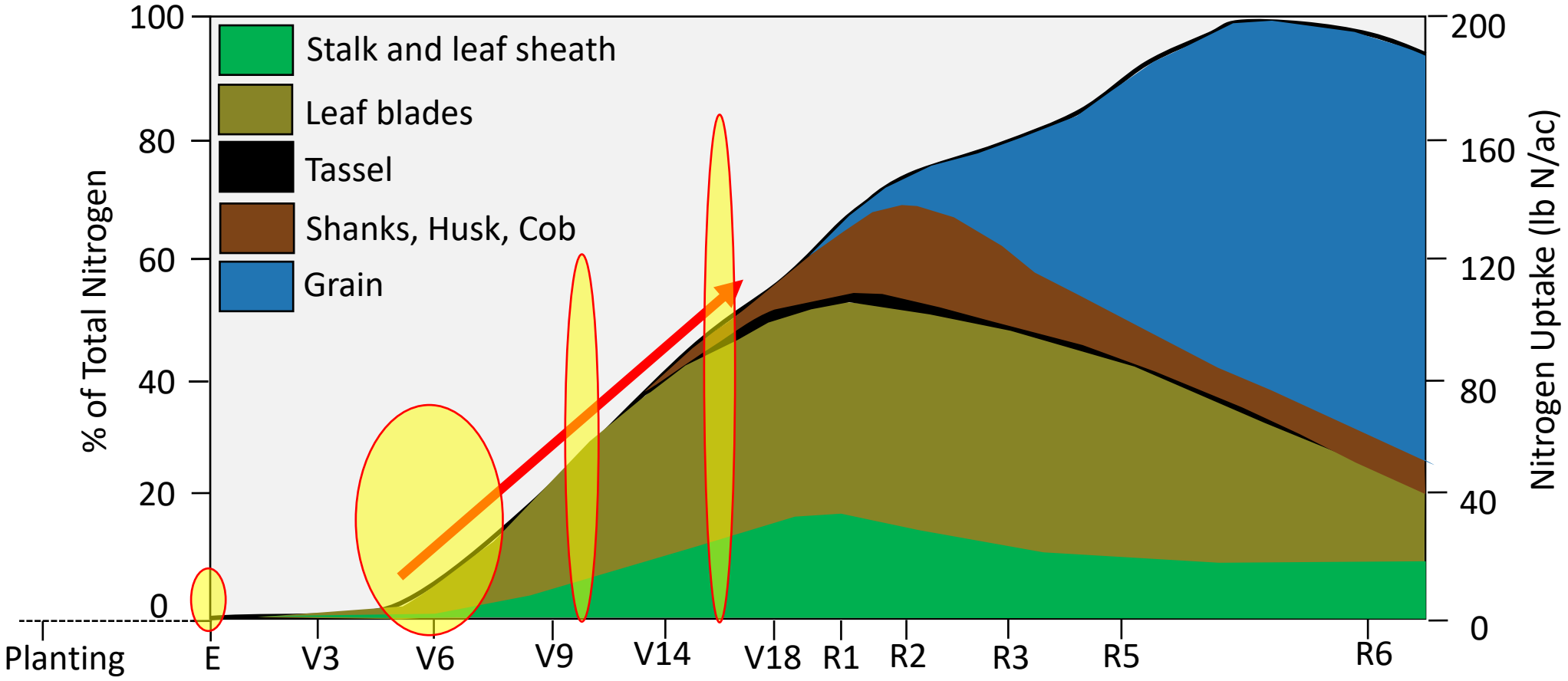
Corn Yield Map

Temporal Variability



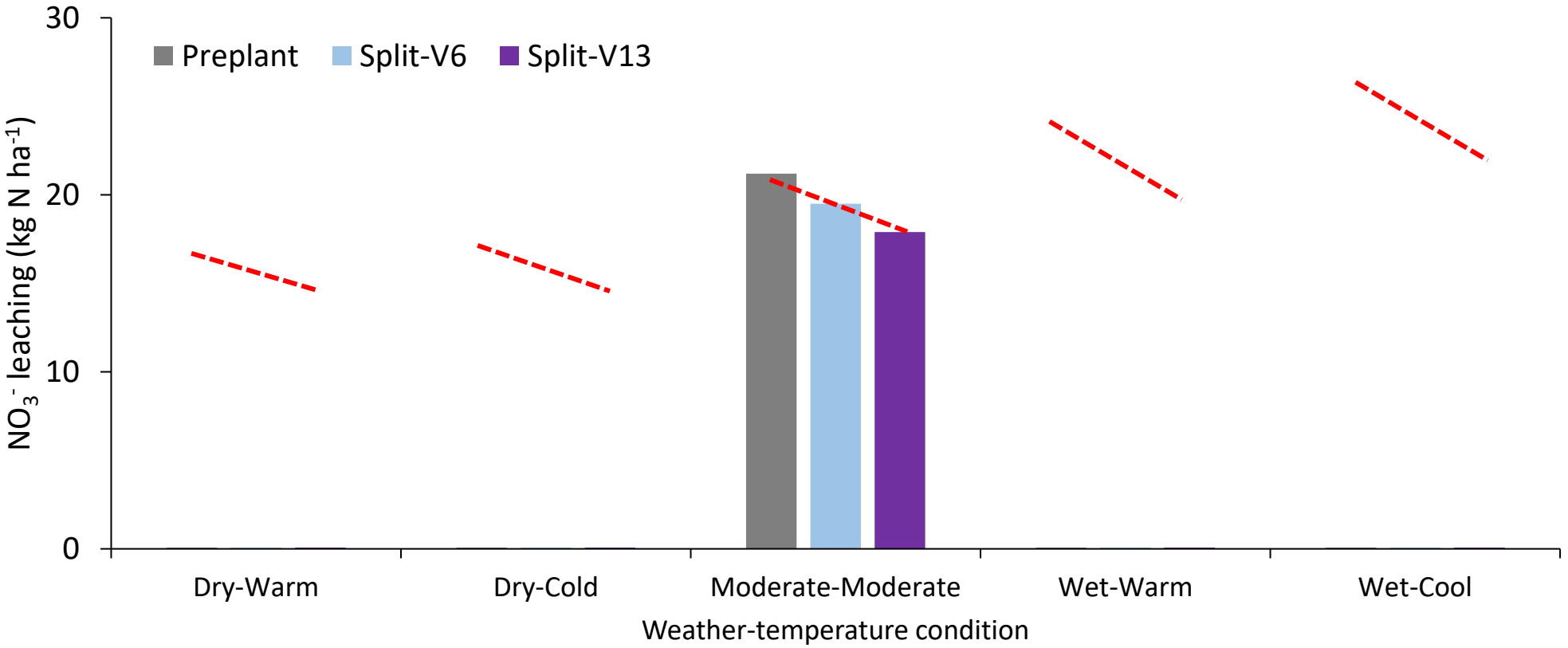
Temporal variability of corn N needs across the season. *Source: Iowa State University Extension.*

Temporal Variability



Abendroth et al., 2011, Corn growth and development. PMR 1009, Iowa State University Extension and Outreach, Ames, Iowa.

