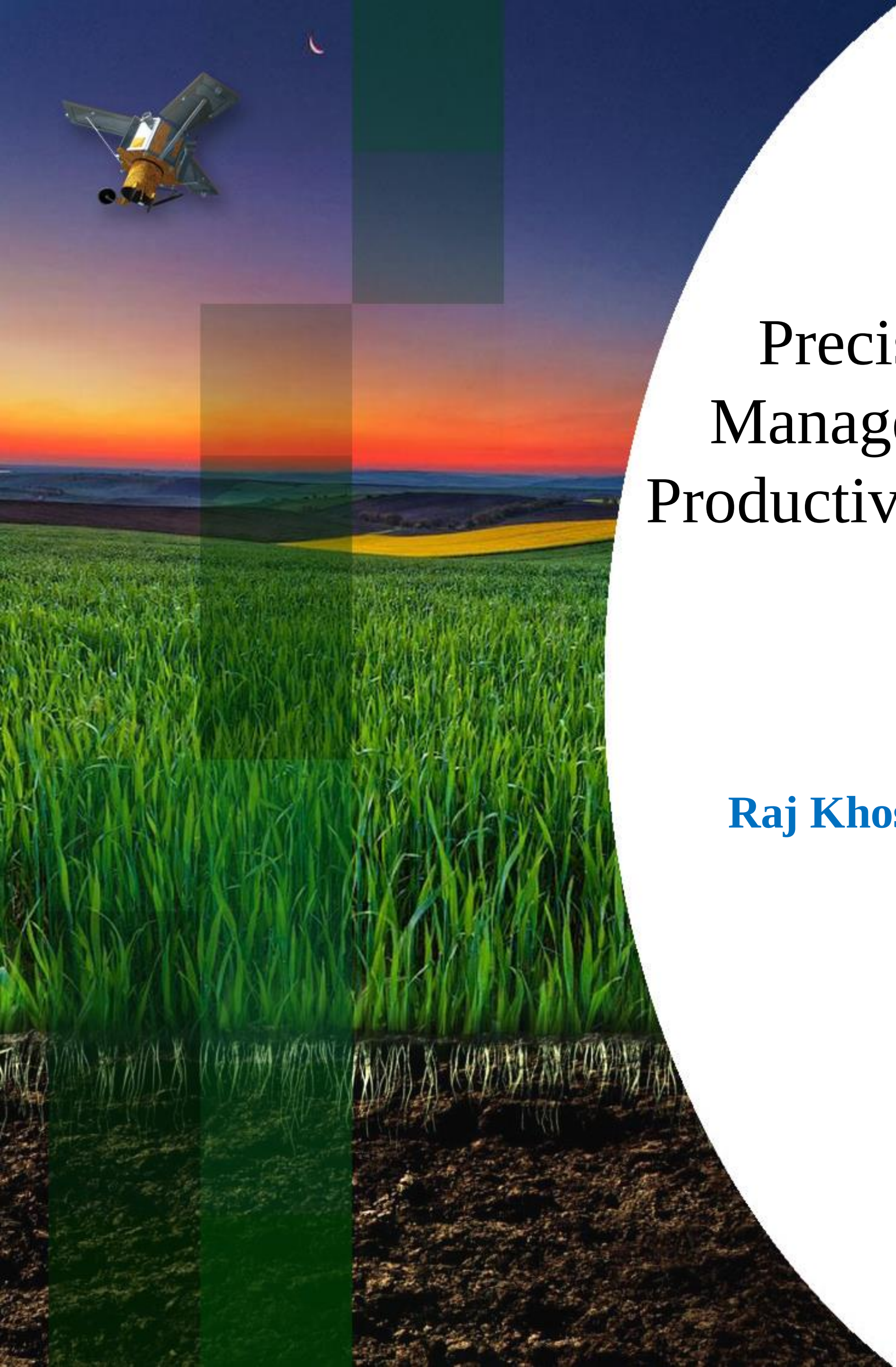

Precision-Water, -Nitrogen and -Seed Management for Enhancing Efficiency, Productivity, and Profitability of Irrigated Cropping Systems

Raj Khosla, Jose Chavez, Allan Andales, Robin Reich and Louis Longchamps

Colorado State University

Fluid Fertilizer Forum

February 2016

Basic agronomy

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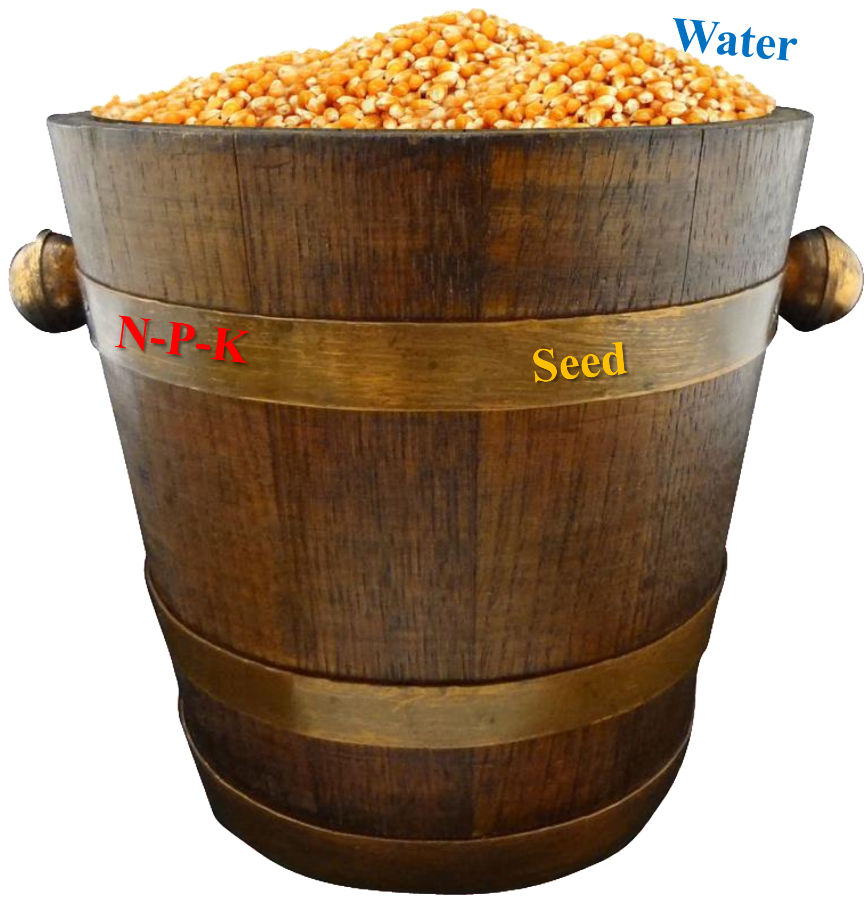
+

=

Law of limiting factors

Law of limiting factors



N prescription algorithm

?

Accounting for yield

$$N = 35 + 1.2\ lbs\ N \times (EY)$$

Accounting for yield and soil N

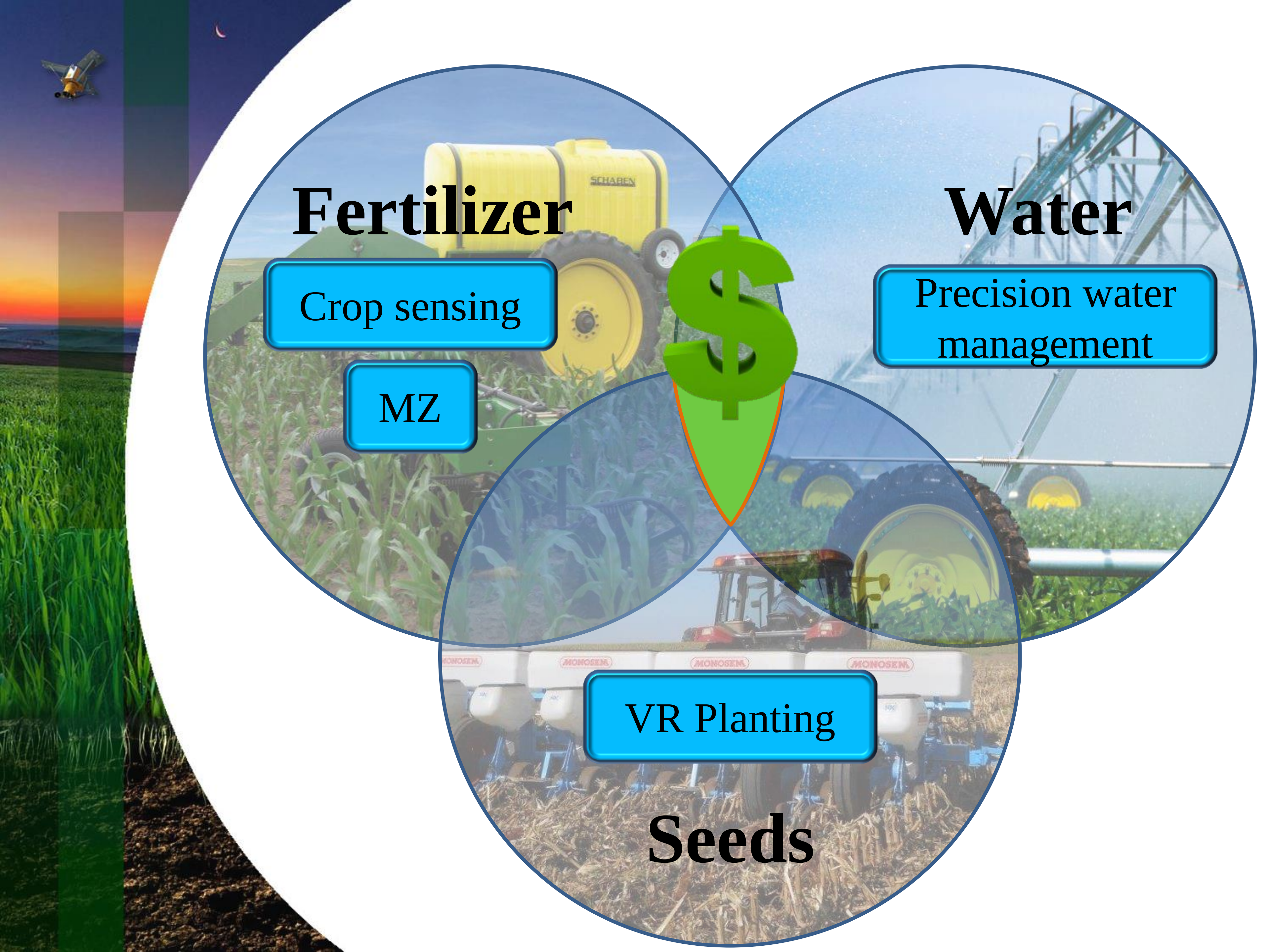
$$N = 35 + [1.2\ lbs\ N \times (EY)] - [8 \times ppm\ NO_3N] - [0.14 \times (EY) \times \%OM]$$

Accounting for yield, soil N and crop status

$$N = \{35 + [1.2\ lbs\ N \times (EY)] - [Soil\ N]\} \times [RichStrip_{NDVI}/Target_{NDVI}]$$

Accounting for yield, soil N, crop status and seed and irrigation rate

$$N = \{35 + [1.2\ lbs\ N \times (EY)] - [Soil\ N]\} \div [NDVI] \times Seed\ Rate \times Irrigation$$


