Proximal Sensing For Early Detection of Nitrogen Deficiency in Corn

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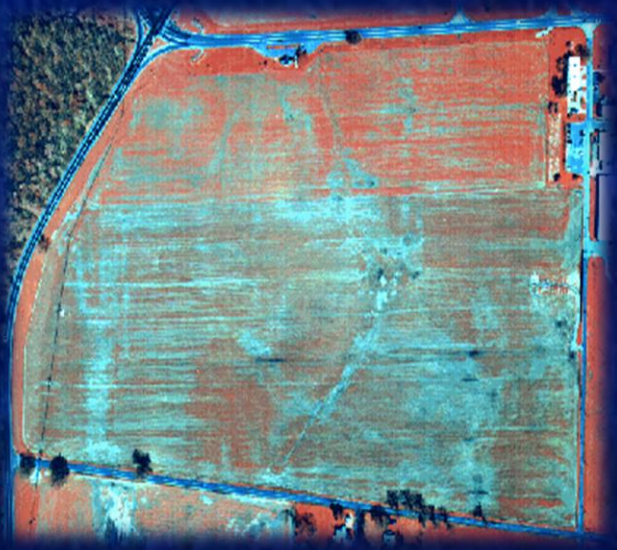
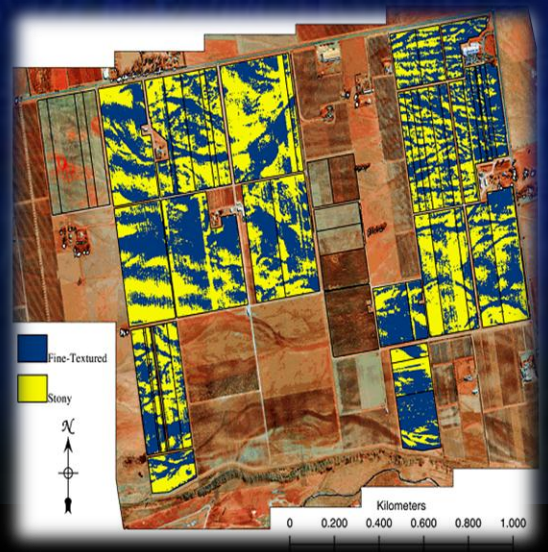
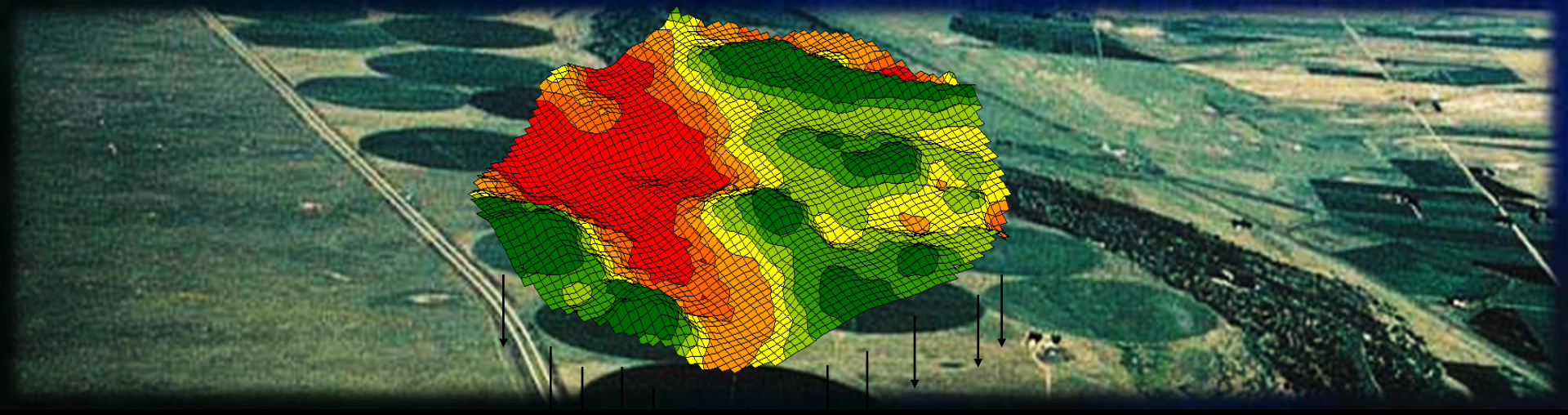
Precision management

- Precision agronomists
- developing techniques
- to quantify spatial variability in soil properties and crop canopies
- to practice precision management





- Changes in soils across landscape and within fields is documented globally
- traditional or uniform nutrient applications results in under and over application of nutrients in many parts of the field



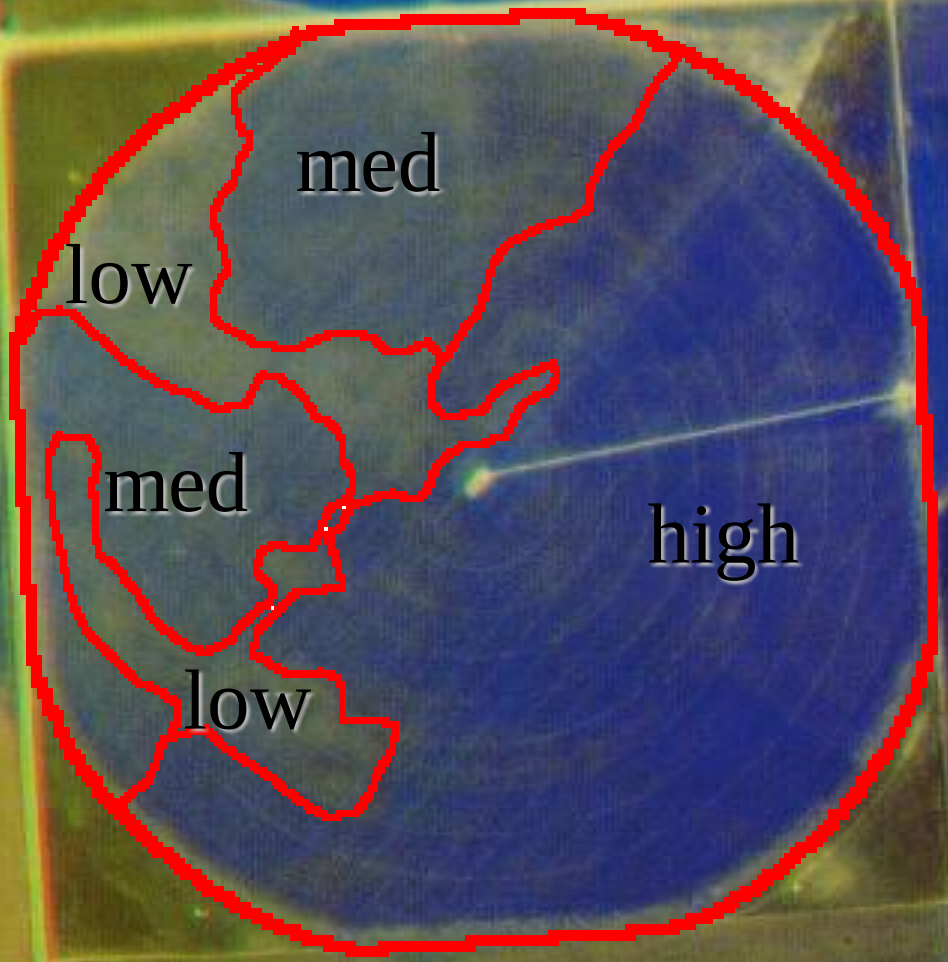
How to address spatial variability?