Split-application & N losses



- NO_3^- leaching falls by **19.3%** (split V6) and **21.3%** (split V13)
- **Split application reduces leaching** under most weather conditions compared to pre-plant N applications

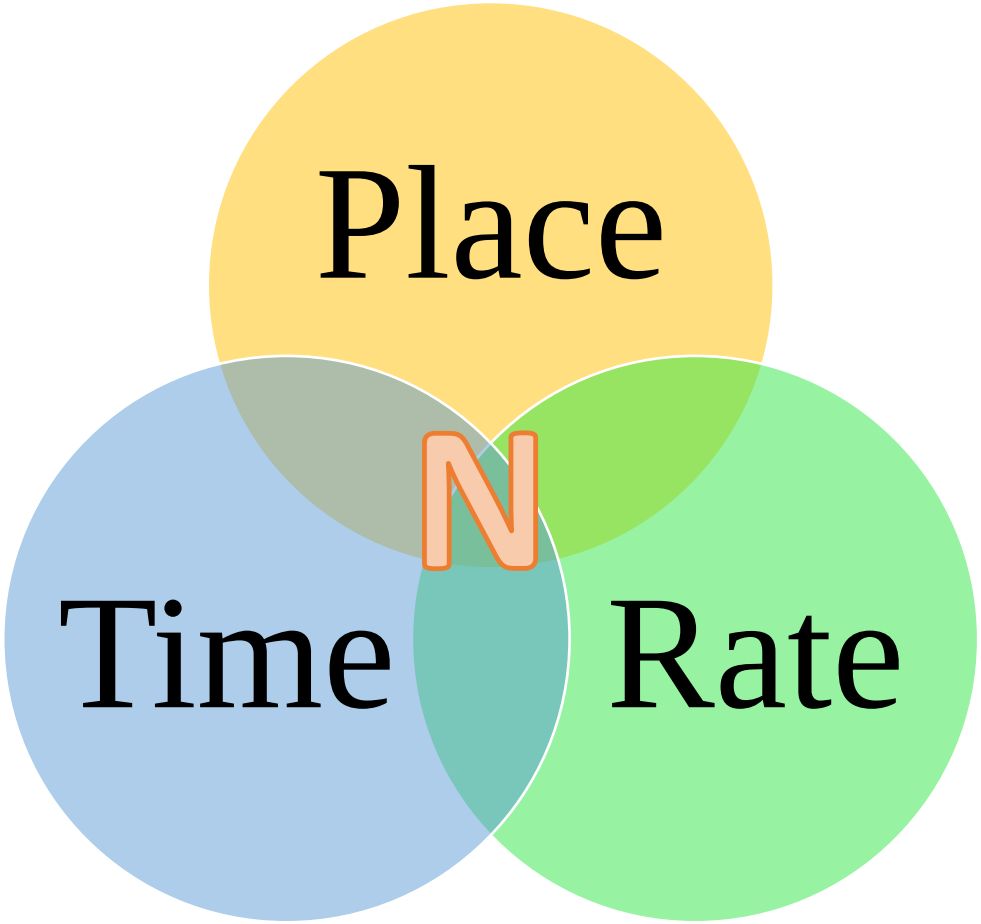
Kabir et al., 2021. Adjusting nitrogen rates with split applications: Modelled effects on N losses and profits across weather scenarios. *European Journal of Agronomy*, 129, p.126328.

Precision N Management

- In this project, we are studying the added benefits of N application in both, "**time and space**", from pre-plant through mid- to late-season, on corn yield.
- Objectives:

Applying N

a) **R**ight Input - N
b) **R**ight Place
c) **R**ight Time
d) **R**ight Rate
e) **R**ight Manner



Precision N Management

Right Place

- Site Specific Management Zones
  - Low
  - Medium
  - High

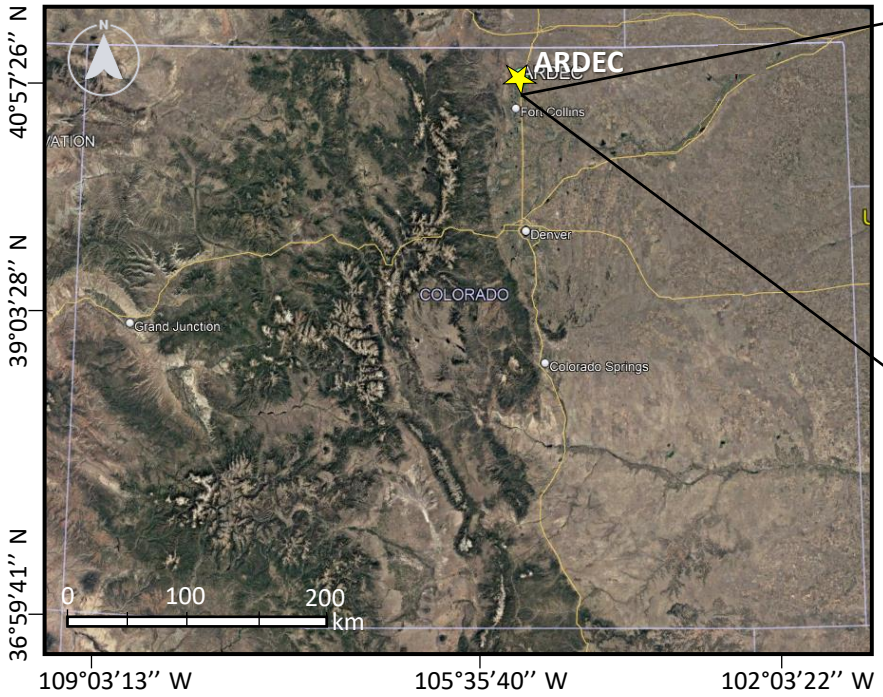
Right Time

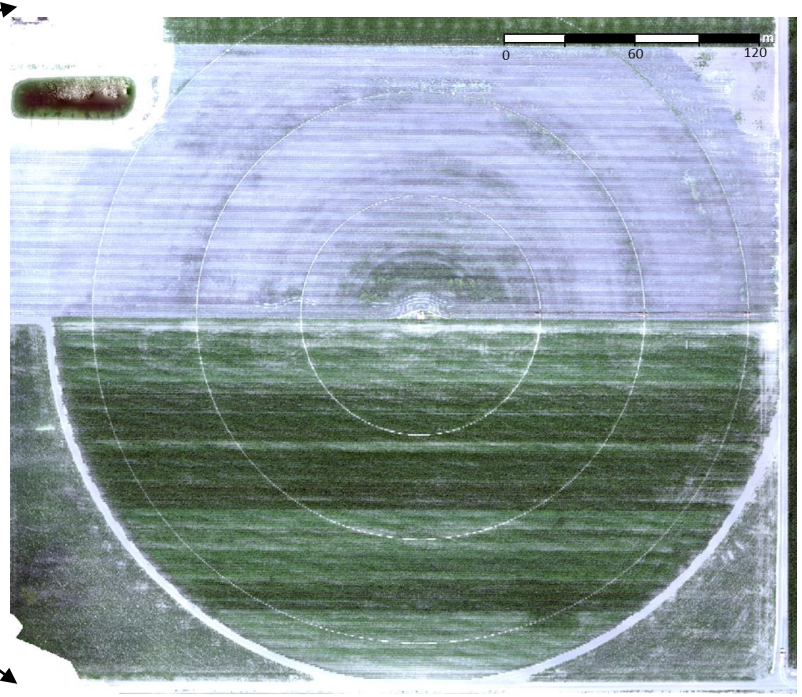
- Four Growth Stages
  - Emergence
  - V6-V8
  - V12
  - V16