Fertilizer
Crop sensing
MZ
Water
Precision water management
$
VR Planting
Seeds

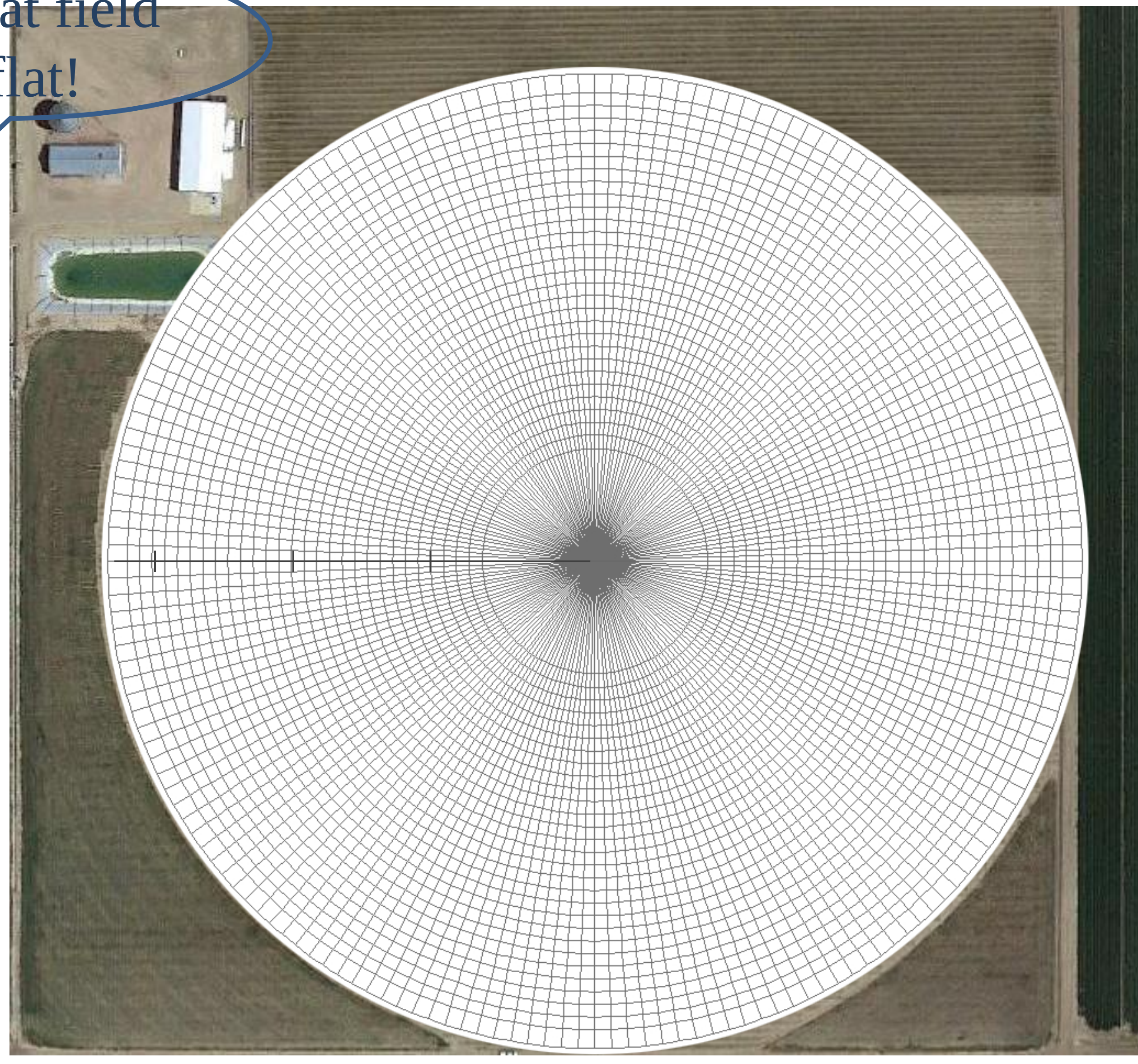
Objectives of the project

1. Quantify spatial and temporal variability in soil water balance across the 22 acre precision pivot equipped field

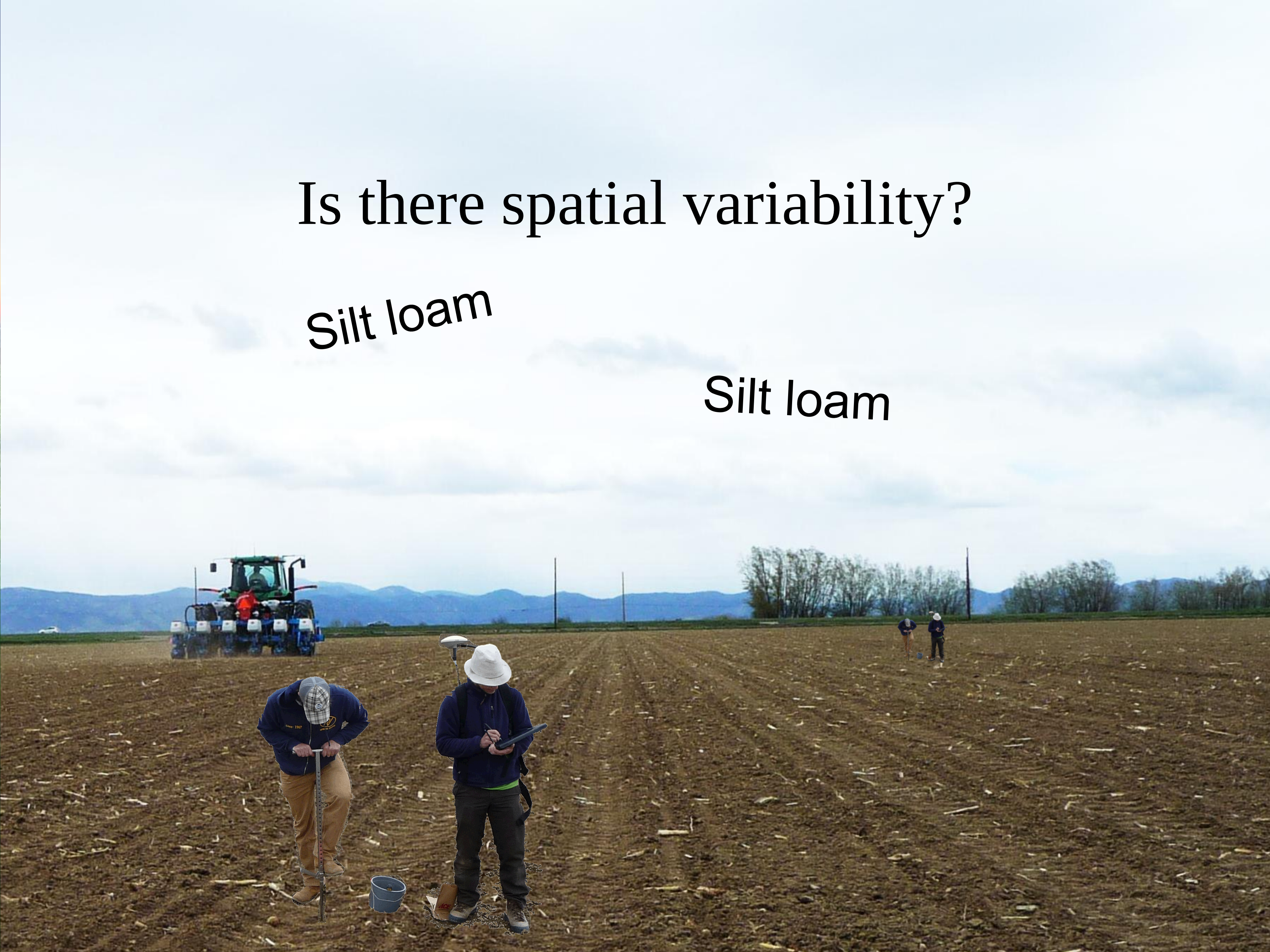
2. Develop early season (corn growth stage V4-V6) in-season precision nitrogen management system for irrigated corn.

3. Evaluate variable rate seeding in conjunction with variably managed water and nutrient crop field.

I. Water Management



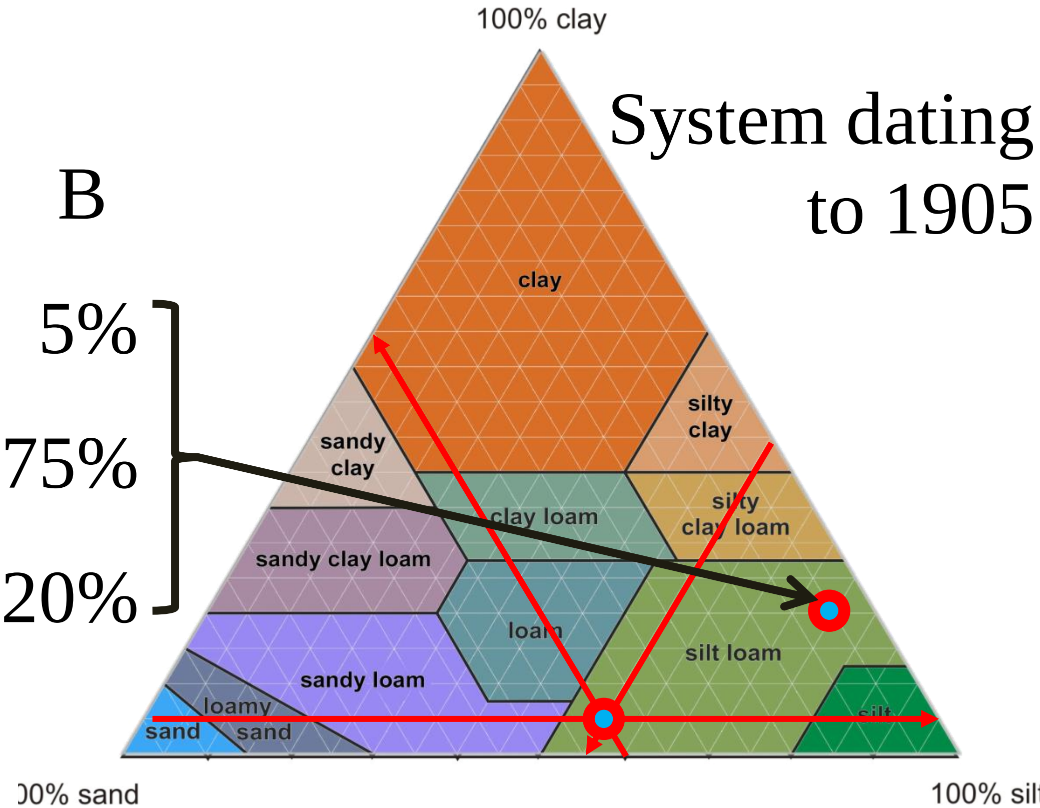
No variability?

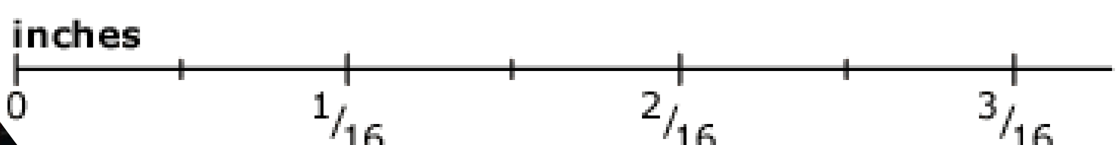

Is there spatial variability?
Silt loam
Silt loam

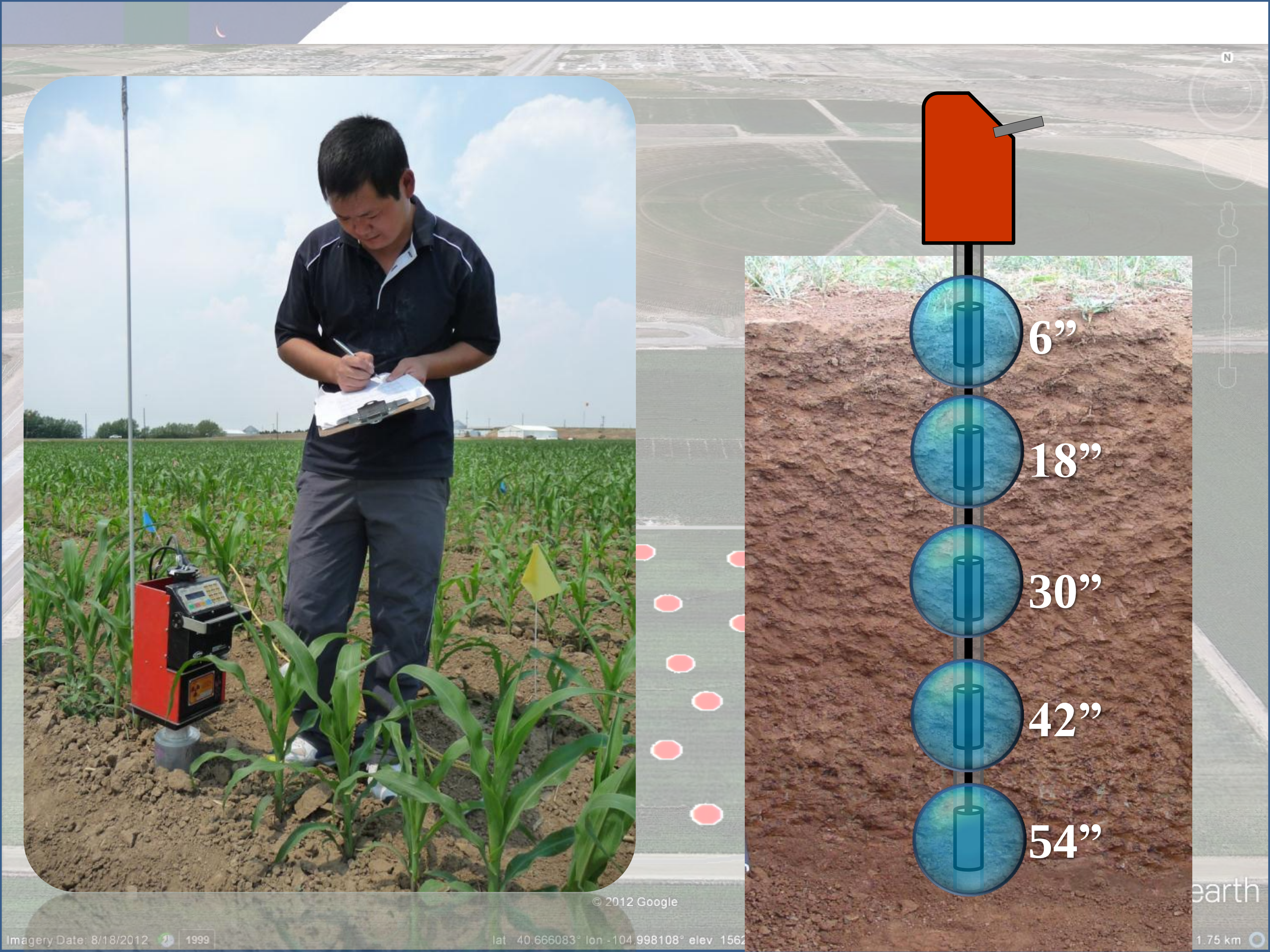
System dating to 1905

	A	B
Sand:	39%	5%
Silt:	55%	75%
Clay:	6%	20%

Silt loam



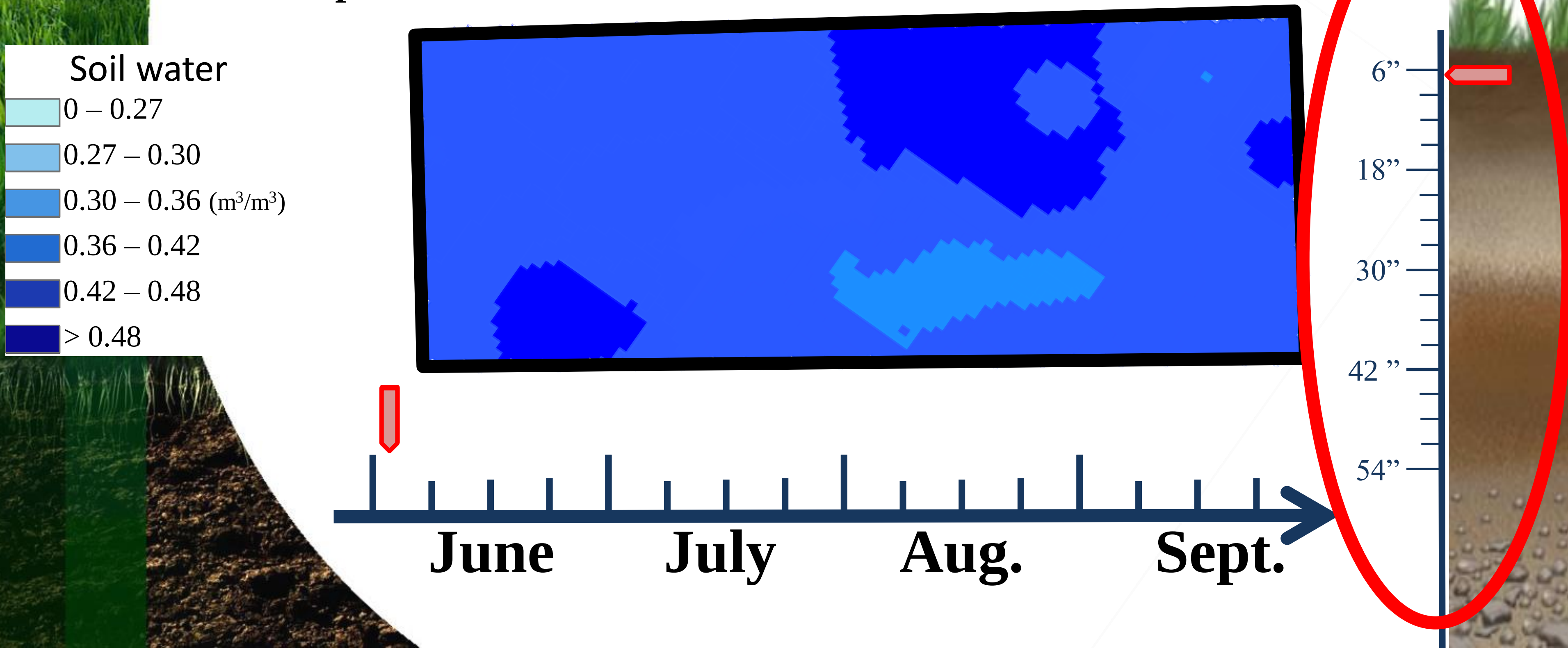



6”
18”
30”
42”
54”
© 2012 Google
Imagery Date: 8/18/2012
1999
lat 40.666083° lon -104.998108° elev
1.75 km

<u>Spatial and Temporal</u> variability

- There is significant <u>spatial</u> variability
- There is significant <u>temporal</u> variability in soil moisture at the field scale across the crop growing season.
- The <u>temporal</u> range of soil moisture is fairly large in depth and shorter at the surface

Example



Practical implications

- Spatial variability in soil water may justify a Variable-Rate Irrigation
- Spatial range of variability is conducive to a management zones approach
- Water management zones delineated using data from deeper soil profile are more stable in time
- Top soil is harder to map and uniform rate may be better at early stages when roots are in the top soil (*our hypothesis*)

1. *Quantifying variability of soil water content*

Published September 11, 2015

Soil & Water Management & Conservation

Spatial and Temporal Variability of Soil Water Content in Leveled Fi...