- Soil sensing
- Crop canopy sensing

Soil sensing

- Management Zones:
  A sub-region of a field that expresses a homogeneous combination of yield limiting factors

Soil sensing…



Management Zones are delineated on farm fields
by classifying the field into different sections or zones.

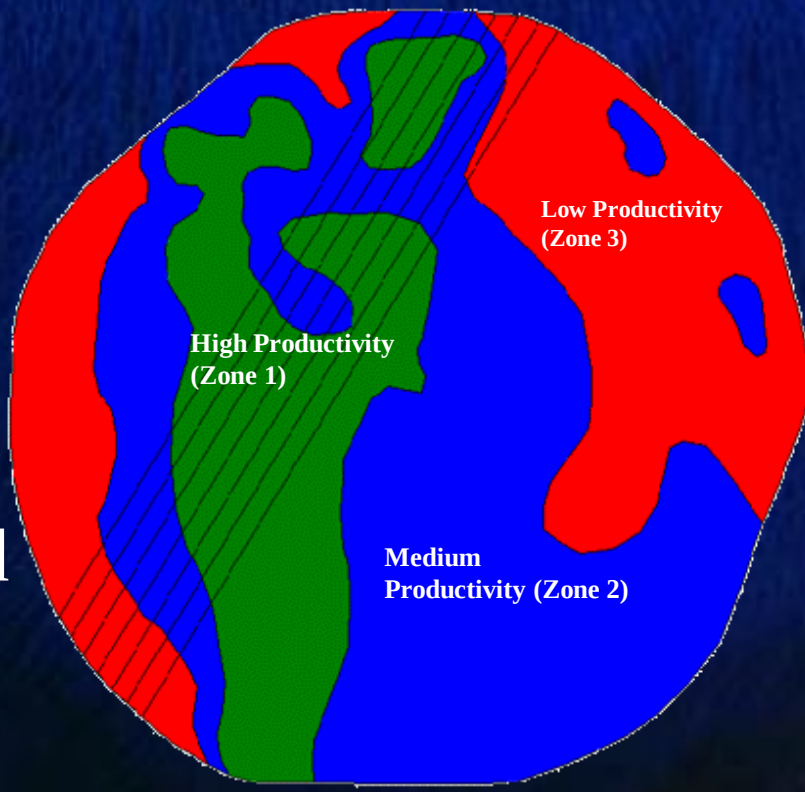
Based on the research conducted in Colorado*

* CSU, USDA-ARS, Centennial Ag Inc.

Soil sensing

- Management Zones:
  A sub-region of a field that expresses a homogeneous combination of yield limiting factors

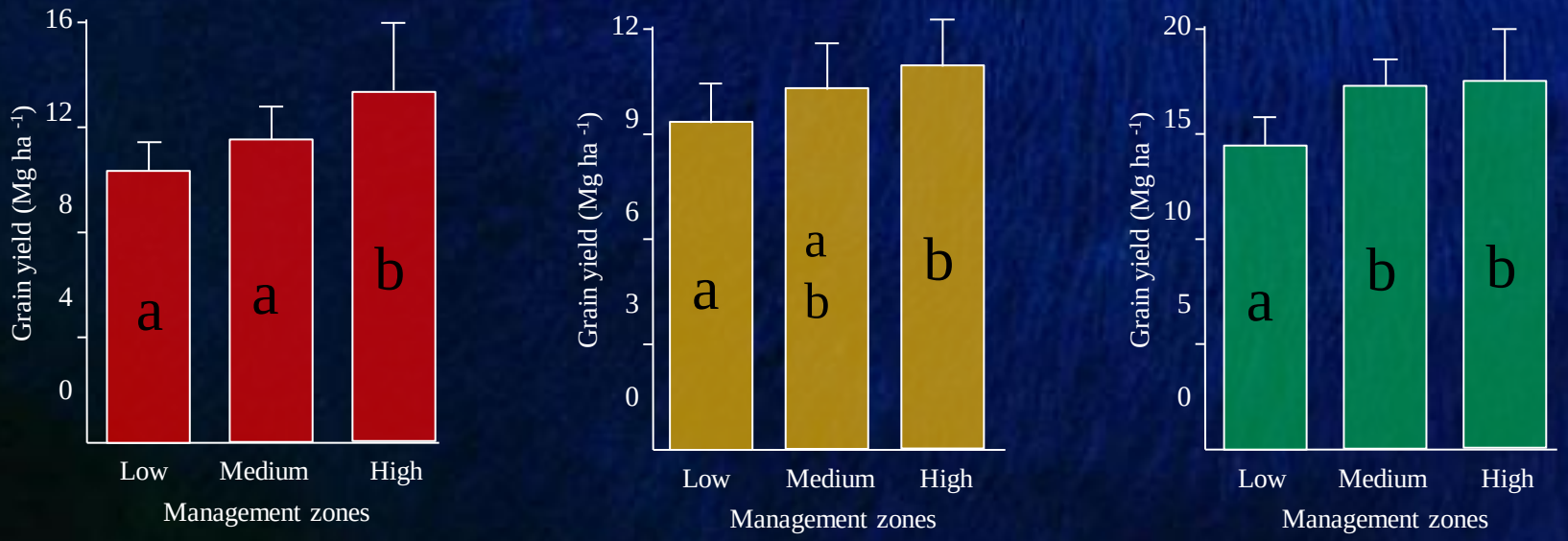
- In Colorado, we have developed four techniques of delineating management zones