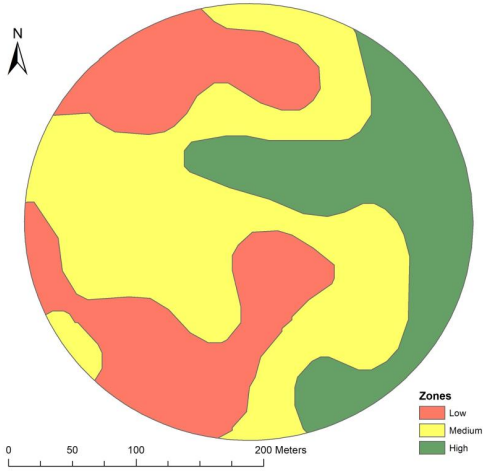
Right Rate

- 0
- 50
- 100
- 150
- 200
- 250 lb/acre

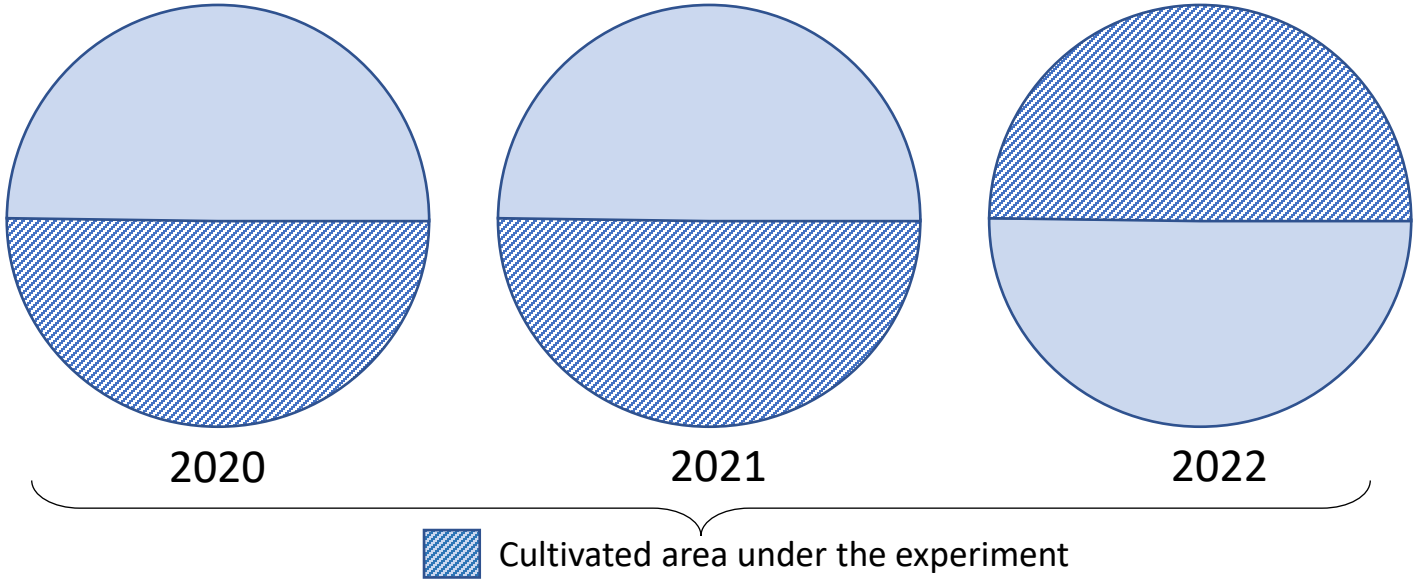
Site characteristics







Management zones



Methods

Planting (April 29, 2022)

- Corn Variety: DKC47-54 SSTX (DeKalb)
- Seed Rate: 34,000 seeds/ac
- Planter: Six-row John Deere Precision Vacuum Planter

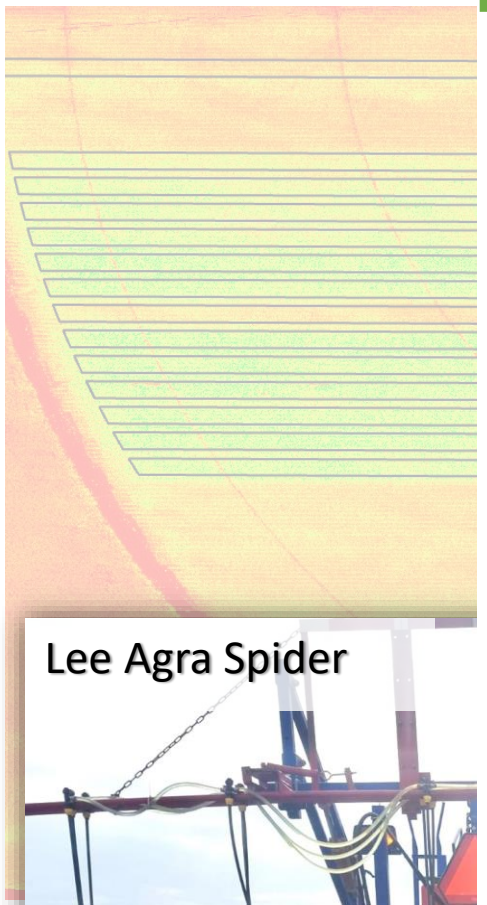
Agronomic Operations

- Standard Herbicide Application
- Irrigation with Center Pivot System

Grain Harvest (October 25, 2022)

- 8-row Case IH model 1660 Combine Harvester with a Trimble Yield Monitor

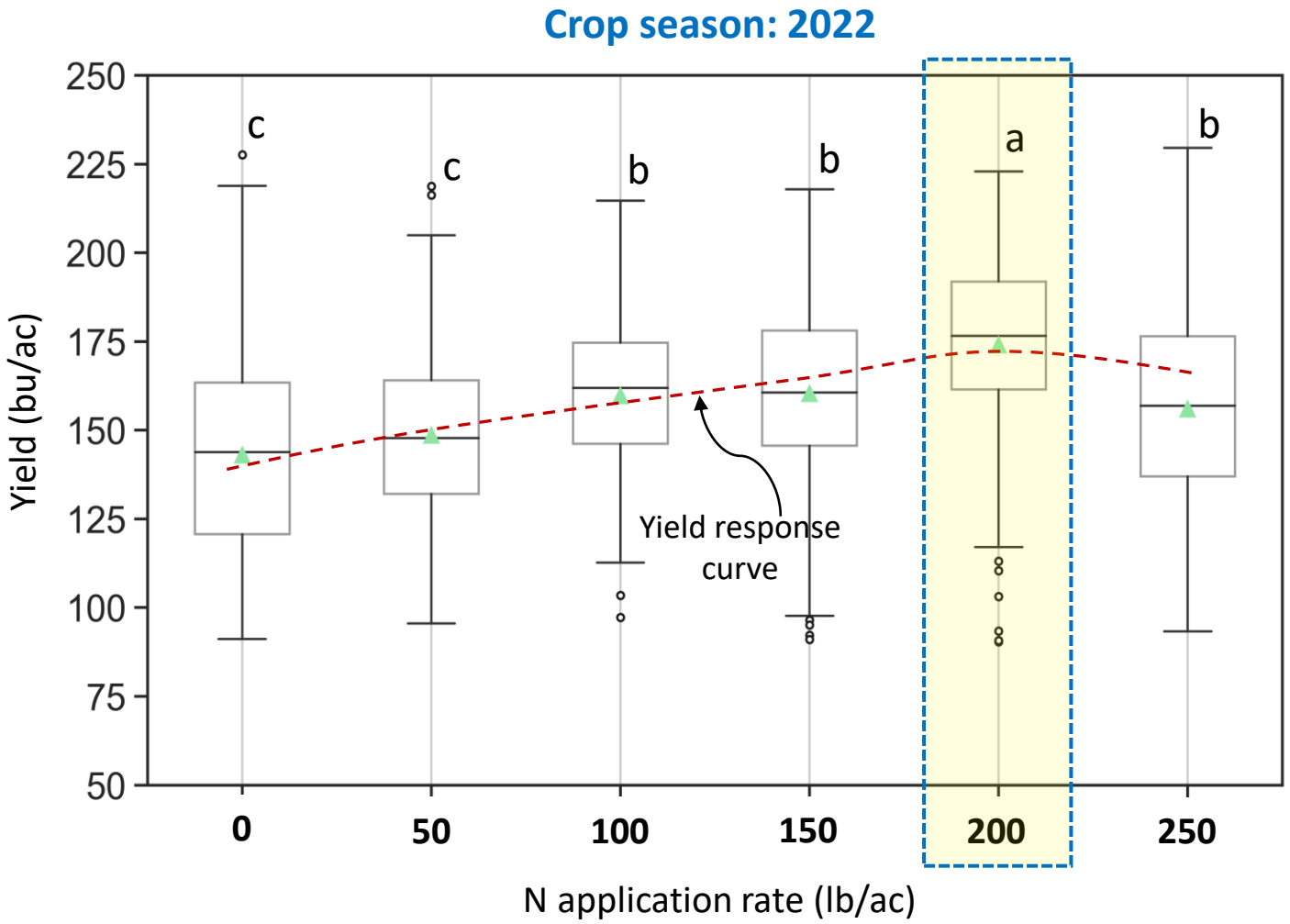
N treatments



N management Strategies	N rate (lb/acre)				Total N lb/acre	Treatment
	Crop growth stages					
	Emergence	V6-V8	V12	V16		