L. Longchamps*
R. Khosl...

...ısed at a specific depth. Although ...cy of soil water ...ter content mea- ...o be spatially de- ...2009). A strong ...hese sites, a lim- ...ugh information ...profile from 0 to ...n spatial depen- ...eason for Site 1 ...happening along ...ce of roots in the

...ing neutron probes.

ACKNOWLEDGMENTS

We acknowledge the assistance received from a number of individuals towards completion of this study notably, Neil Hansen, Allan Andales, J.R. Hermann, Jessica Gerk, Chris Fryrear, and Mark Collins. This project was partly funded by USDA–Natural Resource Conservation Services–Conservation Innovation Grant, Colorado State University Agricultural Experiment Station, Colorado Corn Growers Administrative Committee, the 21st Century Equipment Inc., John Deere–Water, Inc., and the Fluid Fertilizer Foundation.

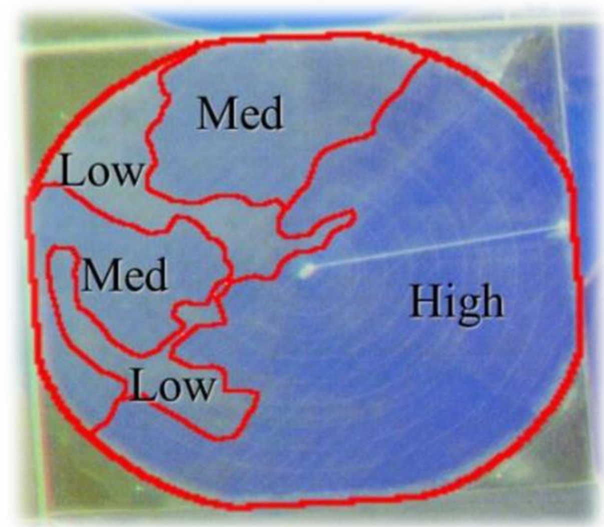
REFERENCES

Abdullah, K.B. 2006. Use of water and land for food security and environmental sustainability. Irrig. Drain. 55:219–222. doi:10.1002/ird.254

...FC, field capacity; MAD, maximum allowed depletion; VRI, variable rate irrigation. ...AWC, available water content; CV,

2. Early season N management using remote sensing

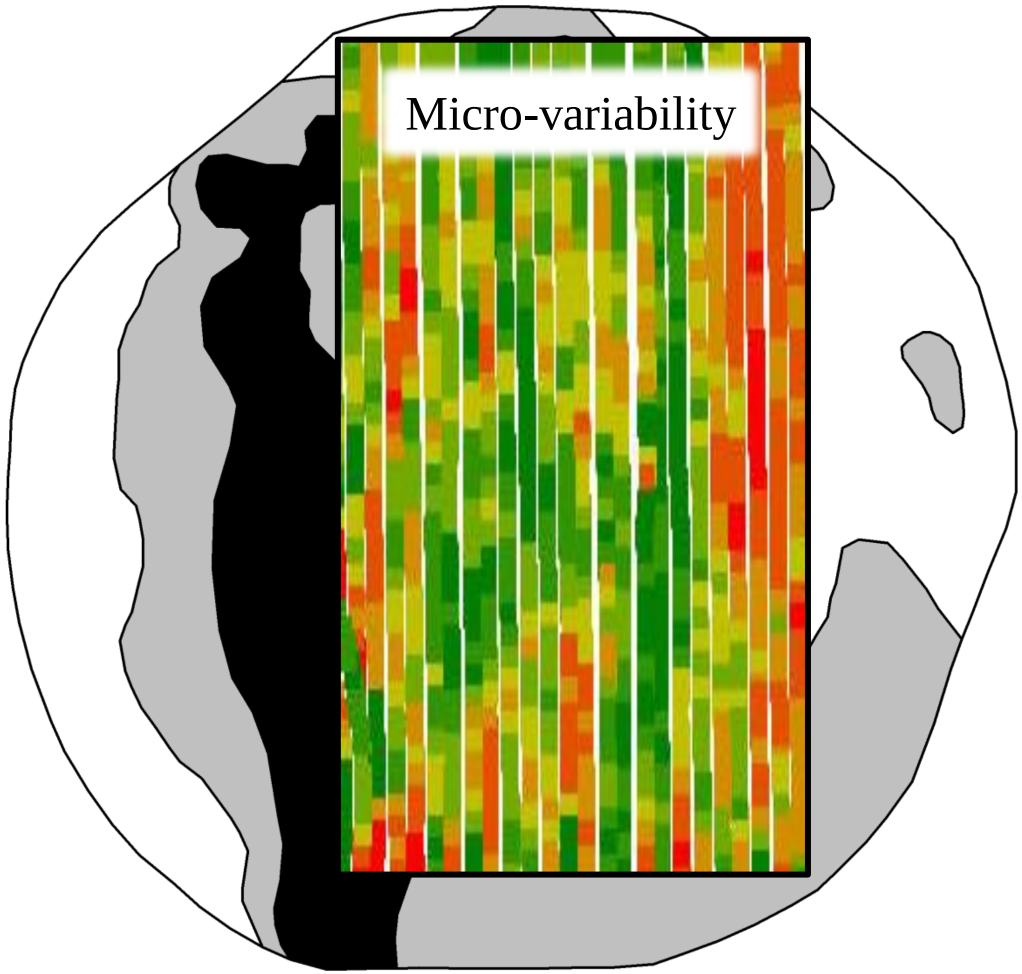
Active remote-sensing
(micro-management)



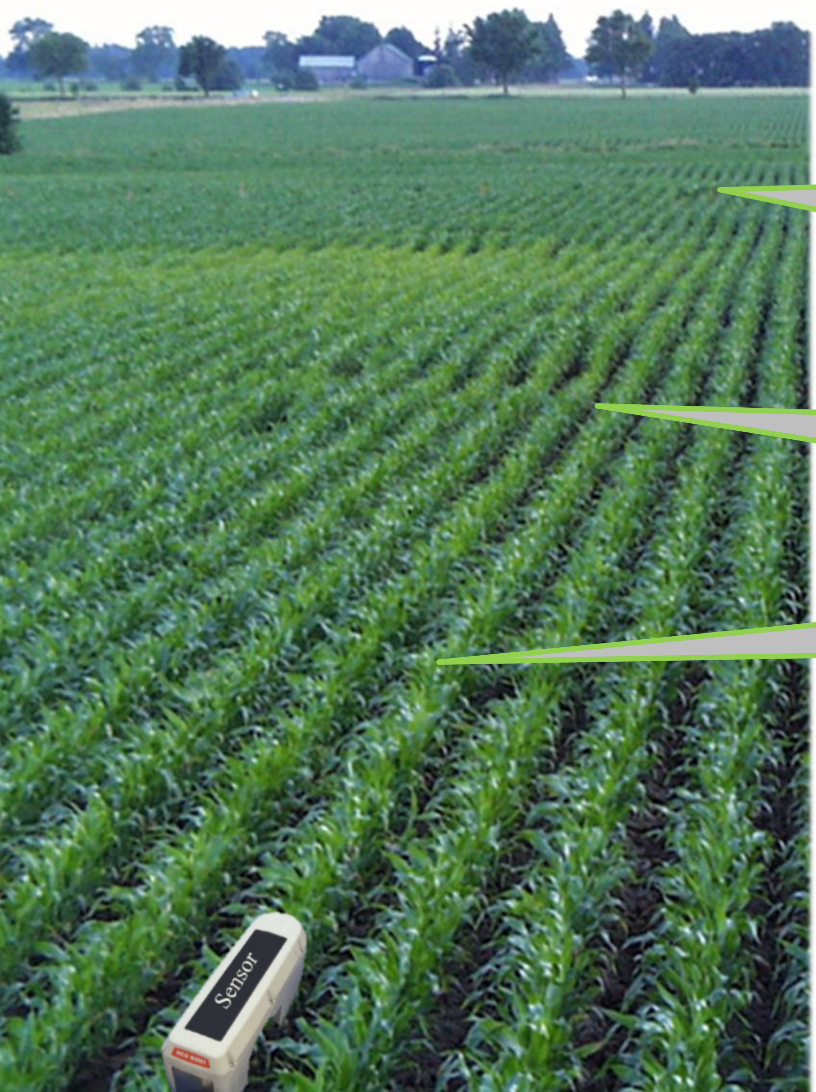
Management zones
(macro-management)

Coupling site-specific management zones with active proximal sensors

Attempt to manage both, macro- and micro-variability in farm-fields



$$N\ Rate\ (kg\ ha^{-1}) = (135.3 \times (NDVI_{Ref.} / NDVI_{Target})^2) - (134.8 \times (NDVI_{Ref.} / NDVI_{Target})) + 1$$



NDVI
0.41

~96 lb/A

NDVI
0.41

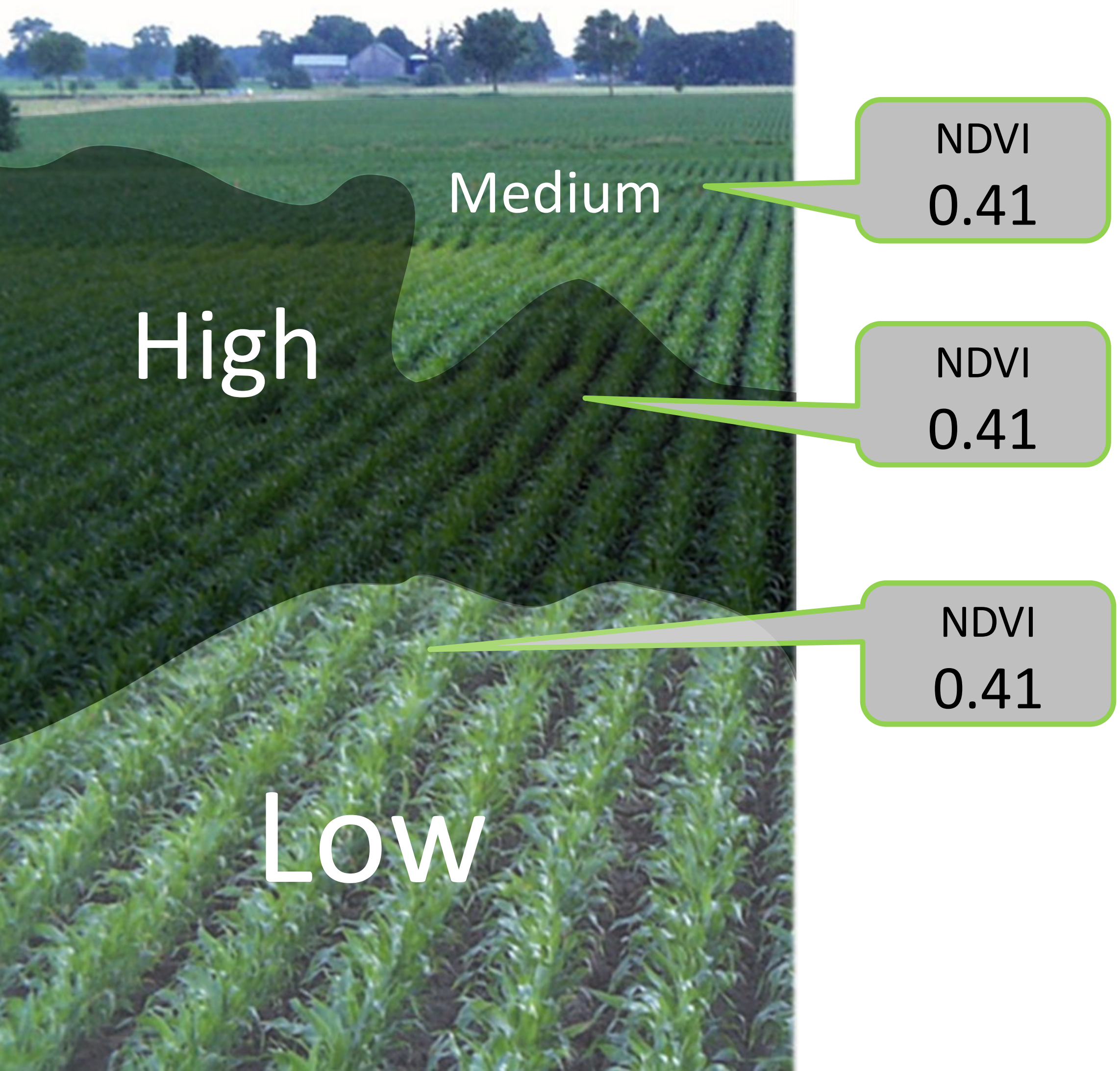
~96 lb/A

NDVI
0.41

~96 lb/A

N Rate (kg ha^{-1}) = $(135.3 \times (NDVI_{Ref.} / NDVI_{Target})^2) - (134.8 \times (NDVI_{Ref.} / NDVI_{Target})) + 1$