50 ha irrigated Maize field with Management Zones

Soil sensing…

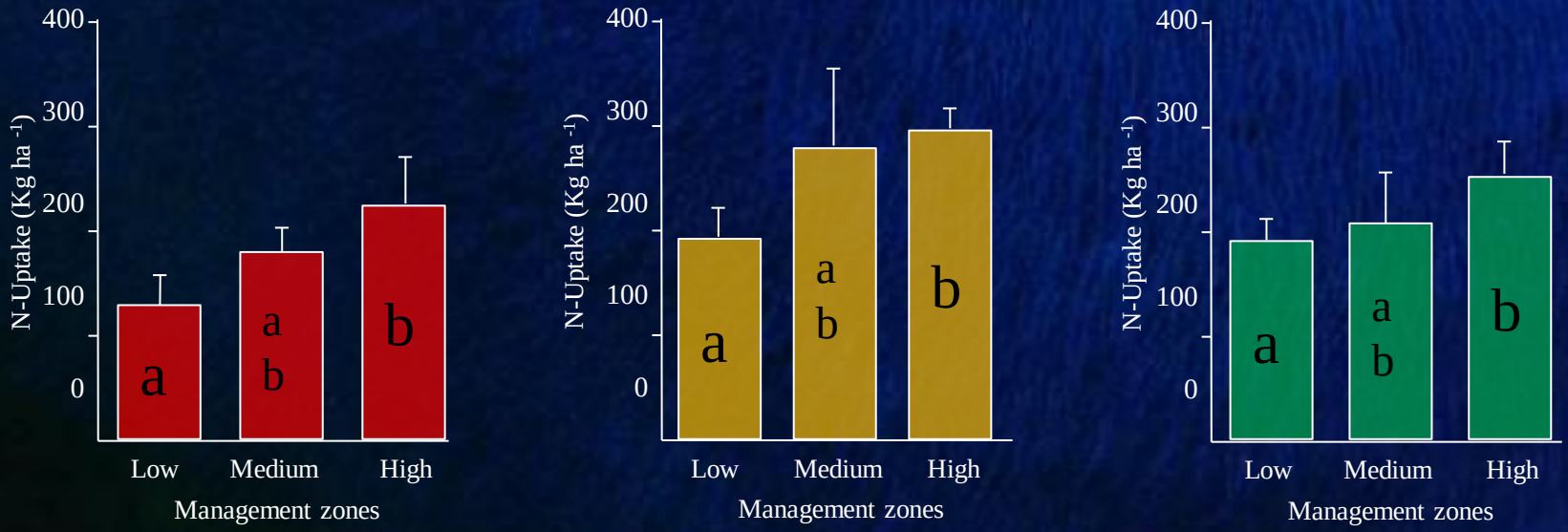
Mean grain yield across MZs



In 9 out of 10 site years we can separate low from high zone but NOT low from medium or medium from high zones based on grain yield

Soil sensing…

Mean N-uptake across MZs



Again we could separate low from high zone but NOT low from medium or medium from high zones for most years.

Precision Nutrient Management Across Soil Zones…

- has shown to enhance:

  (i) overall grain yield of the field,

  (ii) nutrient use efficiency,

  (iii) net $ returns to farmers and

  (iv) reduces overall nutrient losses from the field.

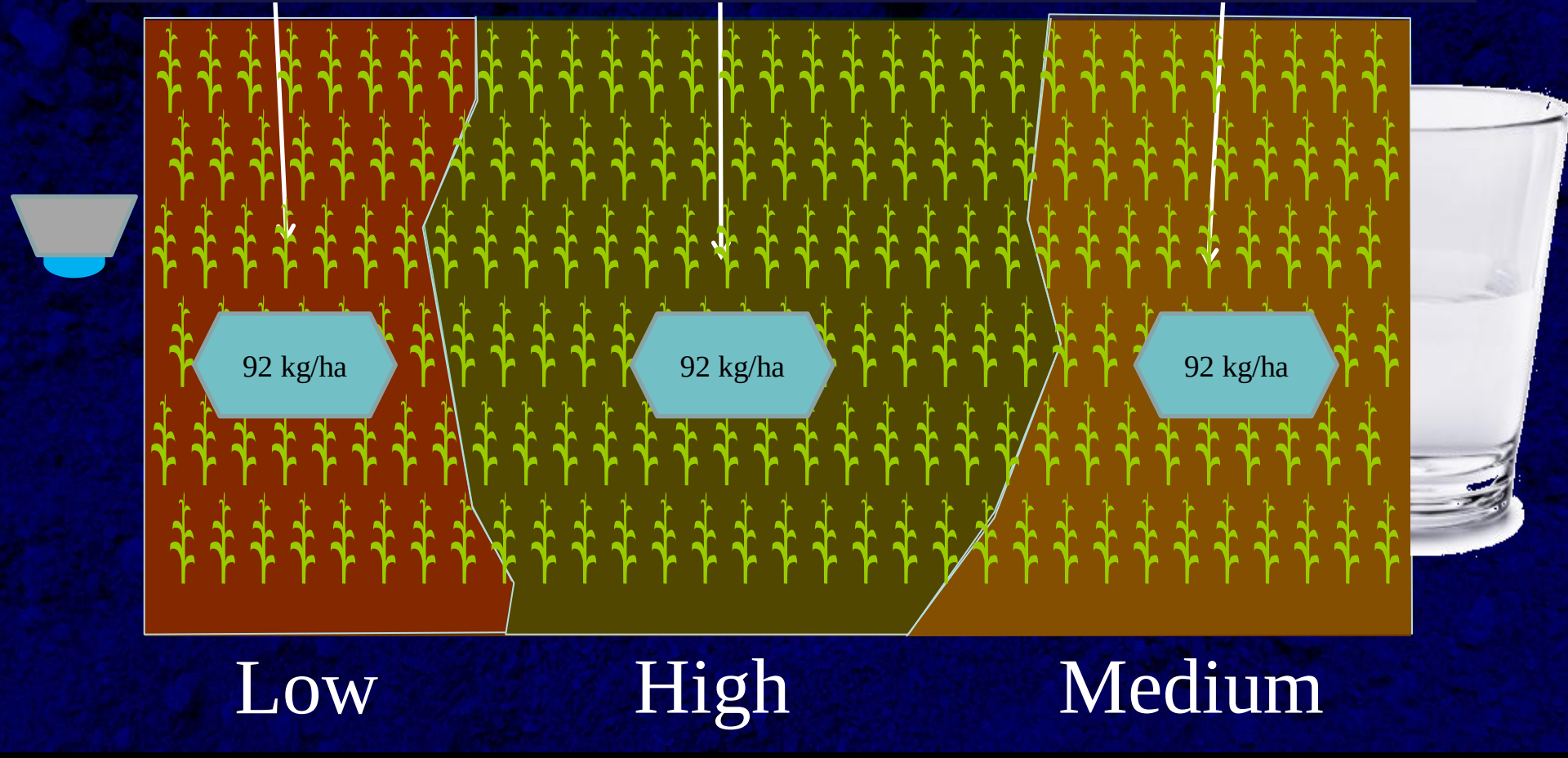
- What's the problem?