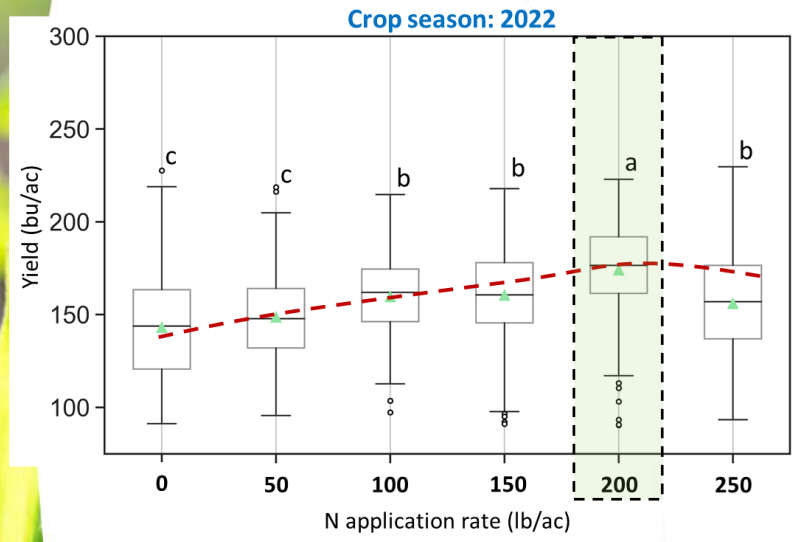
Uniform N Application: Single Split at Emergence

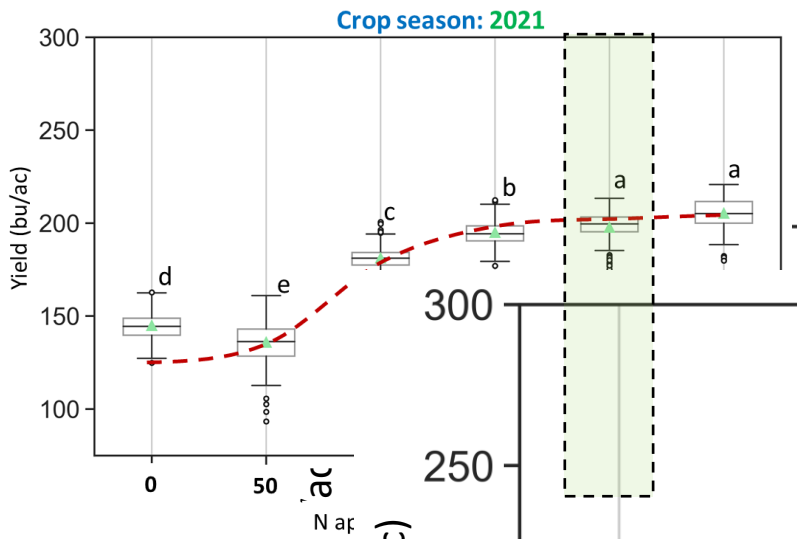
- Yield was responsive to different N application rates
- The mean yield value (**174 ± 25 bu/ac**) for 200 lbs/ac N was significantly higher than other treatments
- Applying 250 lb/ac did not provide yield benefit

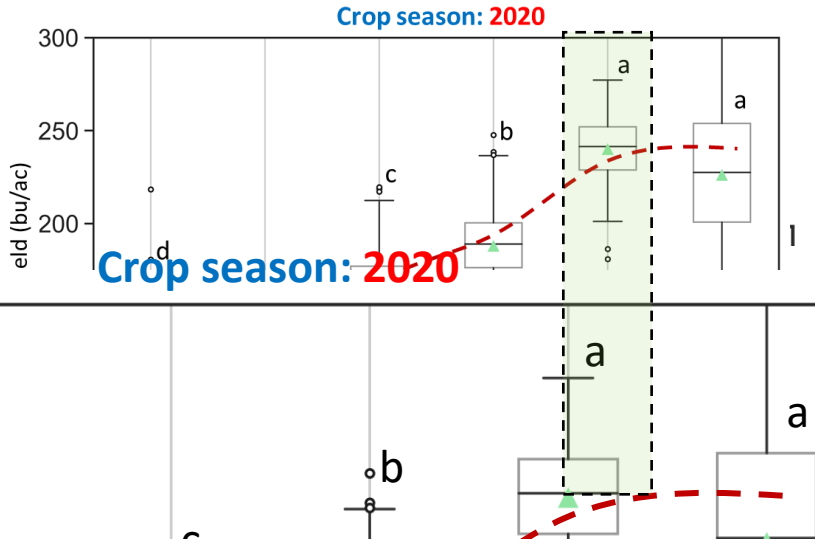


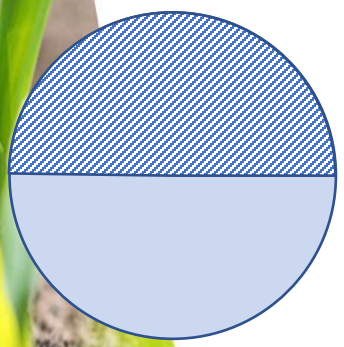
**Statistical significance is presented with Tukey's HSD post hoc test group symbology (a, b, c, d, e) with p<0.05.*