Crop properties + Soil Properties



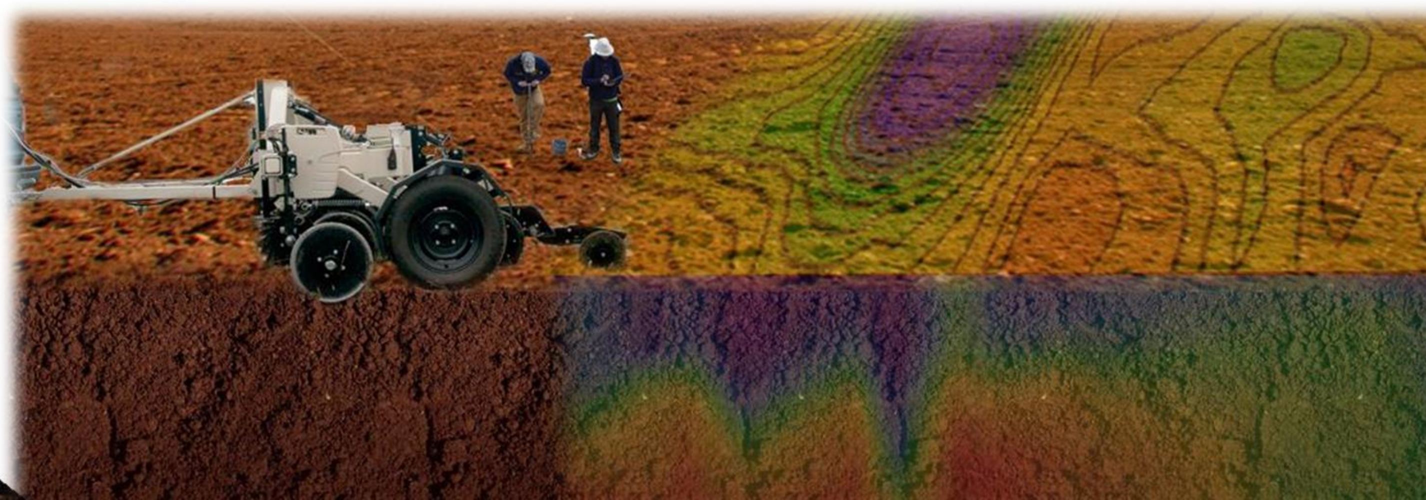
~92 lb/A

~144 lb/A

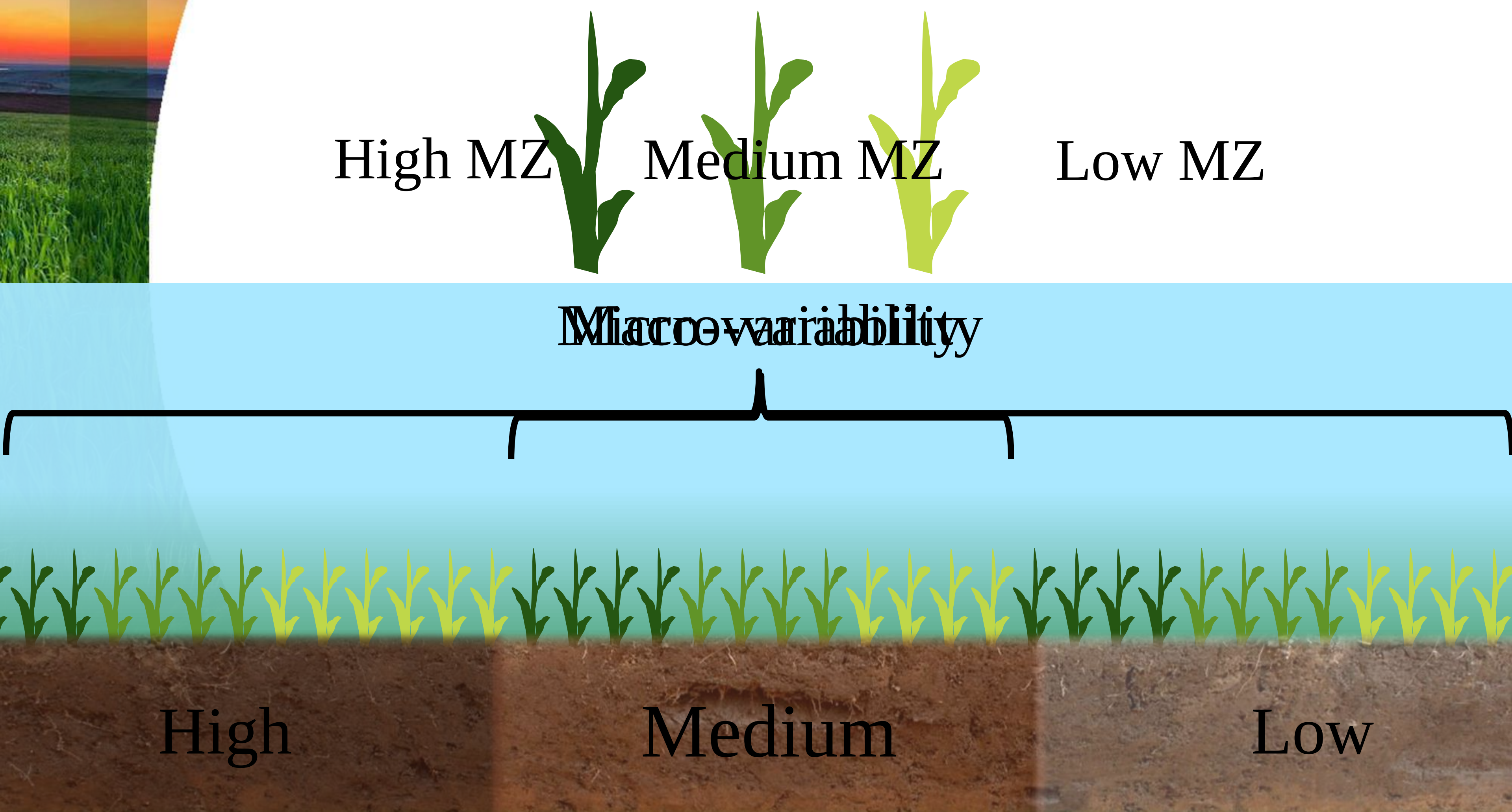
~37 lb/A

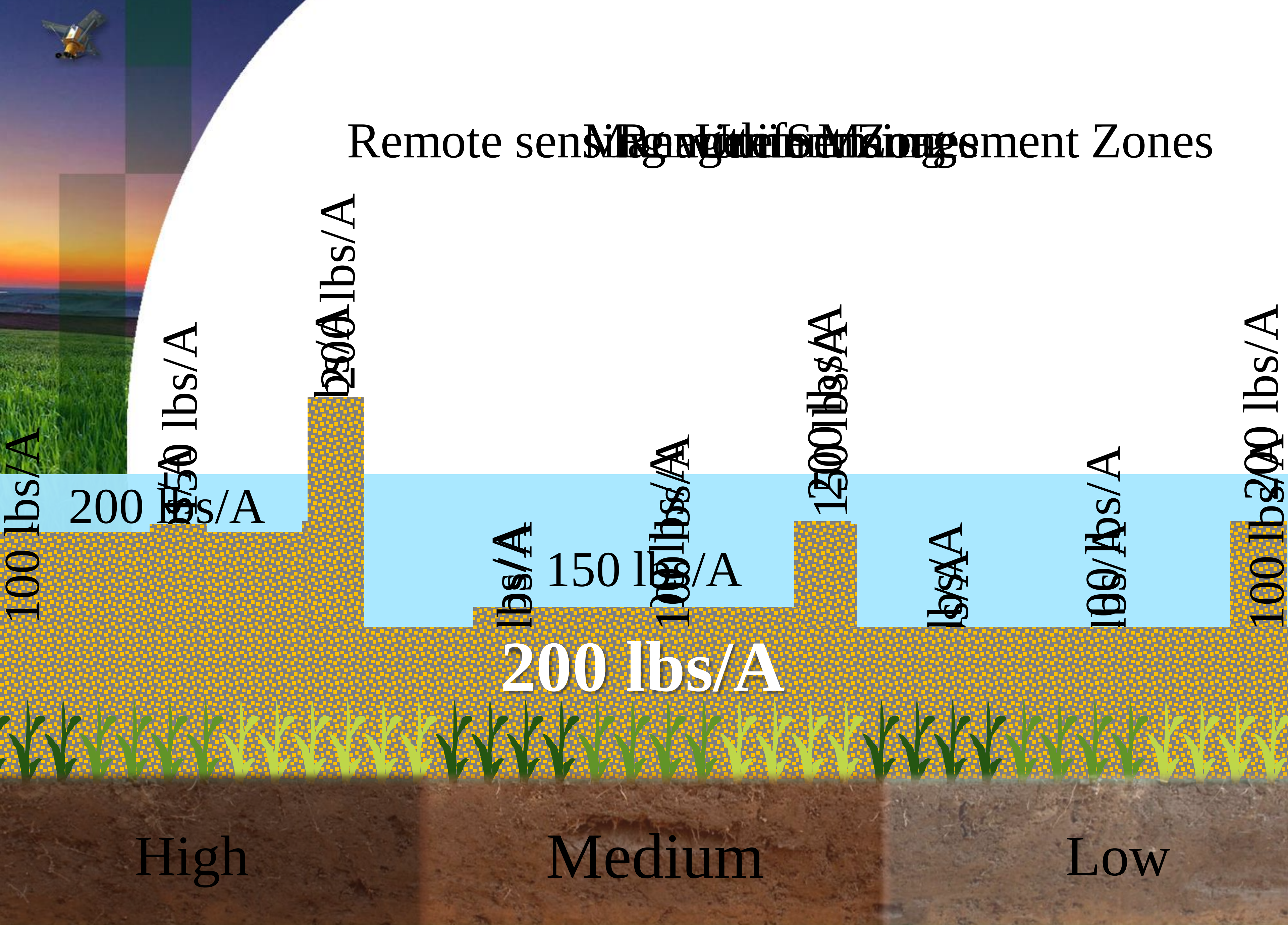
2. Early season N management using remote sensing