0.41

0.41

0.41

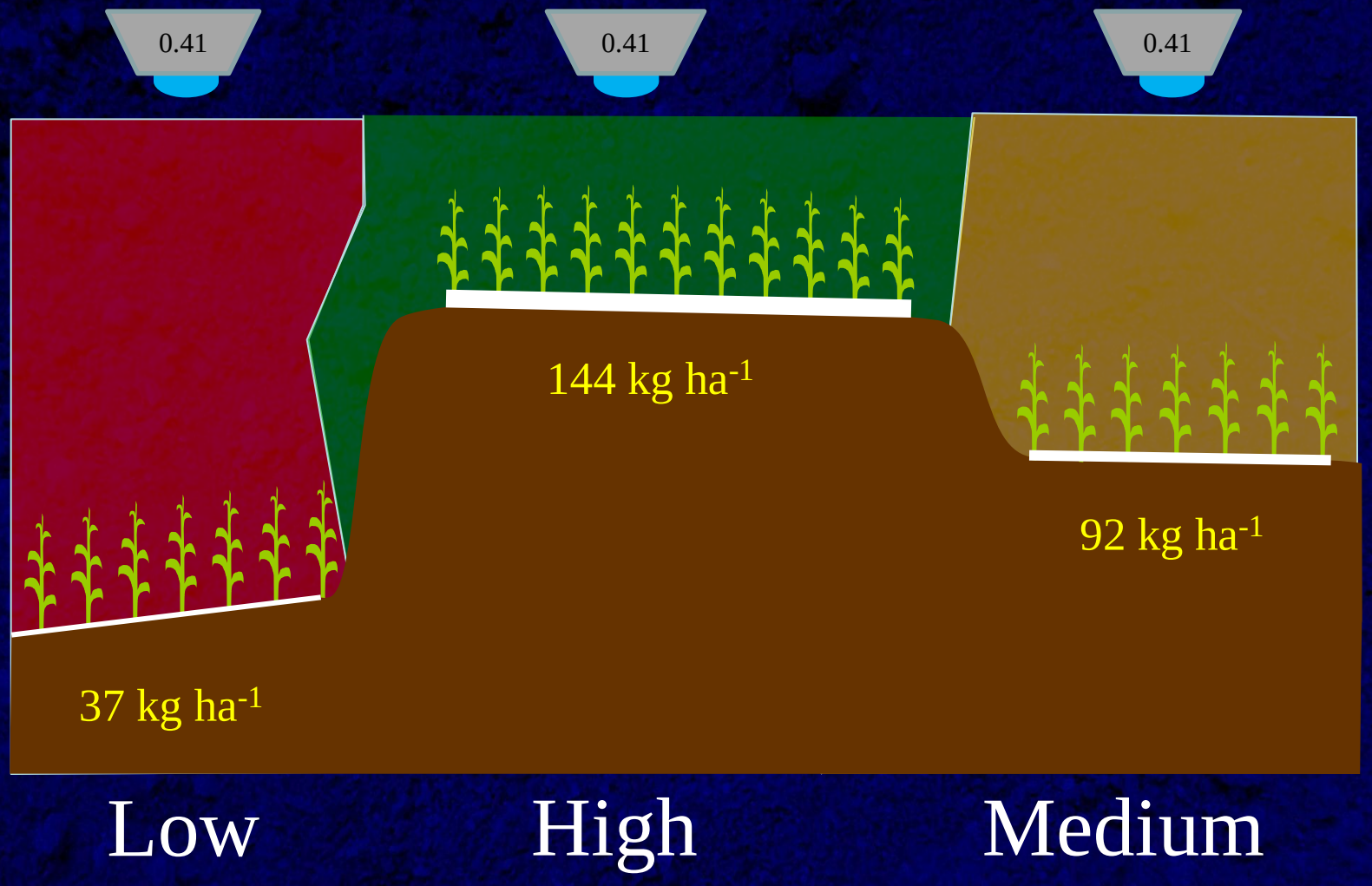
$$\text{N Rate (kg ha}^{-1}) = (135.3 \times (\text{NDVI}_{\text{Ref.}} / \text{NDVI}_{\text{Target}})^2) - (134.8 \times (\text{NDVI}_{\text{Ref.}} / \text{NDVI}_{\text{Target}})) + 1$$



Low

High

Medium


0.41
0.41
0.41
144 kg ha-1
92 kg ha-1
37 kg ha-1
Low
High
Medium

Soil Sensing + Crop Sensing

Soil sensing efforts must be coupled with crop sensing

- to make better and most efficient nutrient management decisions

Previous work with Crop Sensors:

Holland Scientific Crop Circle:

Amber NDVI

-Visible waveband = 590 nm

-Near infrared = 880 nm

NTech Industries GreenSeeker:

Red NDVI

-Red visible waveband = 660 nm

-Near infrared = 770 nm

Visible ~ 400 to 700nm (G, B, R)