Consistence yield response in 3 crop seasons

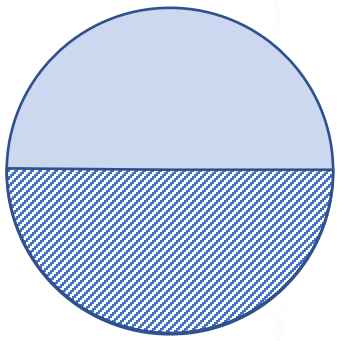




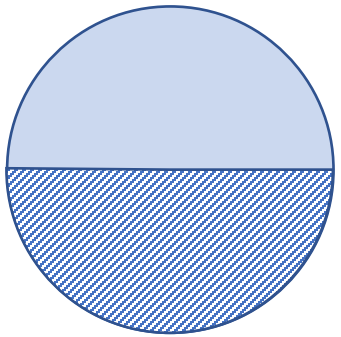




2022

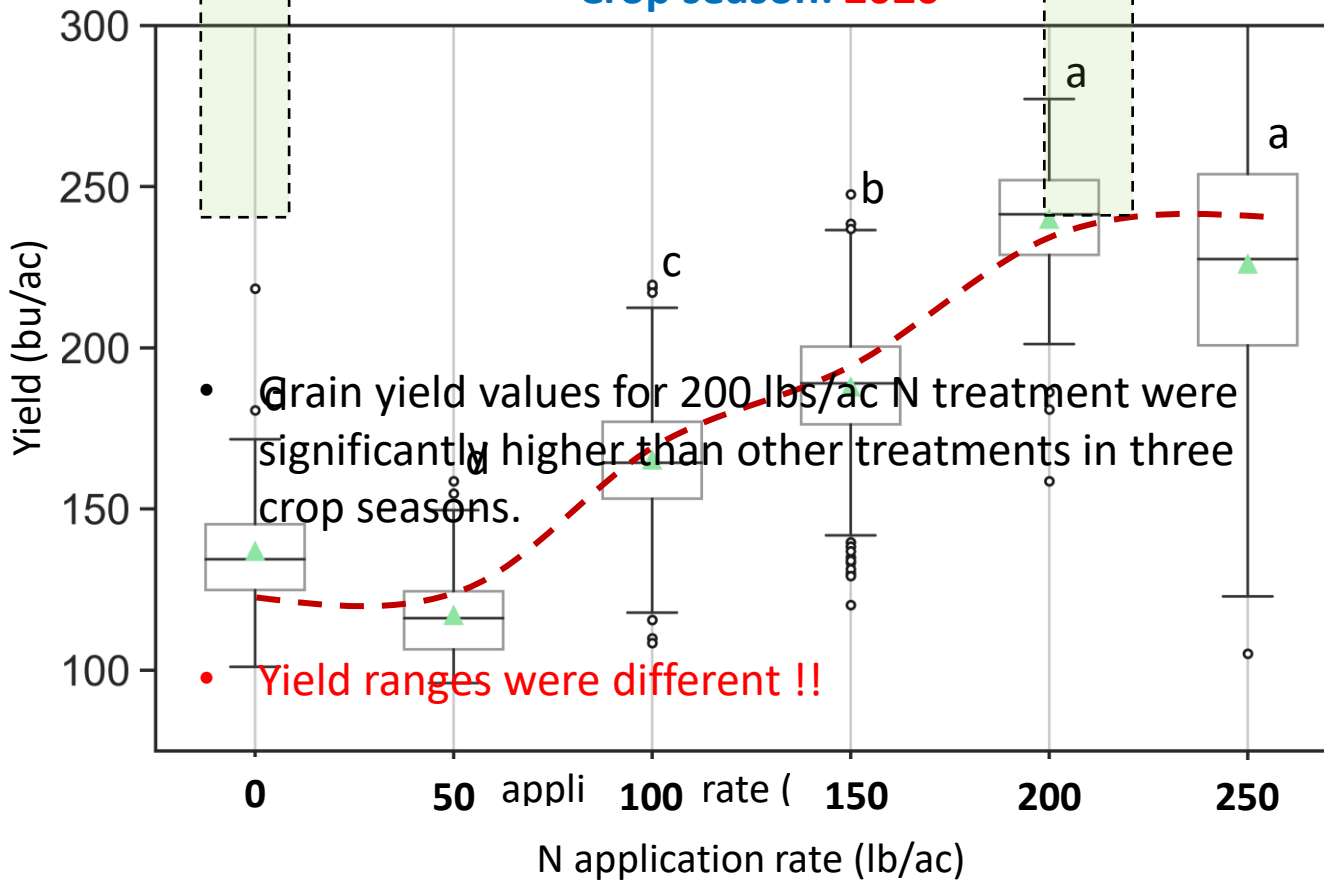


2021



2020

Cultivated area under the experiment



- Grain yield values for 200 lbs/ac N treatment were significantly higher than other treatments in three crop seasons.
- Yield ranges were different !!

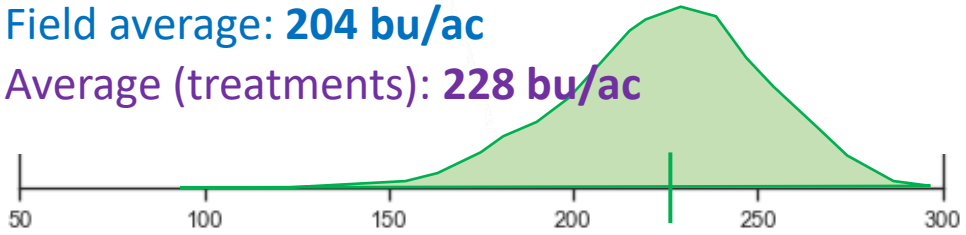
**Statistical significance is presented with Tukey's HSD post hoc test group symbology (a, b, c, d, e) with p<0.05.*