Crop Sensing + Soil Sensing

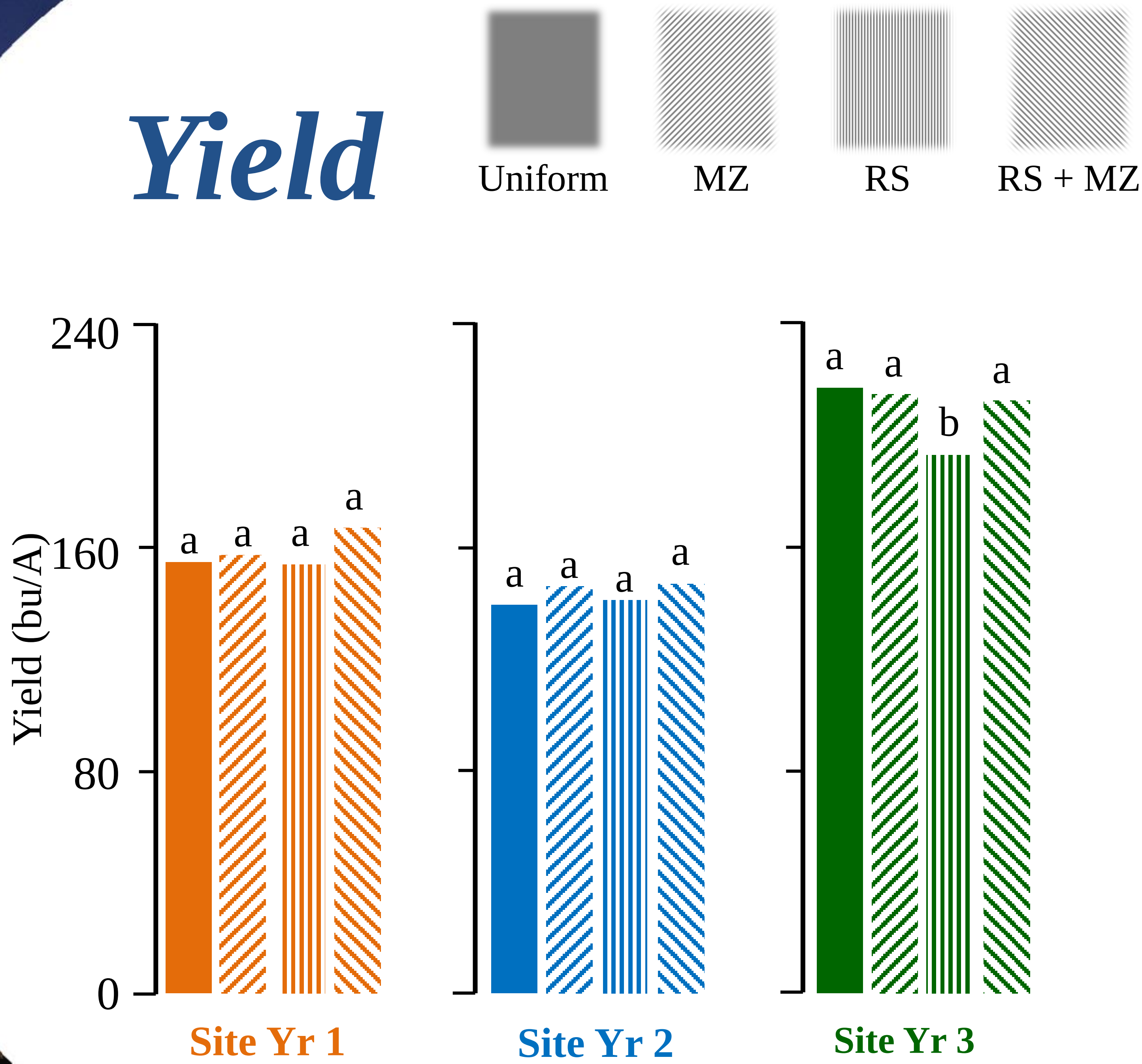


N management strategies



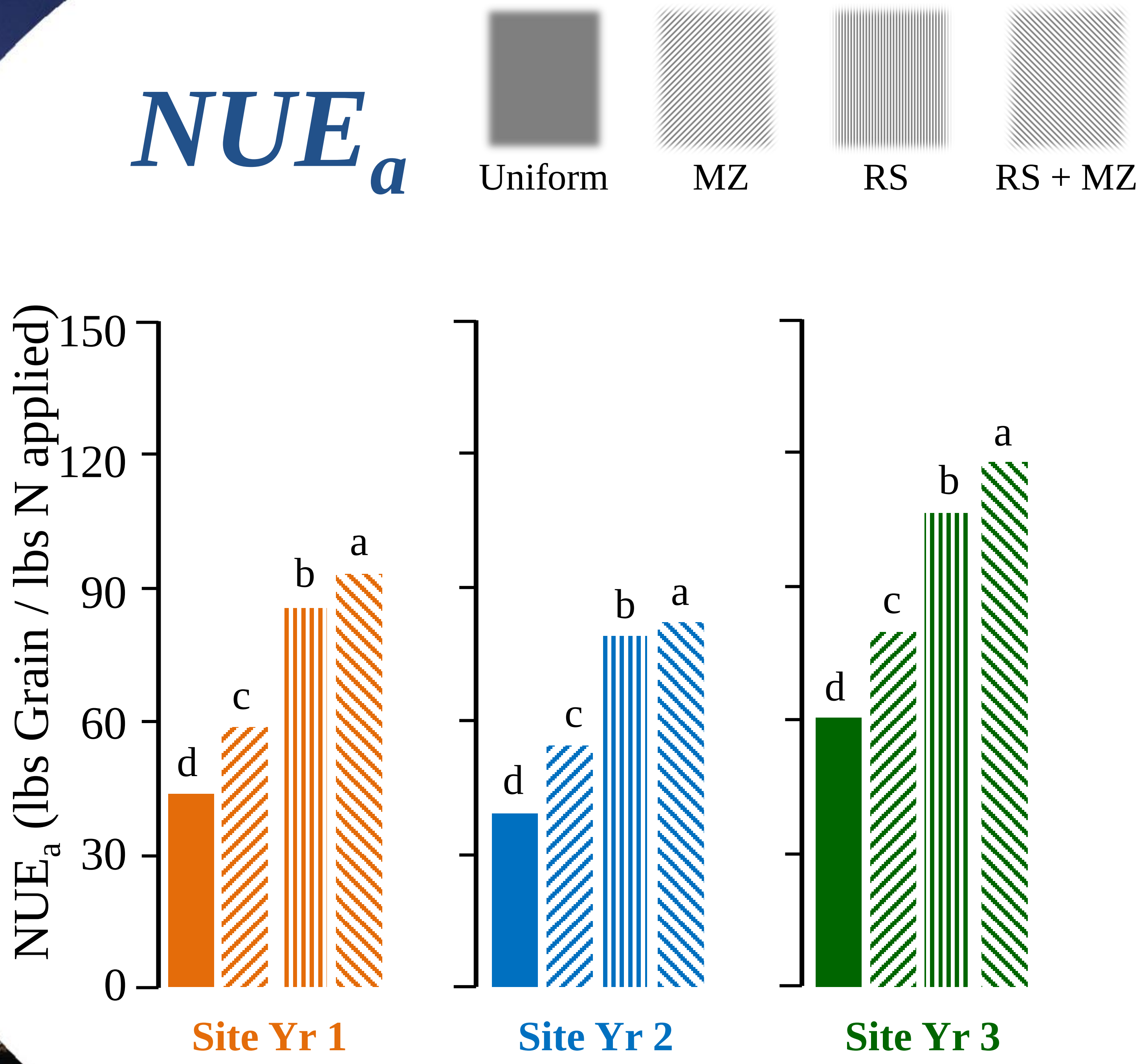

200 lbs/A
150 lbs/A
200 lbs/A
High
Medium
Low

Yield



Uniform
MZ
RS
RS + MZ
240
160
80
0
Yield (bu/A)
a
a
a
a
a
a
a
a
a
a
b
a
Site Yr 1
Site Yr 2
Site Yr 3

NUE_a

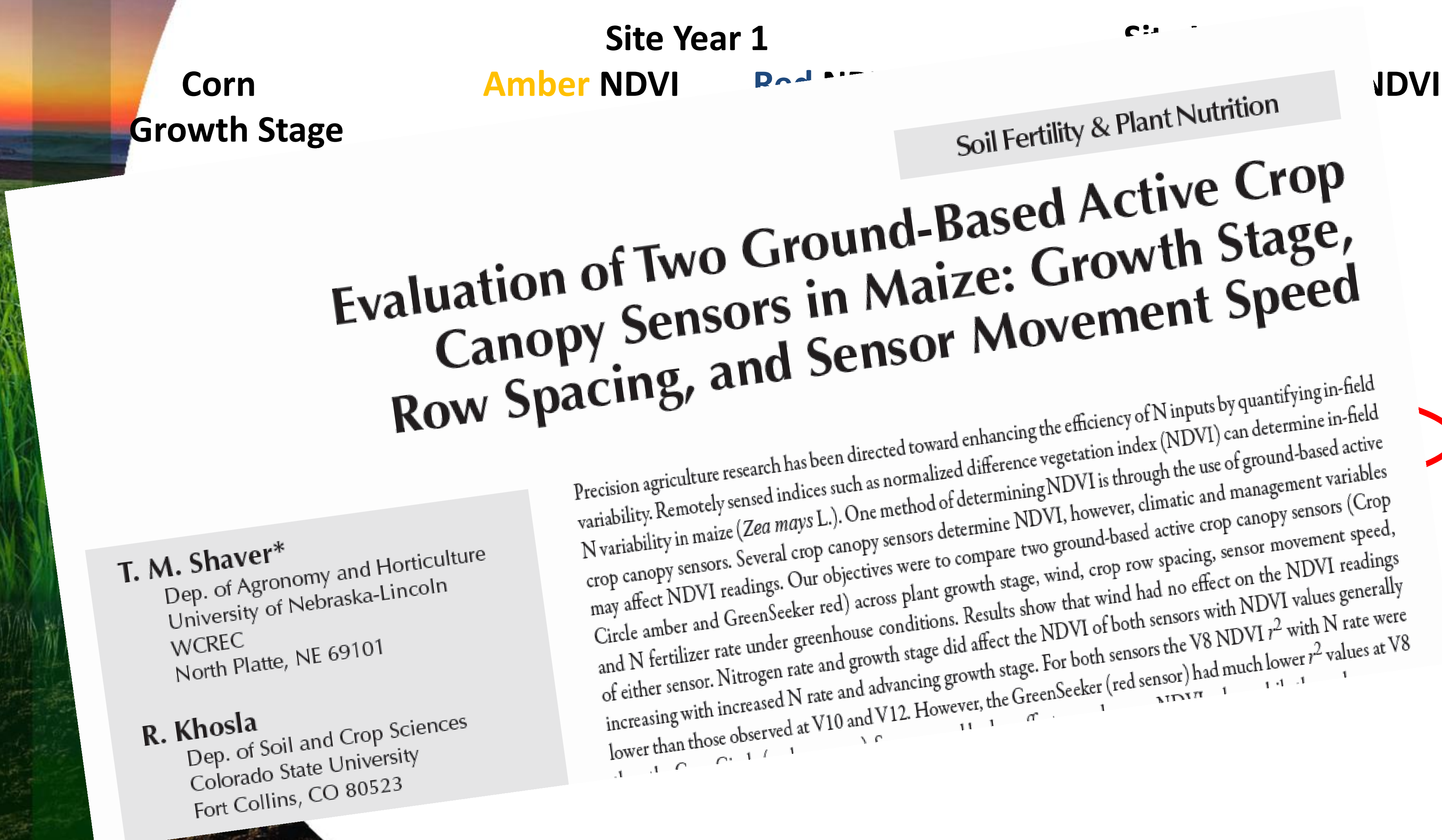


Uniform
MZ
RS
RS + MZ
NUEa (lbs Grain / lbs N applied)
150
120
90
60
30
0
d
c
b
a
d
c
b
a
d
c
b
a
Site Yr 1
Site Yr 2
Site Yr 3

Amber and Red NDVI correlation with nitrogen application rates across site years.

Site Year 1

Corn Growth Stage | Amber NDVI | NDVI



Soil Fertility & Plant Nutrition

Evaluation of Two Ground-Based Active Crop Canopy Sensors in Maize: Growth Stage, Row Spacing, and Sensor Movement Speed

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WCREC
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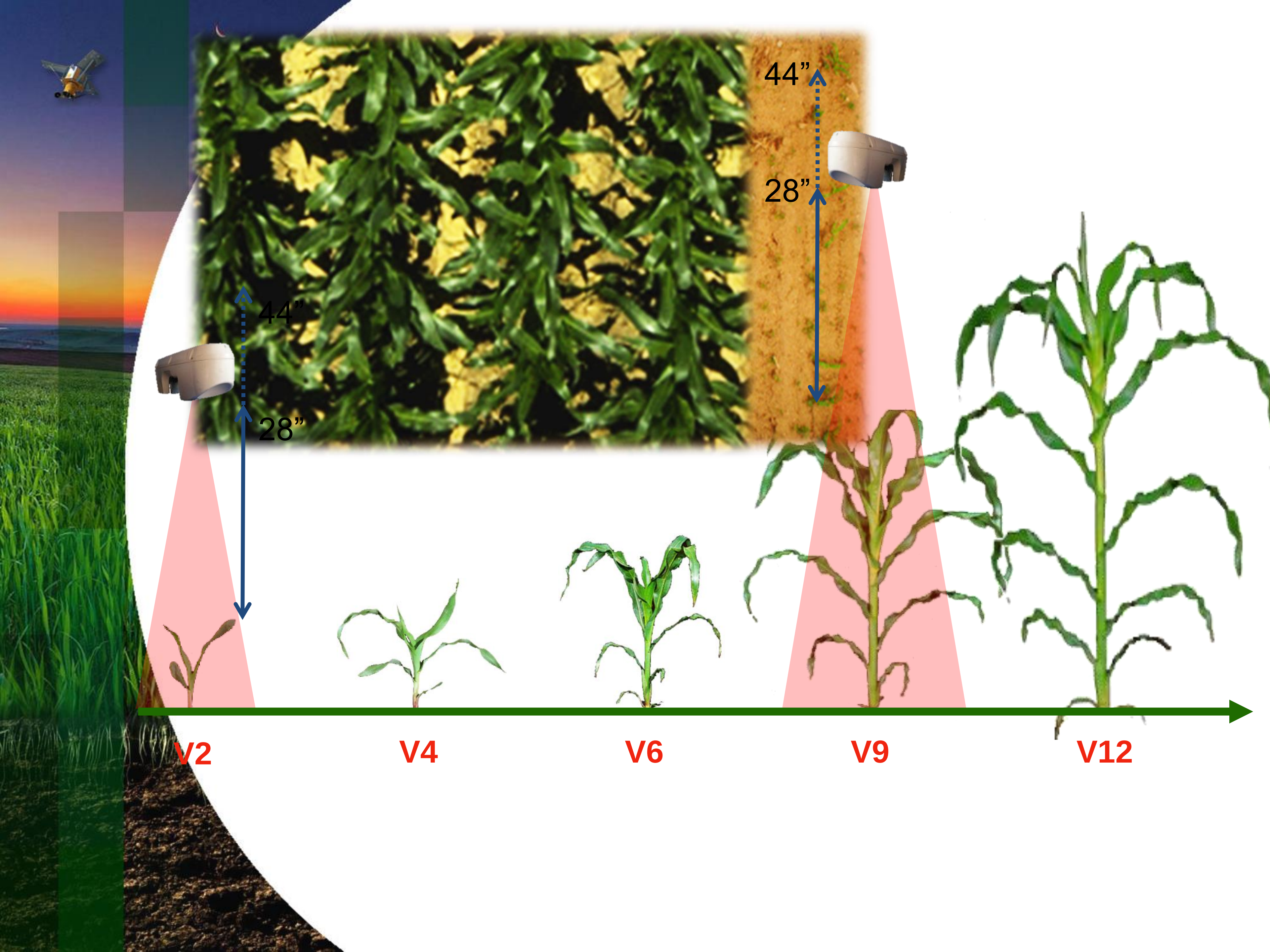
R. Khosla
Dep. of Soil and Crop Sciences
Colorado State University
Fort Collins, CO 80523

Precision agriculture research has been directed toward enhancing the efficiency of N inputs by quantifying in-field variability. Remotely sensed indices such as normalized difference vegetation index (NDVI) can determine in-field N variability in maize (*Zea mays* L.). One method of determining NDVI is through the use of ground-based active crop canopy sensors. Several crop canopy sensors determine NDVI, however, climatic and management variables may affect NDVI readings. Our objectives were to compare two ground-based active crop canopy sensors (Crop Circle amber and GreenSeeker red) across plant growth stage, wind, crop row spacing, sensor movement speed, and N fertilizer rate under greenhouse conditions. Results show that wind had no effect on the NDVI readings of either sensor. Nitrogen rate and growth stage did affect the NDVI of both sensors with NDVI values generally increasing with increased N rate and advancing growth stage. For both sensors the V8 NDVI r^2 with N rate were lower than those observed at V10 and V12. However, the GreenSeeker (red sensor) had much lower r^2 values at V8