Near infrared ranges ~ 750nm to 1400nm

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

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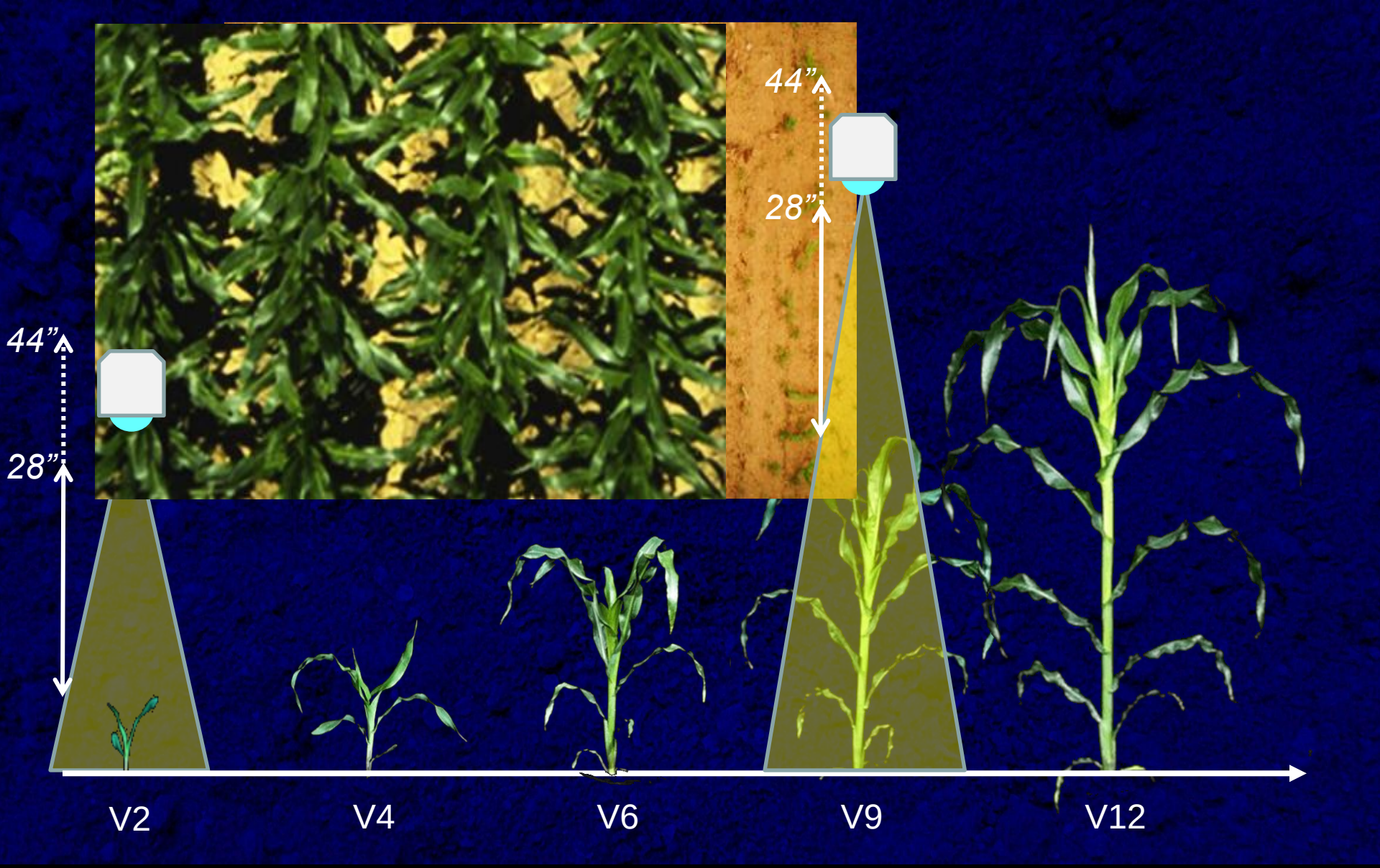
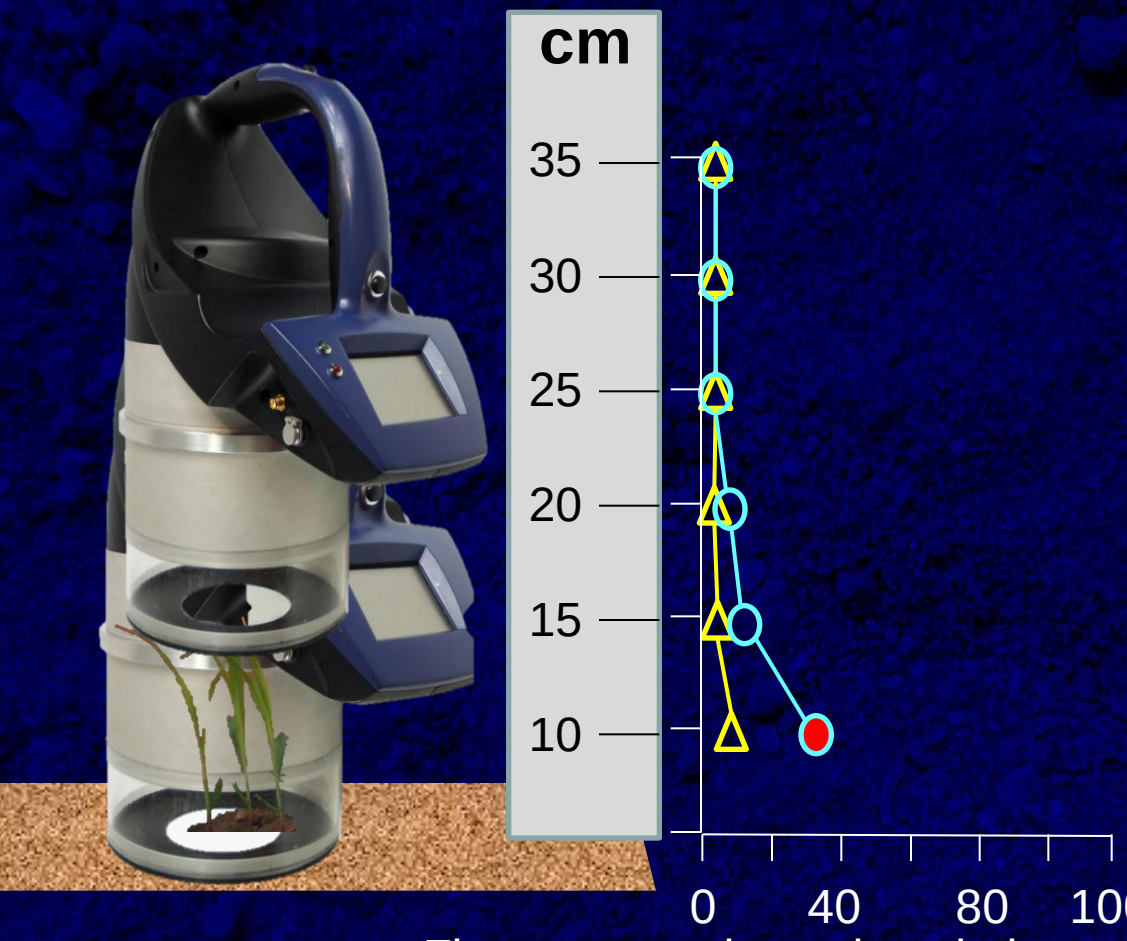