Varying yield distributions

Crop season: **2020**

Field average: **204 bu/ac**

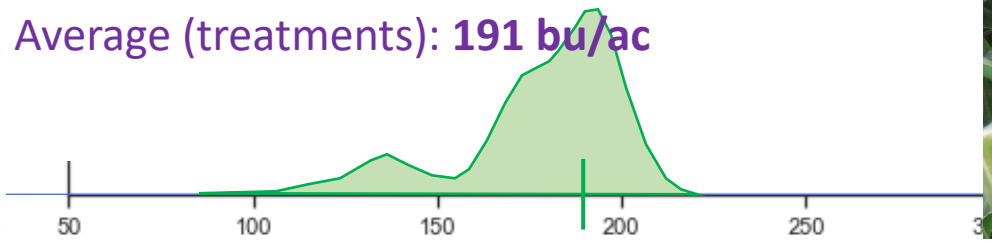
Average (treatments): **228 bu/ac**



Crop season: **2021**

Field average: **163 bu/ac**

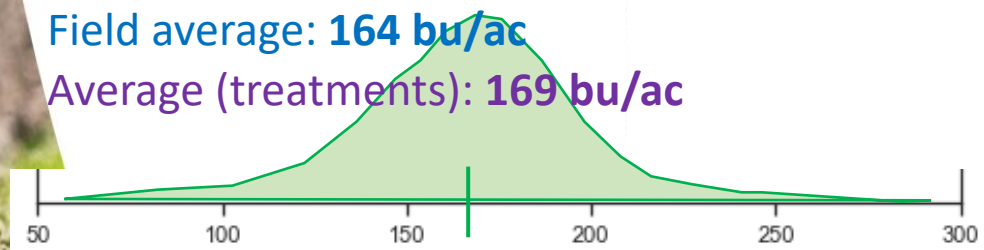
Average (treatments): **191 bu/ac**



Crop season: **2022**

Field average: **164 bu/ac**

Average (treatments): **169 bu/ac**



- Yield loss in 2022 season due to hail damage

Planet Skysat Multi-spectral: 07-30-2022

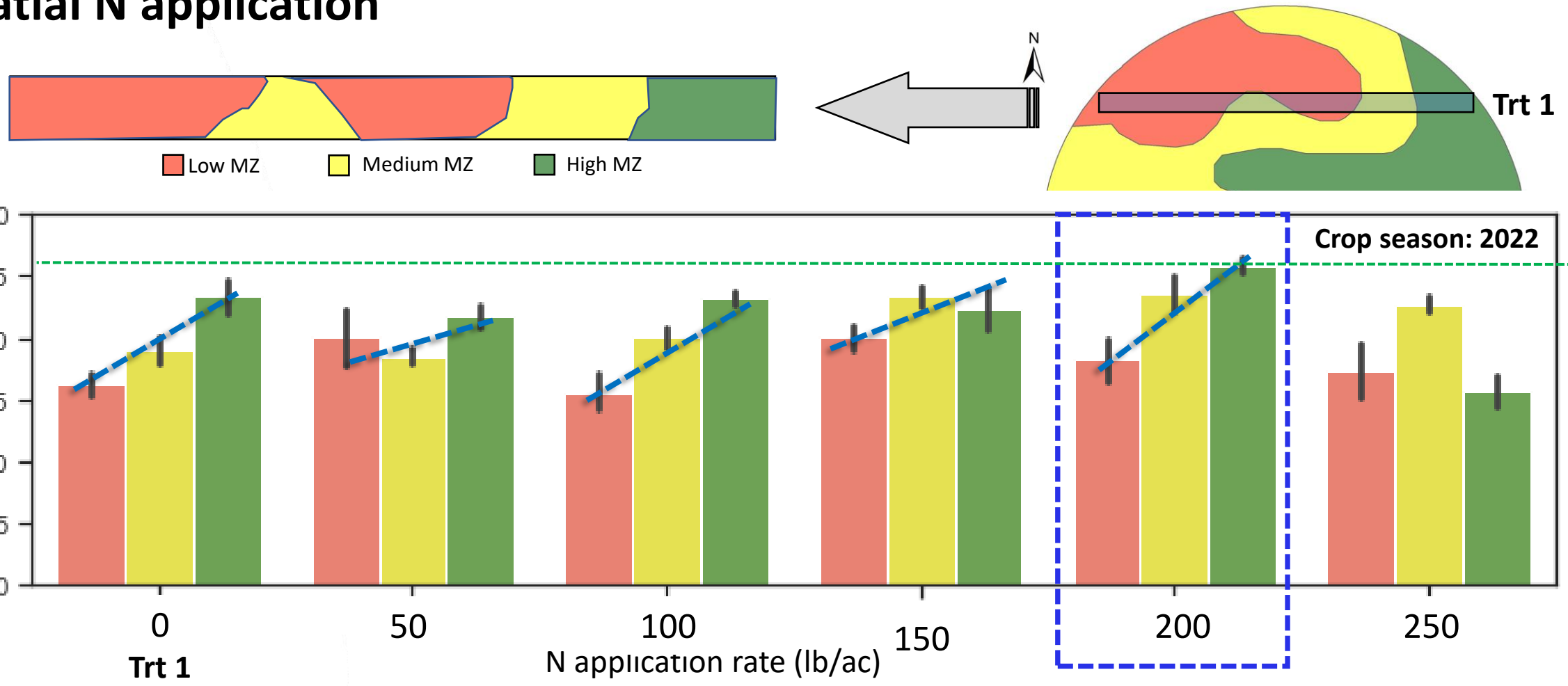
Resolution: 50 cm

UAS Multi-spectral: 08-01-2022

Resolution: 5 cm

Hail damage **uniformly** affected corn field

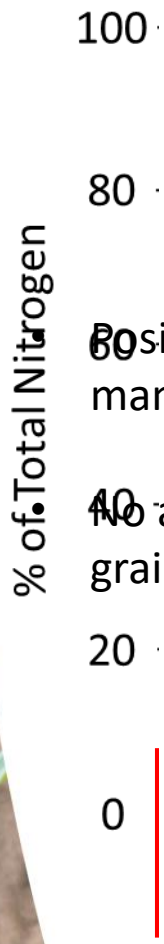
Spatial N application



- Grain yields were consistently higher in high management zones as compared to low and medium zones in five out of 6 N levels
- The 200 lb/ac N attained the highest yield

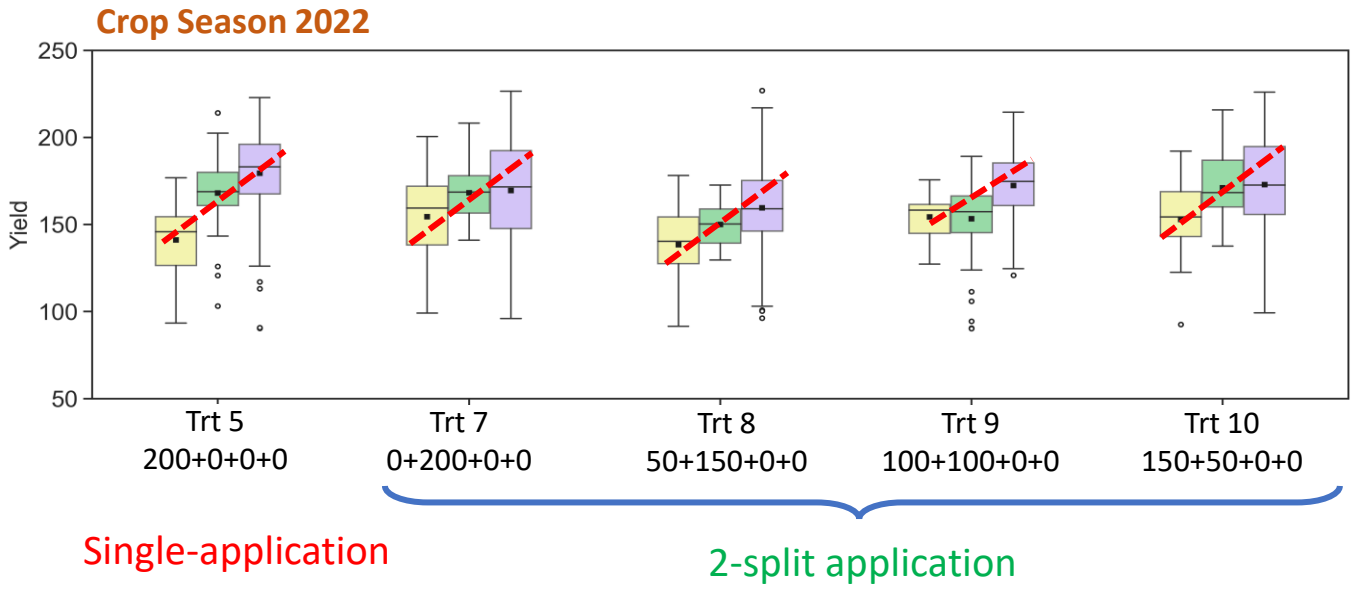
Temporal management

2-split applications @ Emergence and V6-V8



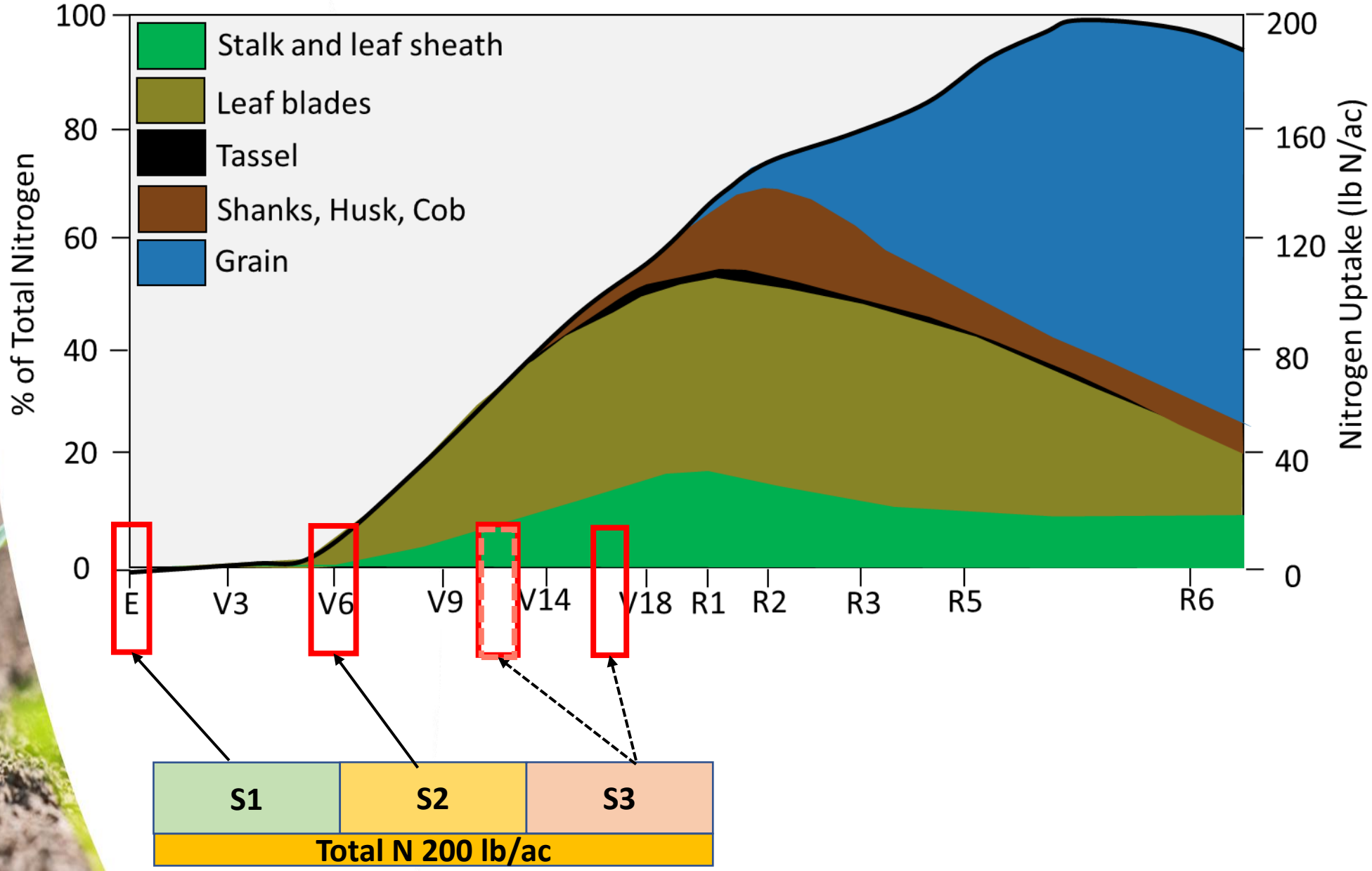
Positive grain yield response across management zones