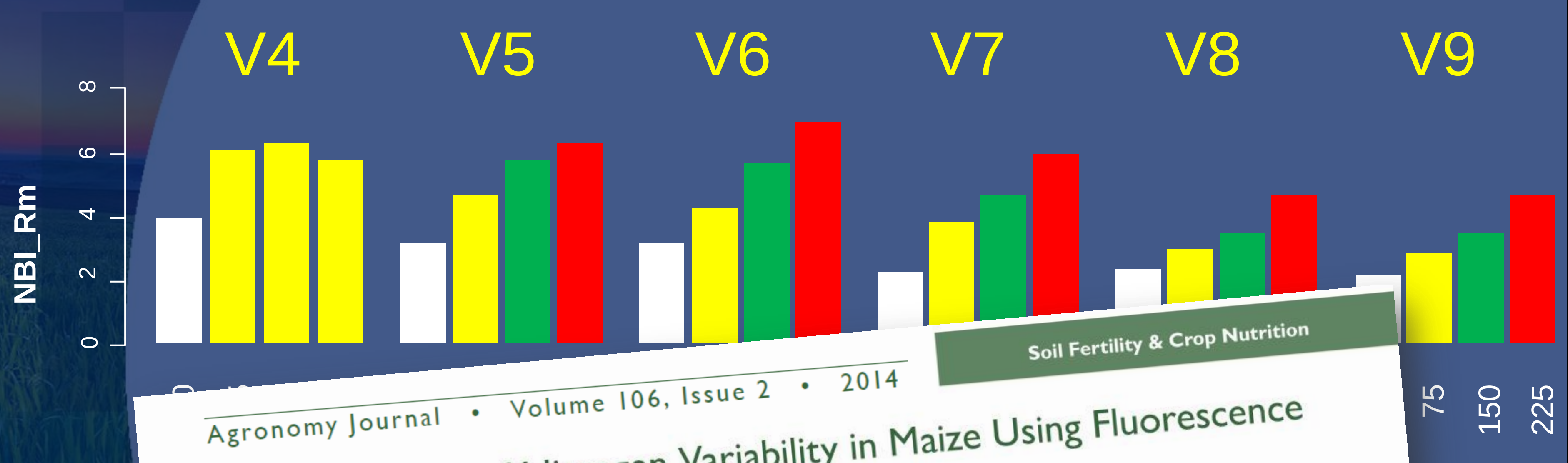


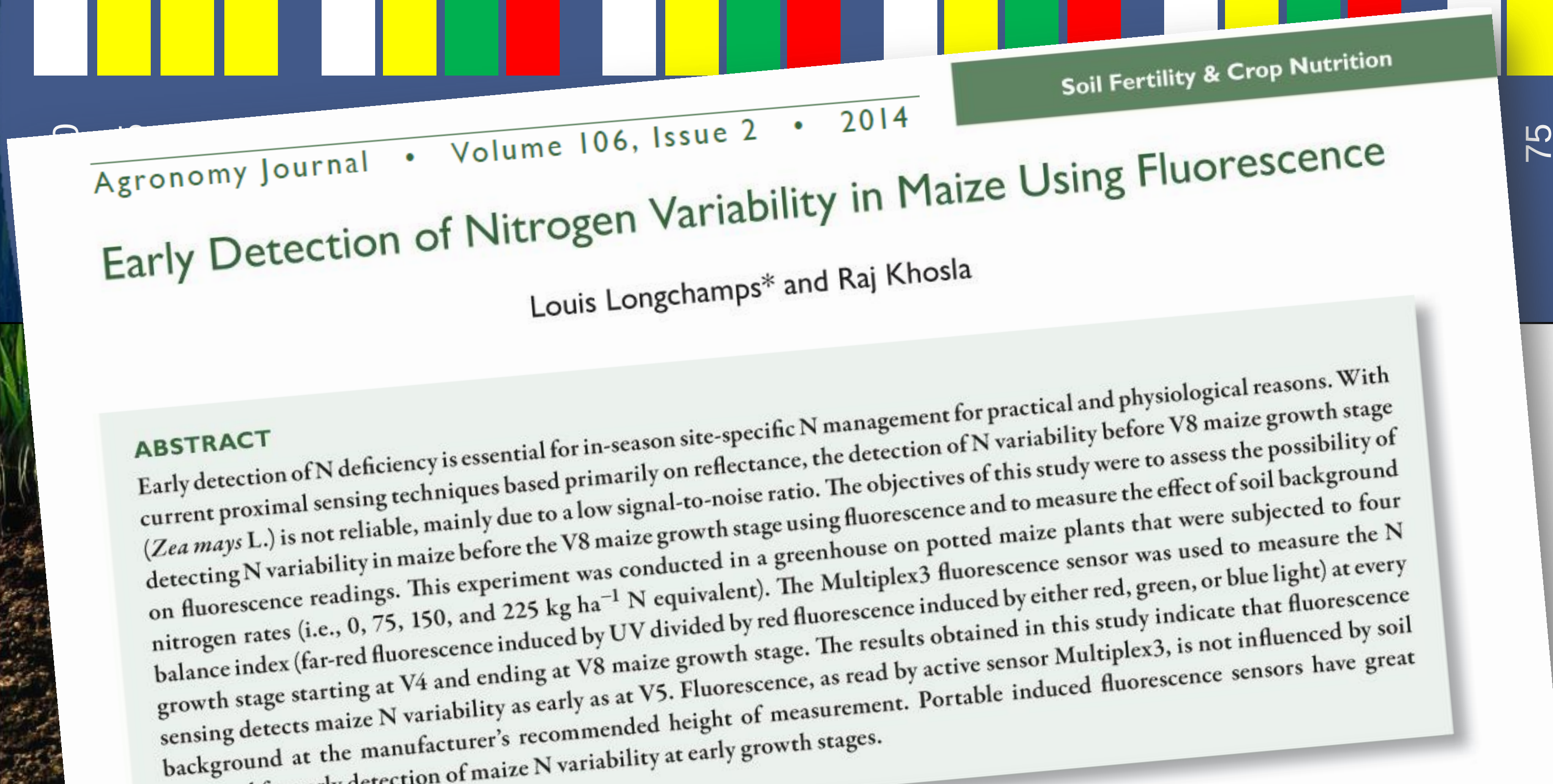
44”
28”
44”
28”
V2
V4
V6
V9
V12

Mulitplex® Fluorescence Sensor

Greenhouse experiment with fluorescence

Greenhouse experiment with fluorescence




Agronomy Journal • Volume 106, Issue 2 • 2014

Soil Fertility & Crop Nutrition

Early Detection of Nitrogen Variability in Maize Using Fluorescence

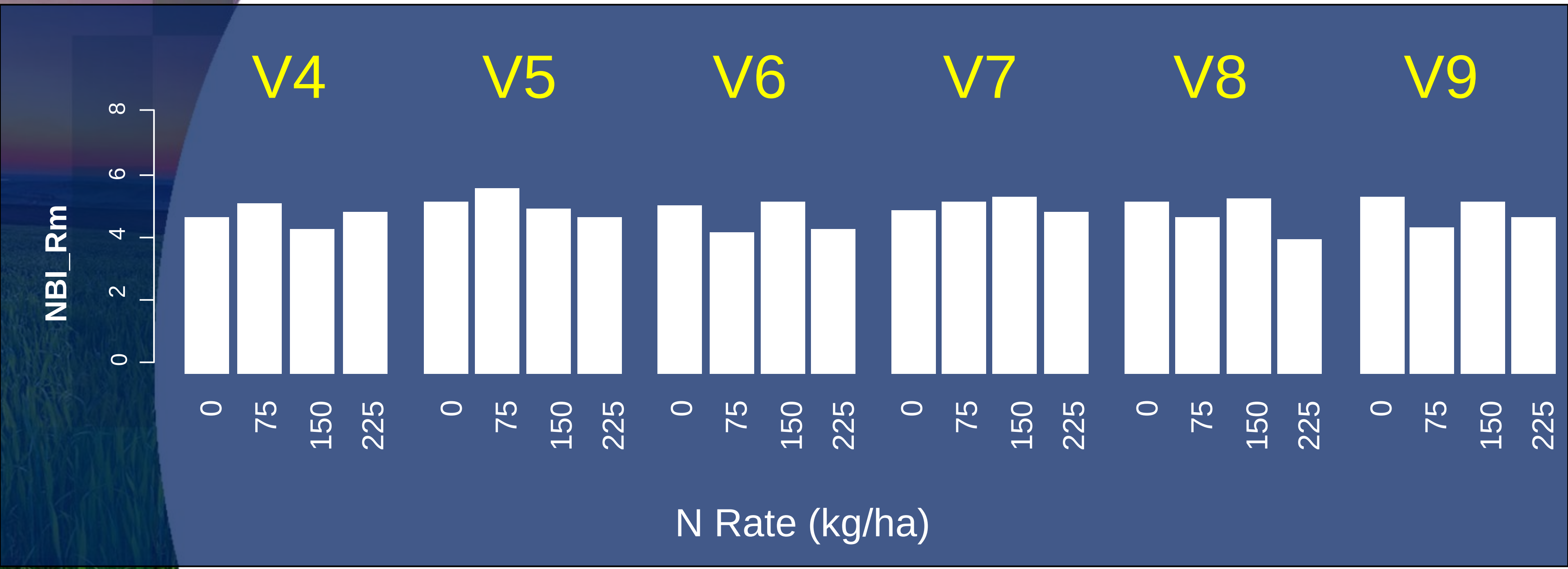
Louis Longchamps* and Raj Khosla

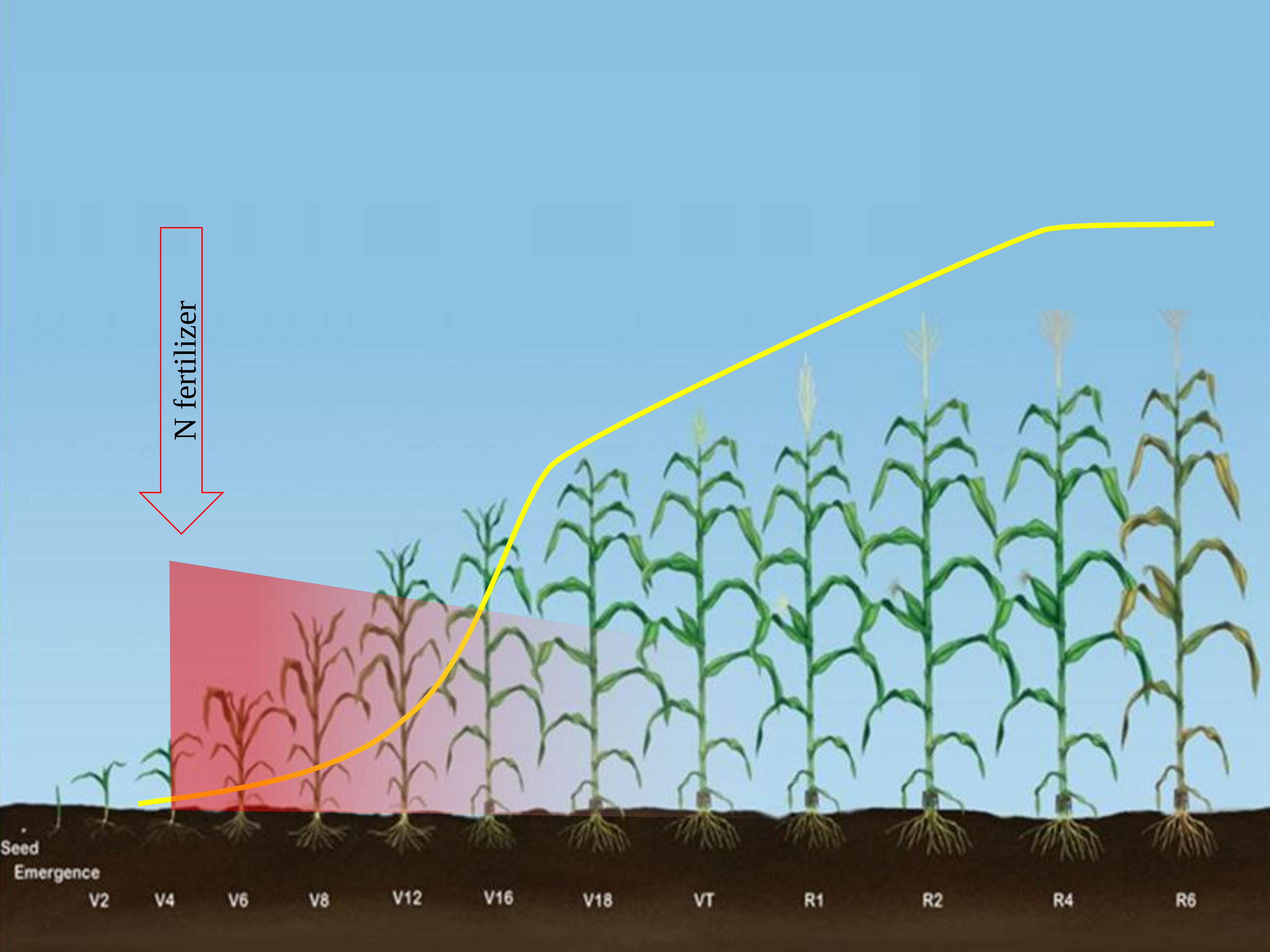
ABSTRACT

Early detection of N deficiency is essential for in-season site-specific N management for practical and physiological reasons. With current proximal sensing techniques based primarily on reflectance, the detection of N variability before V8 maize growth stage (*Zea mays* L.) is not reliable, mainly due to a low signal-to-noise ratio. The objectives of this study were to assess the possibility of detecting N variability in maize before the V8 maize growth stage using fluorescence and to measure the effect of soil background on fluorescence readings. This experiment was conducted in a greenhouse on potted maize plants that were subjected to four nitrogen rates (i.e., 0, 75, 150, and 225 kg ha^{-1} N equivalent). The Multiplex3 fluorescence sensor was used to measure the N balance index (far-red fluorescence induced by UV divided by red fluorescence induced by either red, green, or blue light) at every growth stage starting at V4 and ending at V8 maize growth stage. The results obtained in this study indicate that fluorescence sensing detects maize N variability as early as at V5. Fluorescence, as read by active sensor Multiplex3, is not influenced by soil background at the manufacturer's recommended height of measurement. Portable induced fluorescence sensors have great
...ly detection of maize N variability at early growth stages.

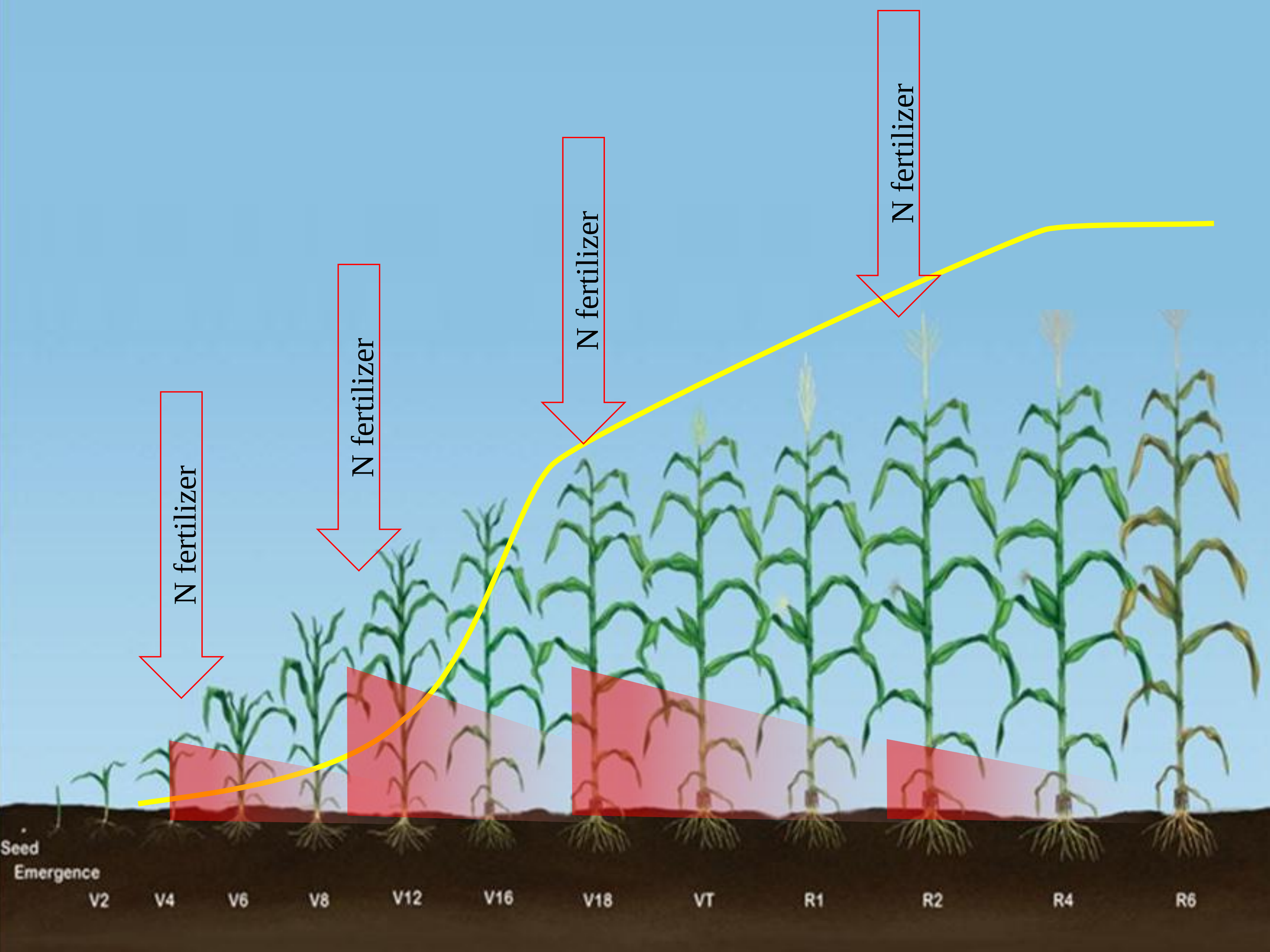

Experiment in the field

Experiment in the field





N fertilizer
Seed
Emergence
V2
V4
V6
V8
V12
V16
V18
VT
R1
R2
R4
R6



N fertilizer
N fertilizer
N fertilizer
N fertilizer
Seed
Emergence
V2
V4
V6
V8
V12
V16
V18
VT
R1
R2
R4
R6