44”
28”
44”
28”
V2
V4
V6
V9
V12

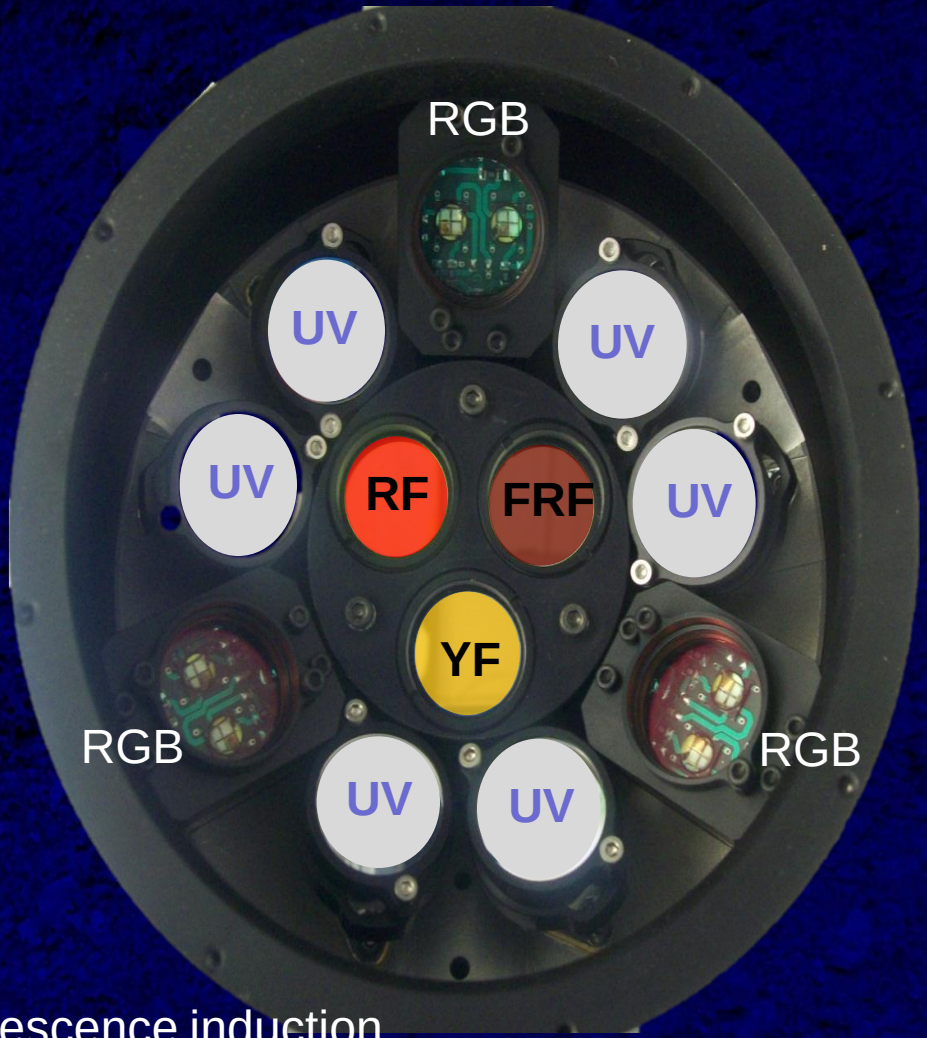
Mulitplex Fluorescence Sensor

Soil background noise



Mulitplex Fluorescence Sensor

Fluorescence signals



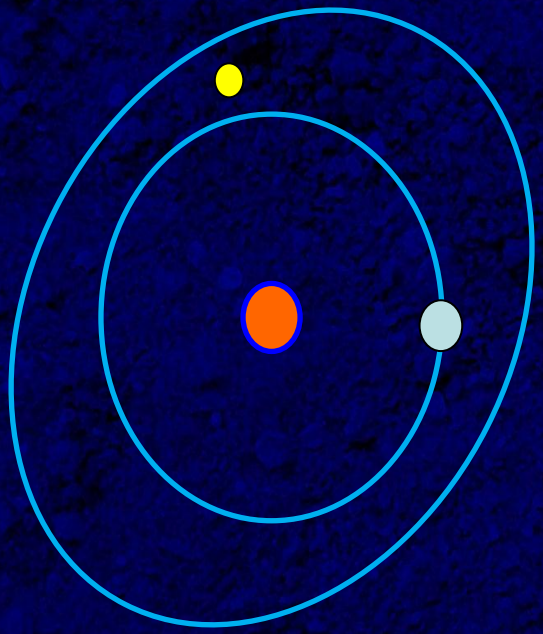
6 UV LEDs – fluorescence induction
3 RGB LEDs - fluorescence induction
1 sensor measuring yellow fluorescence
1 sensor measuring red fluorescence
1 sensor measuring far-red fluorescence