No apparent advantage that is significant in grain yield with two split application



Temporal management

3-split applications @ Emergence, V6-V8, V12 or V16



Temporal management

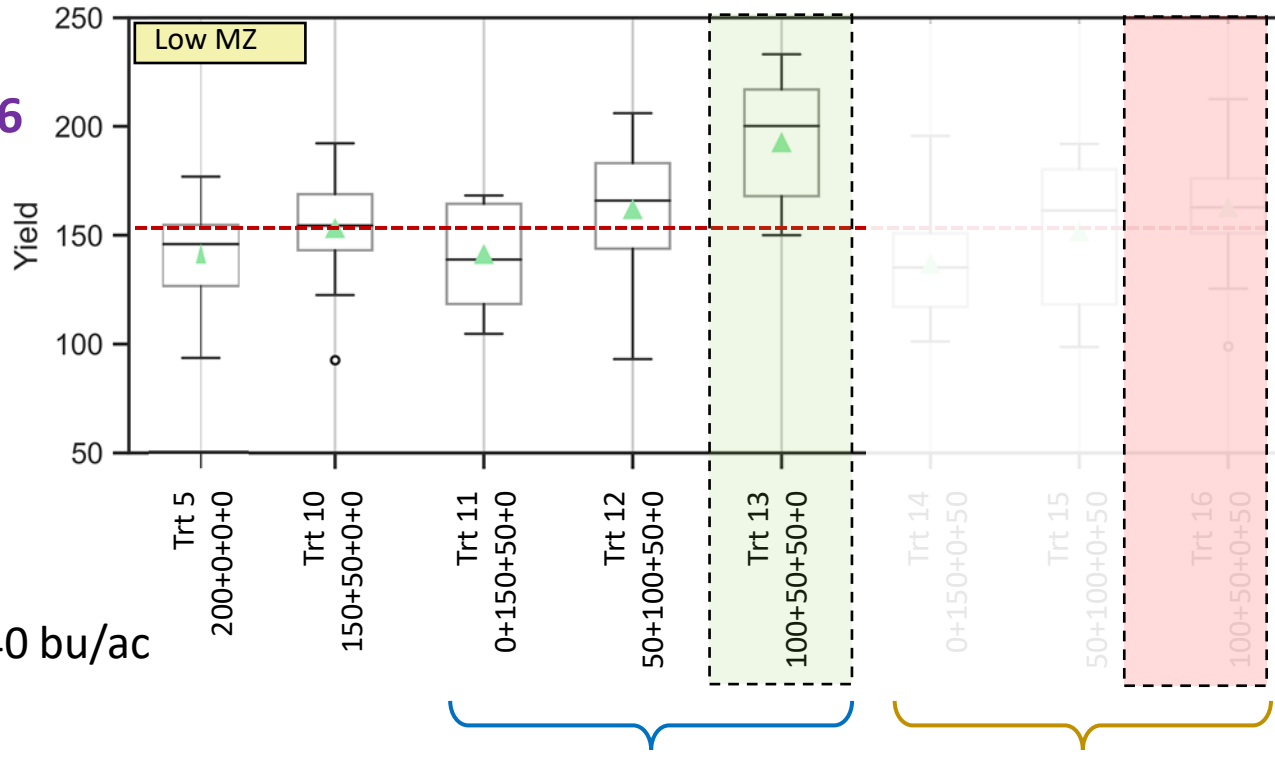
3-split applications @ Emergence, V6-V8, V12 or V16

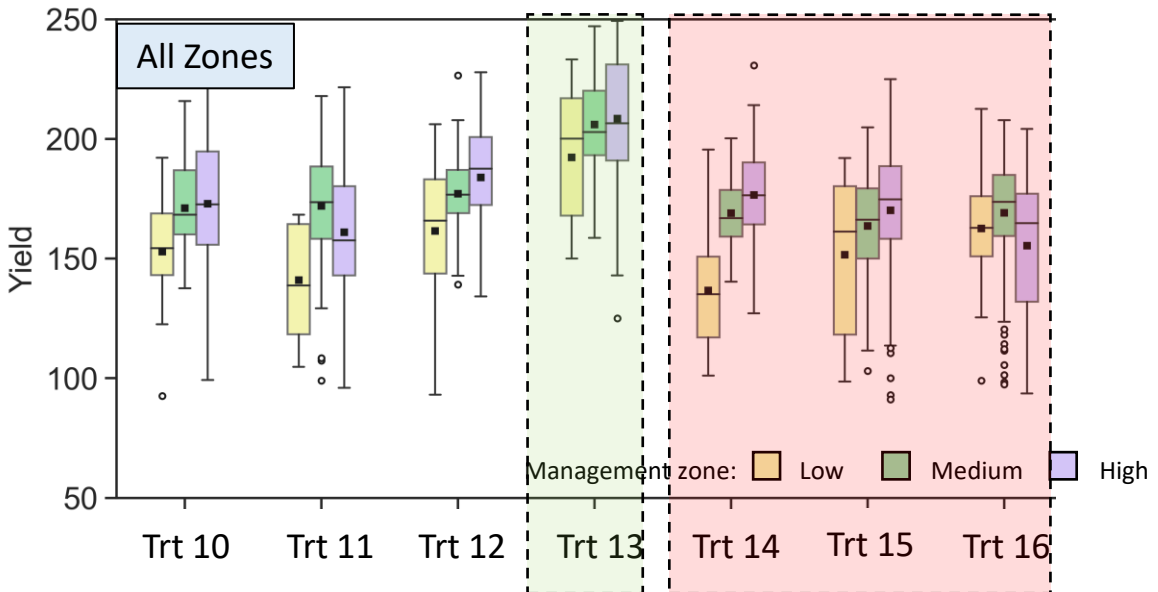
- 3rd Split application at V12 stage:
  Trt 13 (100+50+50+0) produced significantly higher yield of 206 bu/ac.