3. Variable rate seeding in conjunction with water and N

Location: CSU Research farm (ARDEC), Fort Collins, CO

2013

Hybrid: DKC-4620 @ 30”

Planting date: May 15th 2013

Harvest date: Oct. 24th 2013

2014

Hybrid: DKC-4620 @ 30”

Planting date: Apr 29th 2014

Harvest date: Oct. 30th 2014

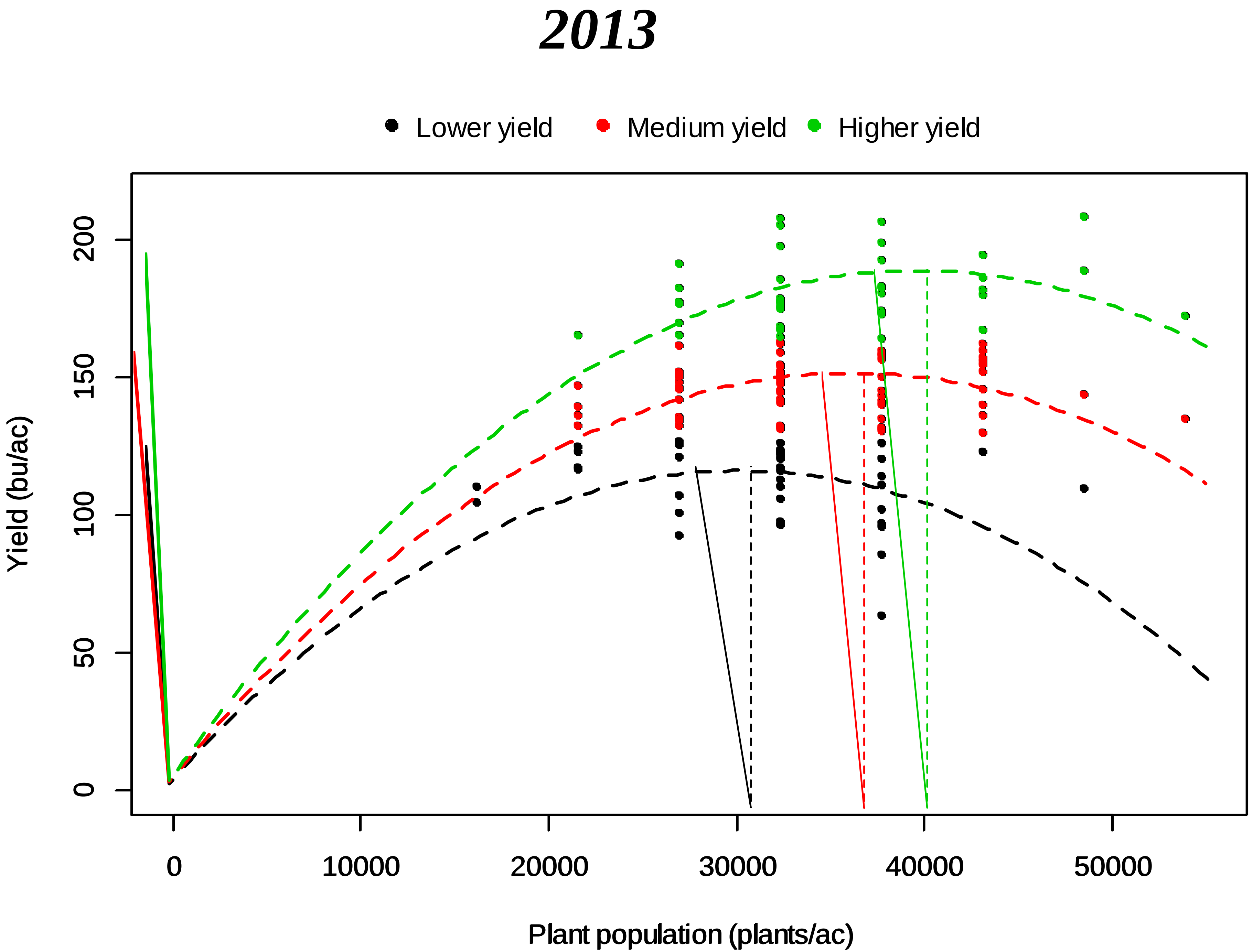
2015

Hybrid: DKC-4620 @ 30”

Planting date: May 27th 2015

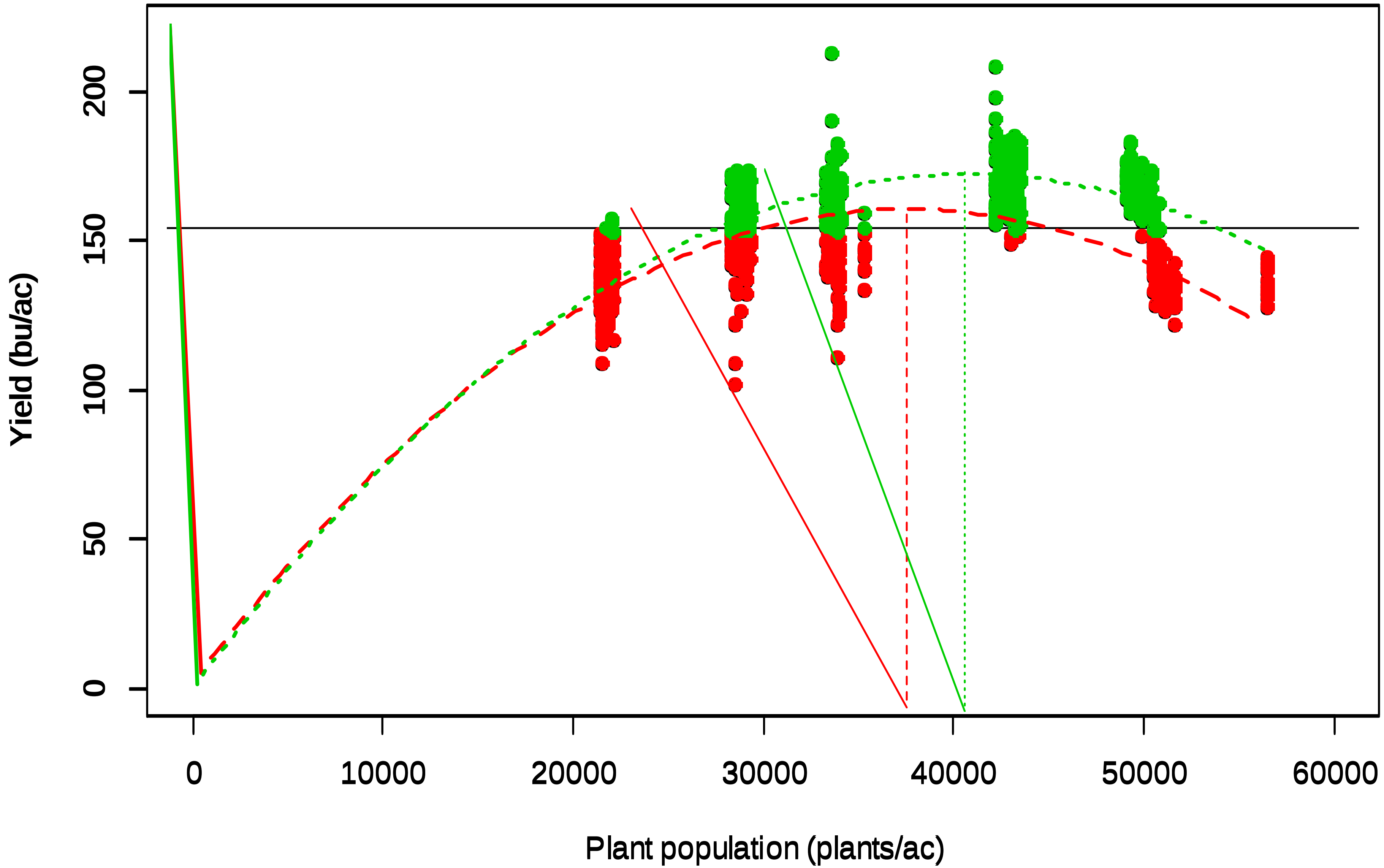
Harvest date: Nov. 19th 2015

For all years, 250 lbs N/ac was supplied and irrigation was supplied based on crop ET



2013
Lower yield
Medium yield
Higher yield
Yield (bu/ac)
0
50
100
150
200
0
10000
20000
30000
40000
50000
Plant population (plants/ac)

2014



Yield (bu/ac)
0
50
100
150
200
0
10000
20000
30000
40000
50000
60000
Plant population (plants/ac)