What is fluorescence

Photon hits an electron

Electron raises from one level of energy

Returns to its fundamental state: emitting a photon



FLUORESCENCE

Chlorophyll fluorescence

Light

Normalized fluorescence intensity

400

600

800

Wavelength

Chl *a* *

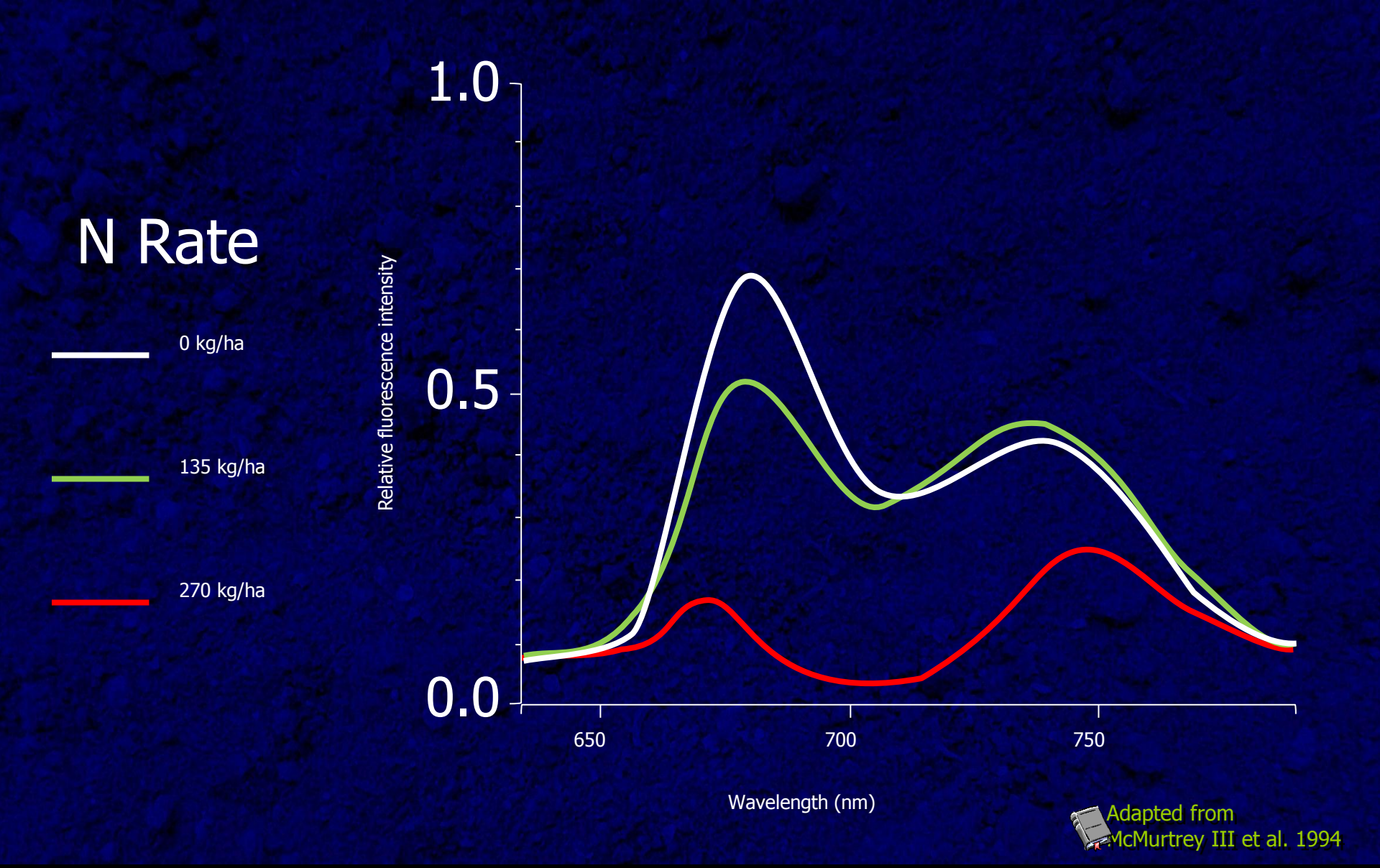
Chl *a*

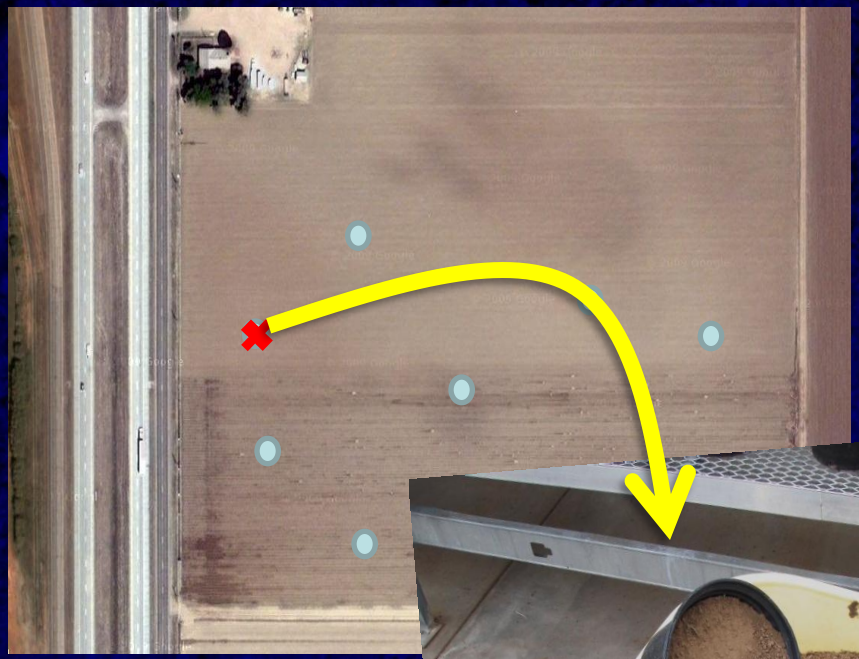
Heat

Photosynthesis

Fluorescence

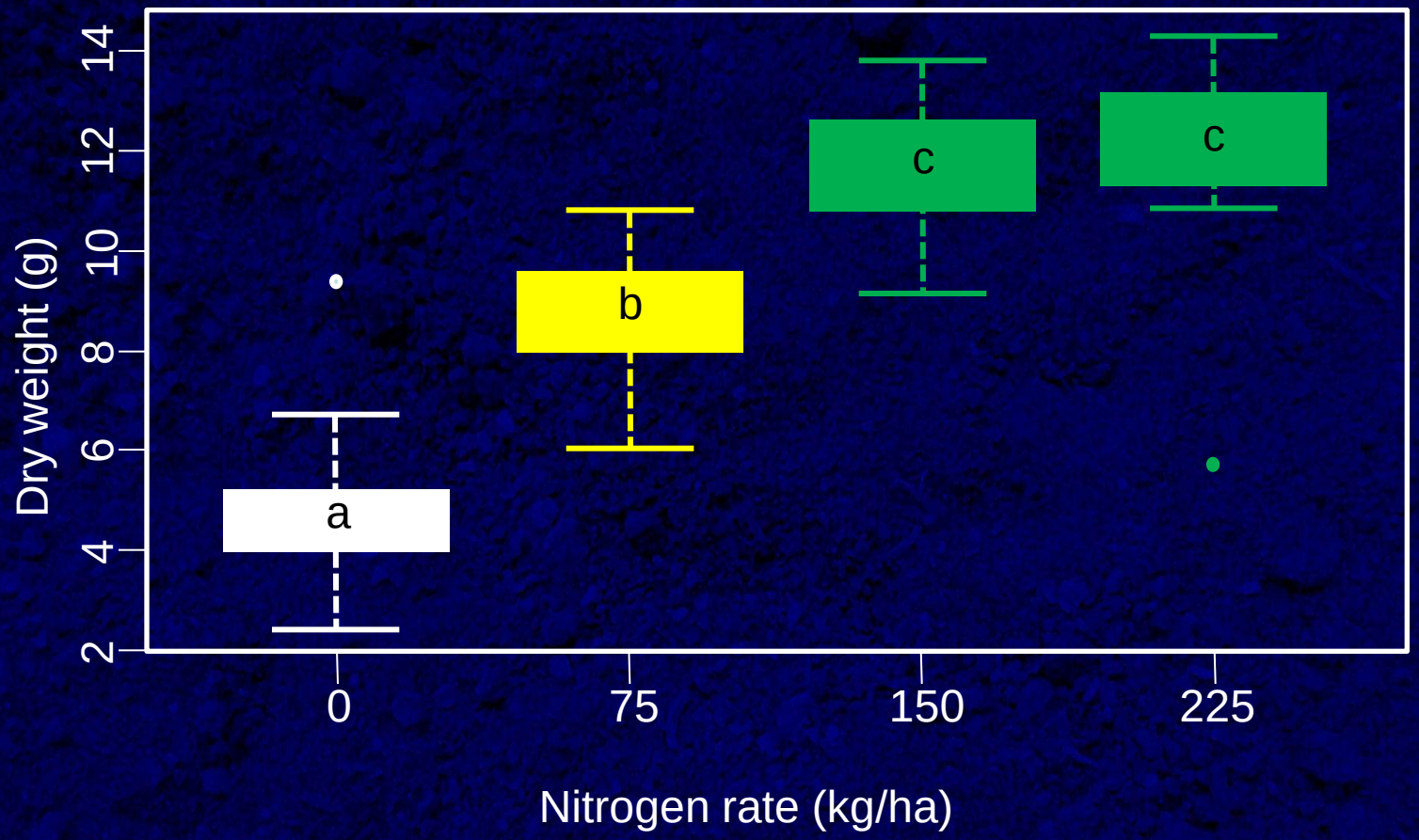
Müller et al., 2001


N Rate
0 kg/ha
135 kg/ha
270 kg/ha
1.0
0.5
0.0
Relative fluorescence intensity
650
700
750
Wavelength (nm)
Adapted from
McMurtrey III et al. 1994