- 50 lb N applied at V16 instead of V12
  (Trt 16 100+50+0+50) stage the grain yield dropped by 40 bu/ac

- In all three management zones Trt 13 (100+50+50+0) produced the highest yield in 3-split application group

- Split applications at V16 produced lower yield in all zones and treatments. No apparent advantage in delaying the 3rd split application to the V16 stage

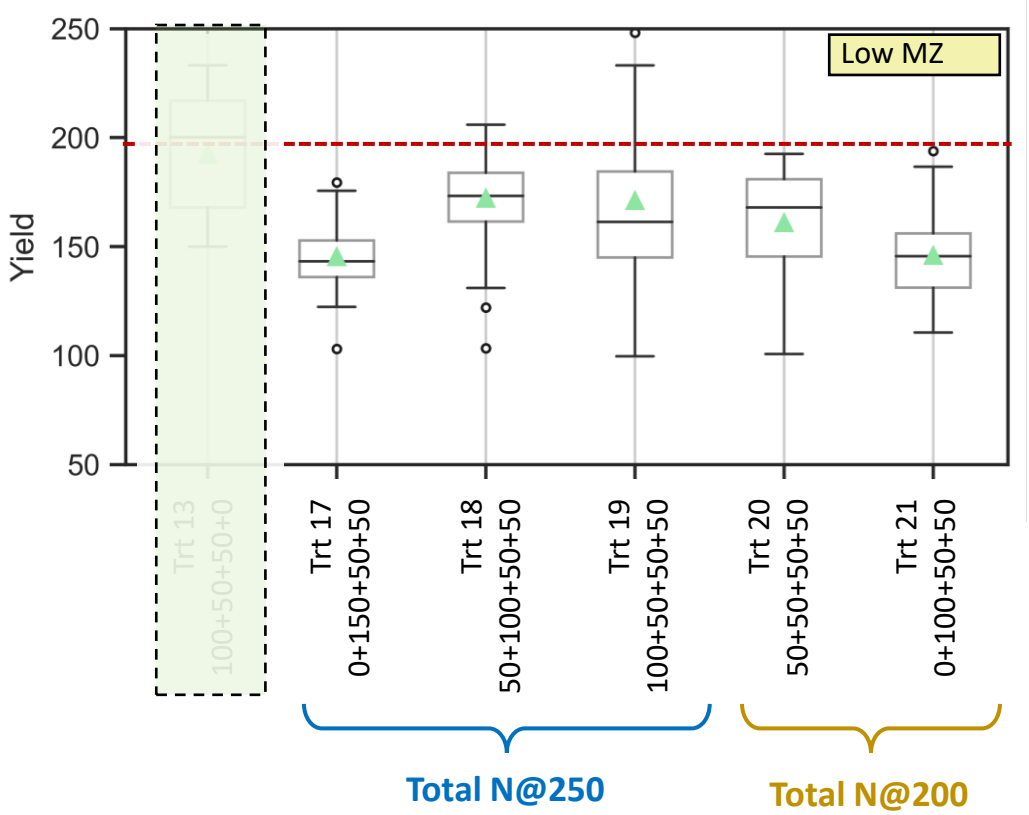




Temporal management

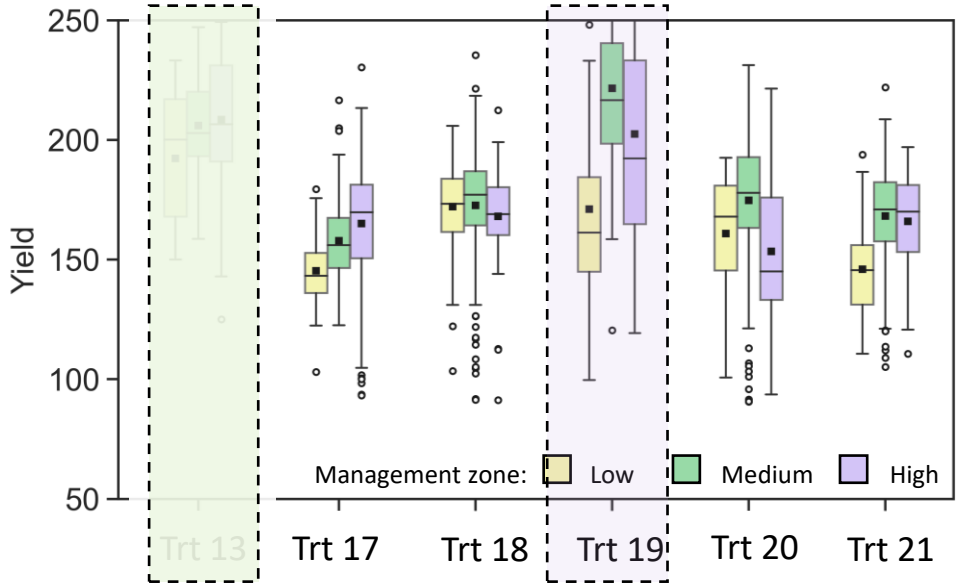
4-split applications @ Emergence, V6-V8, V12 and V16

- In Low MZ, 4-split applications did not produce significant yield benefit
- Increasing the total N-budget to 250 lb/ac total via 4-split did not outperform total 200 lb/ac treatments.
- Trt 13 (100+50+50+0) outperformed the 4-split applications
- In low zones yield for 4-split applications were lower than 3-splits



Comparison of 4-split applications:

- Trt 19 (100+50+50+50) - total of 250 lb/ac N produced higher yield than other 4-split treatments
- However, the differential yield between Trt 19 and Trt 13 is not significant



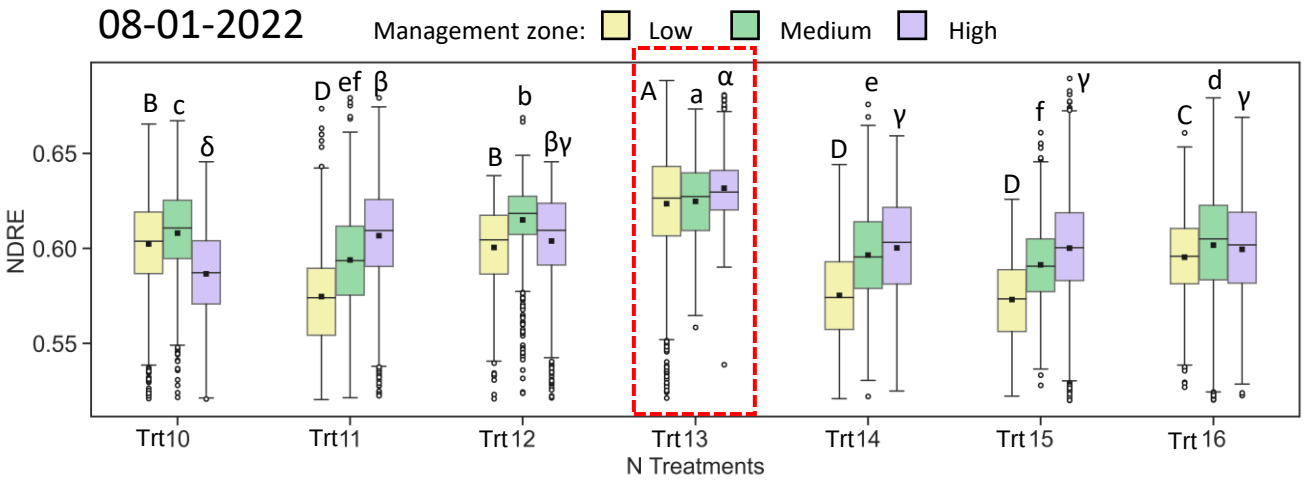
Measuring yield response with optical measurements

- Aerial imagery was collected with a MicaSense Rededge-3 multispectral sensor mounted on a DJI Matrice 100 quadcopter after tasseling.

- Multi-spectral images were used to generate the Normalized Difference Red Edge (NDRE) indices to account vegetation health.

$$\mathrm{NDRE} = \frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{RedEdge}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{RedEdge}}}$$

- NDRE produced varying response across different treatments and management zones.
- NDRE values also indicated Trt 13 (100+50+50+0) as significantly highest mean.
- Highest yield values were also observed for Trt 13 in all MZs.



Conclusions

- Where, when, and how much you apply N to the crop has a significant affect on crop performance
- Spatial management strategy (MZs) continues to be productive.
- Spatial & temporal management of N is favorable when compared to uniform applications of N
- Applying N as late as V12 growth stage performed consistently better across 3 management zones and proved to be the highest yielding strategy
- Applying N late at V16 stage produced unclear yield benefit over 3 yrs

Thank you

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