Data from Pioneer Crop Insights

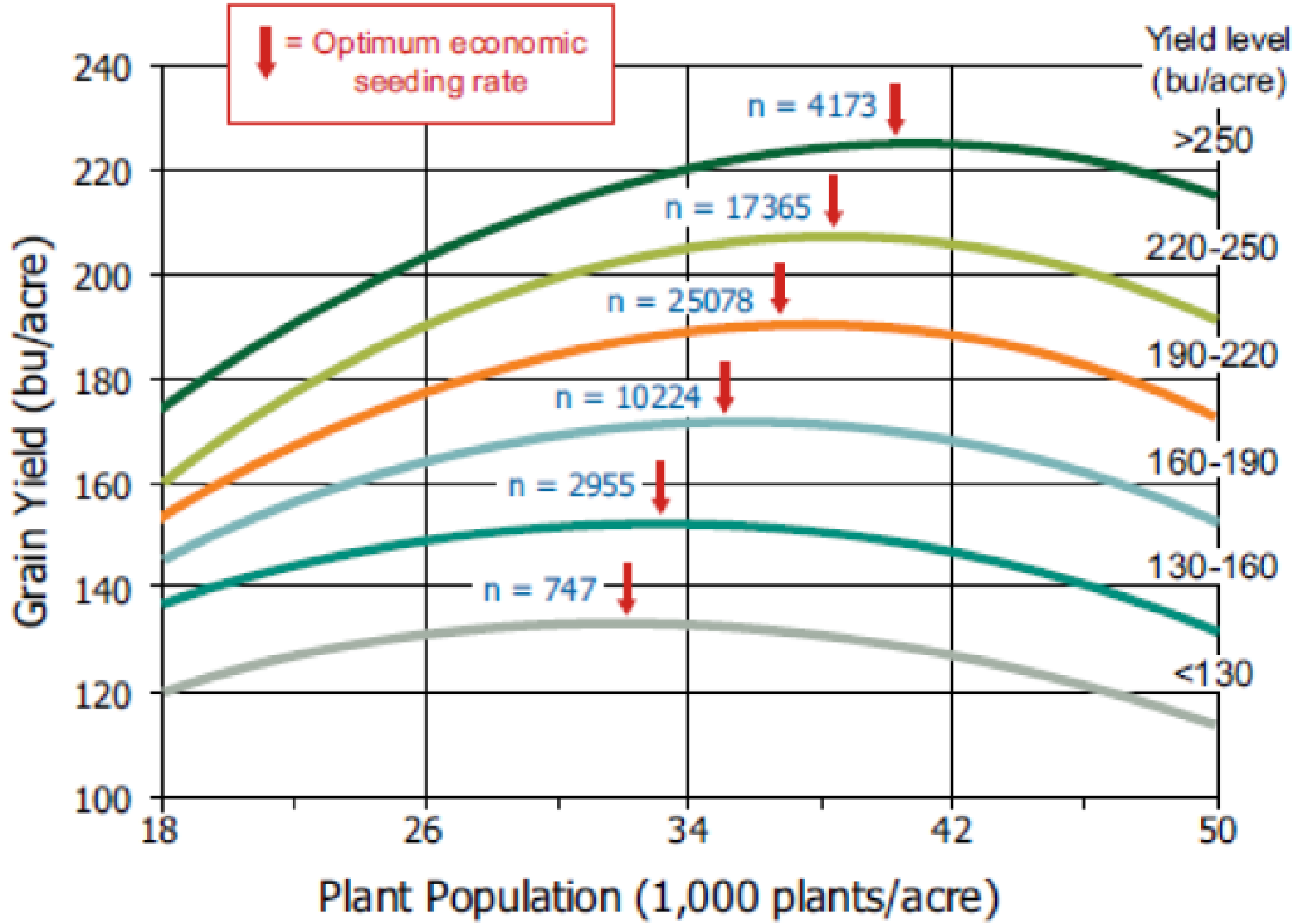
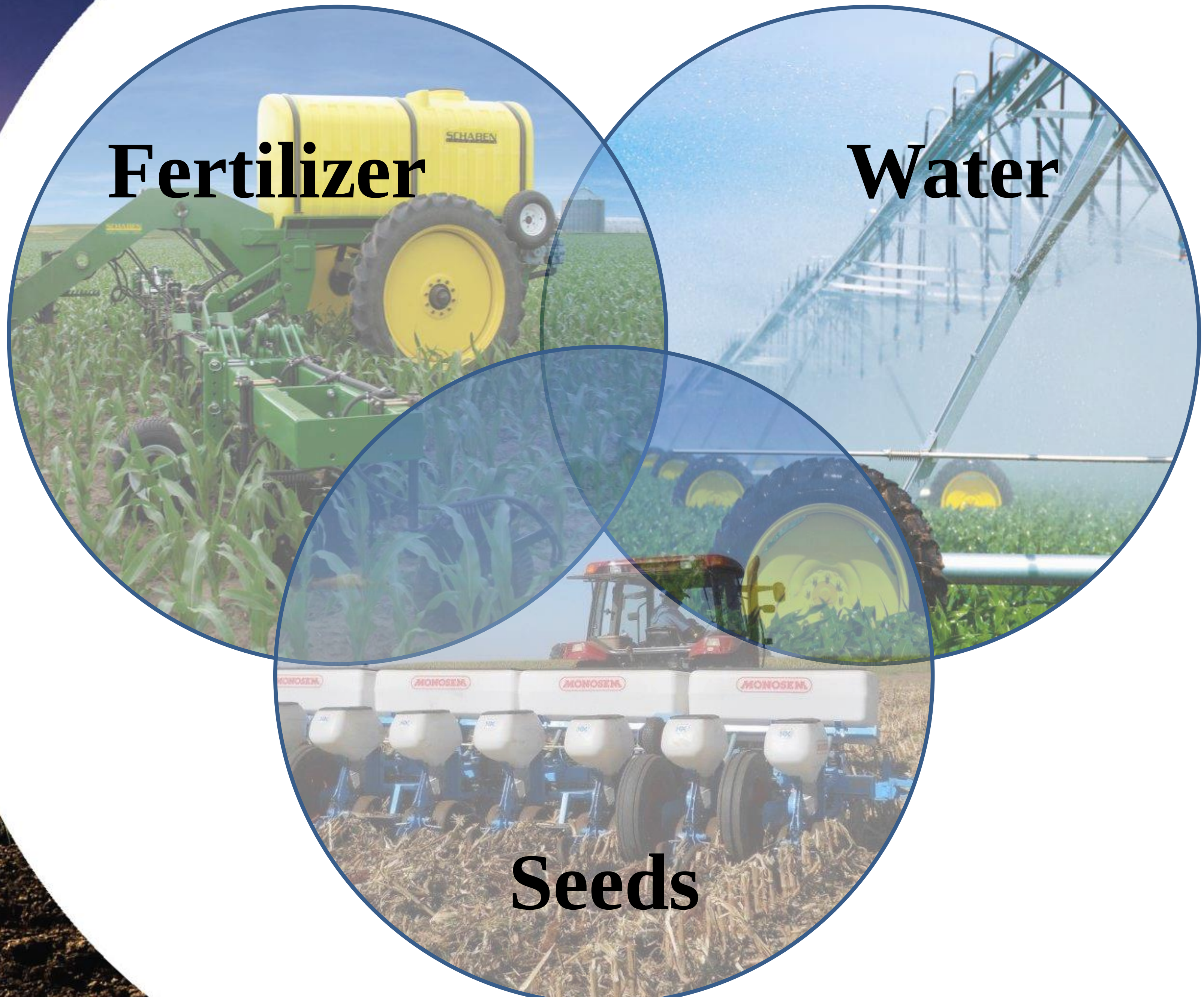
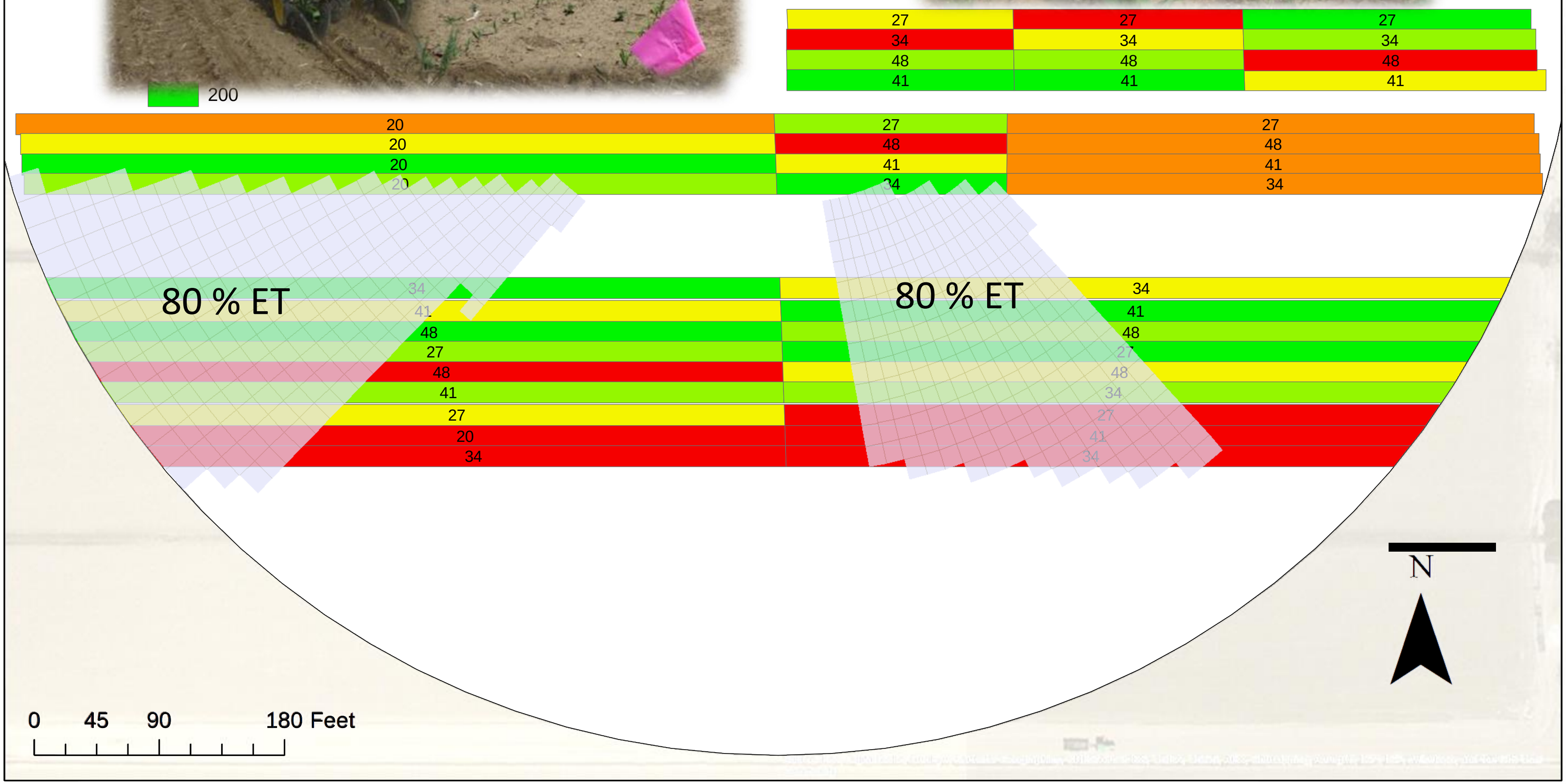


Figure 4. Corn yield response to population and optimum economic seeding rate by location yield level, 2006 to 2012.

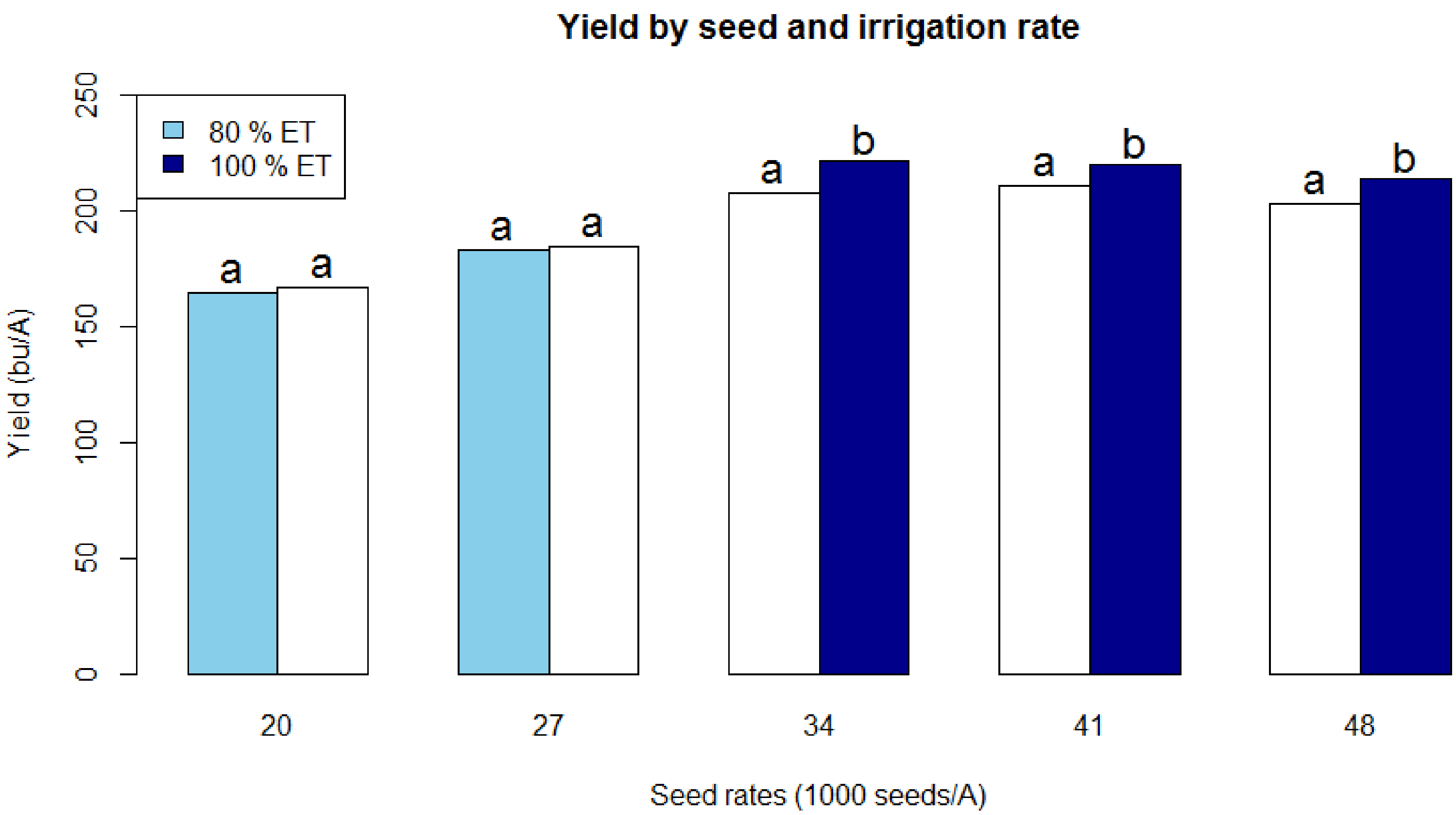
Source: Doerge, T., M. Jeschke, and P. Carter. 2015. Planting Outcome Effects on Corn Yield. Crop Insights 25(1): 1–7.


Fertilizer
Water
Seeds

2015


200
27 27 27
34 34 34
48 48 48
41 41 41
20 27 27
20 48 48
20 41 41
20 34 34
80 % ET
80 % ET
34 34
41 41
48 48
27 27
48 48
41 34
27 27
20 41
34 34
N
0 45 90 180 Feet

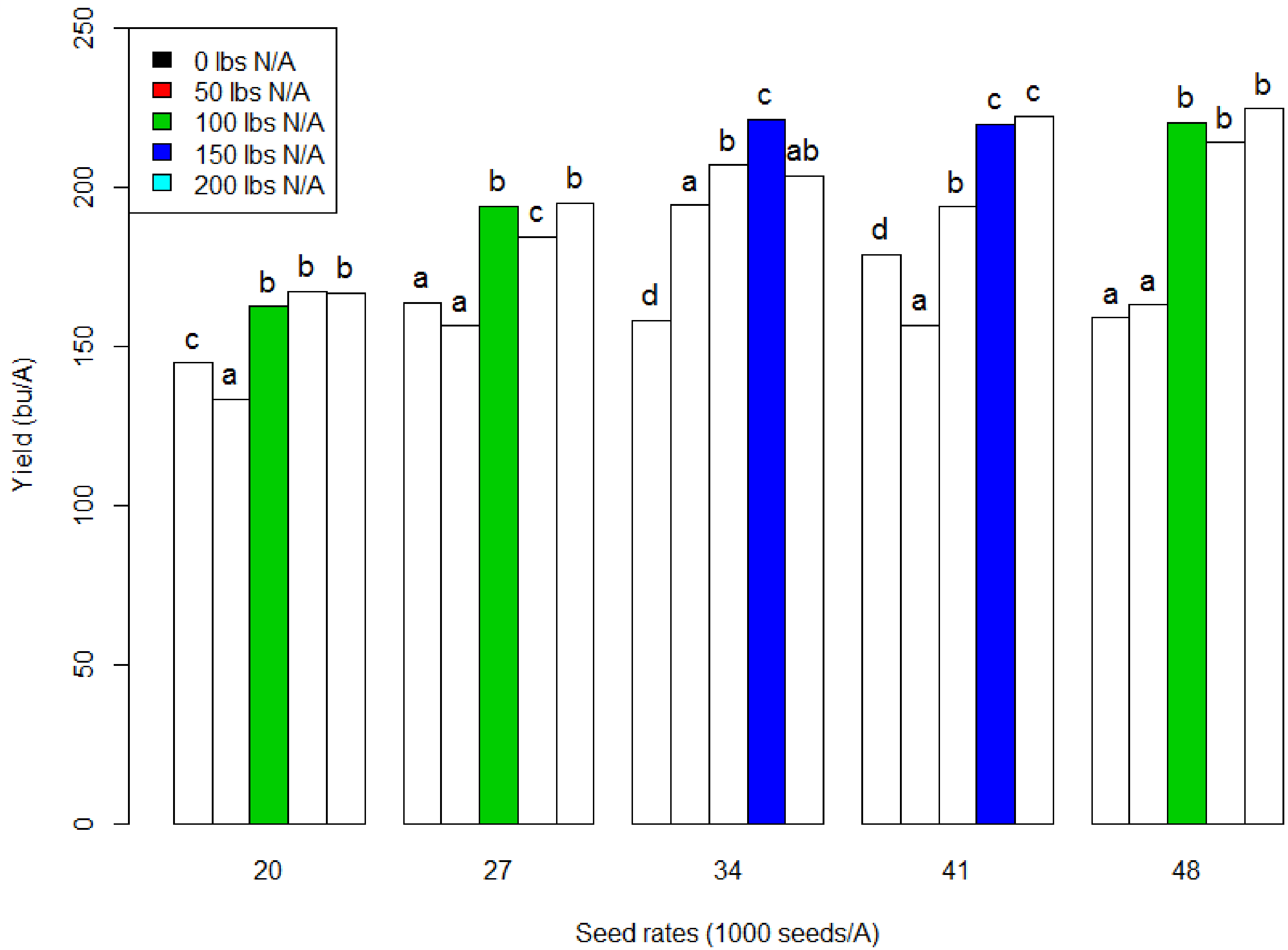
3. Variable rate seeding in conjunction with water and N



Seed rate

Irrigation rate

3. Variable rate seeding in conjunction with water and N



Seed rate

N rate

3. Variable rate seeding in conjunction with water and N

Increased seed rate should be accompanied with increased input rates

Questions:

How to integrate effect of soil properties on seed rate?

How to optimize seed, N, and water for each soil type?

Could we develop an **N algorithm** that incorporates **irrigation** and **seed** rates as well as **soil** properties and **yield** goal?

What is the effect of timing on these interactions?

What is the…..?

Thank you

Raj.Khosla@Colostate.edu

Raj Khosla, Jose Chavez, Allan Andales, Robin Reich and Louis Longchamps

Colorado State University