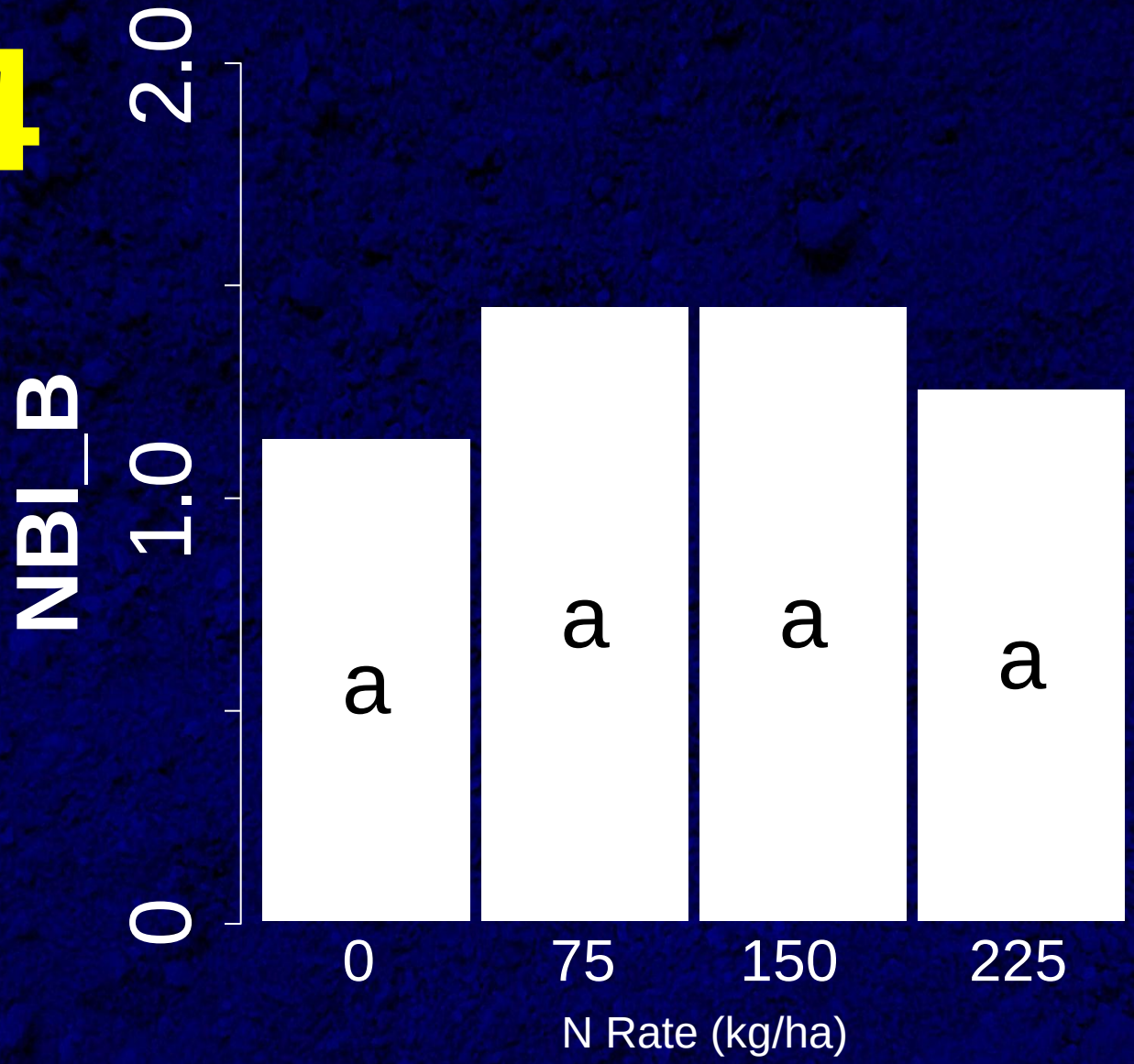


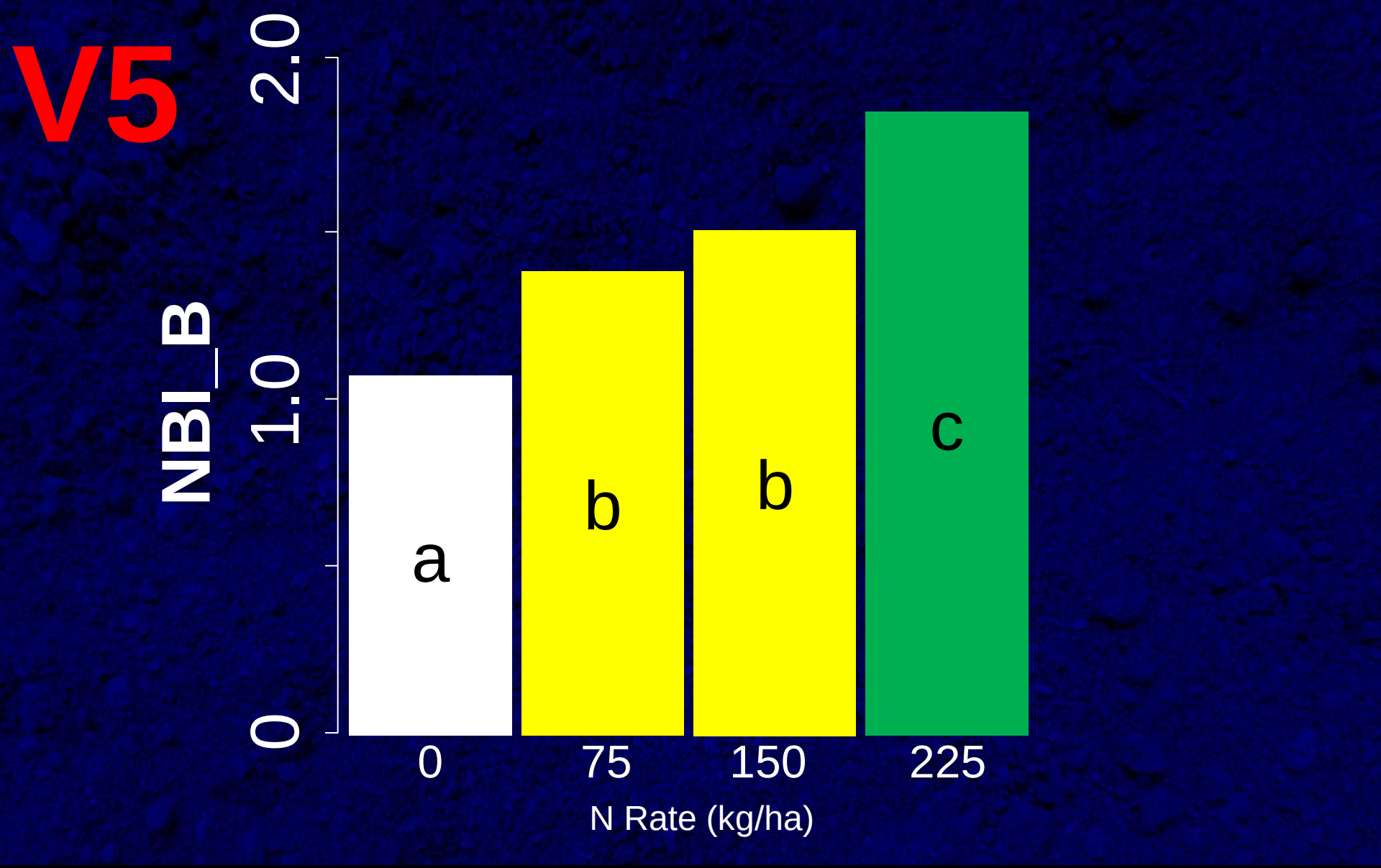
1. 0 kg/ha
2. 75 kg/ha
3. 150 kg/ha
4. 225 kg/ha

Effect of nitrogen rates on dry weight

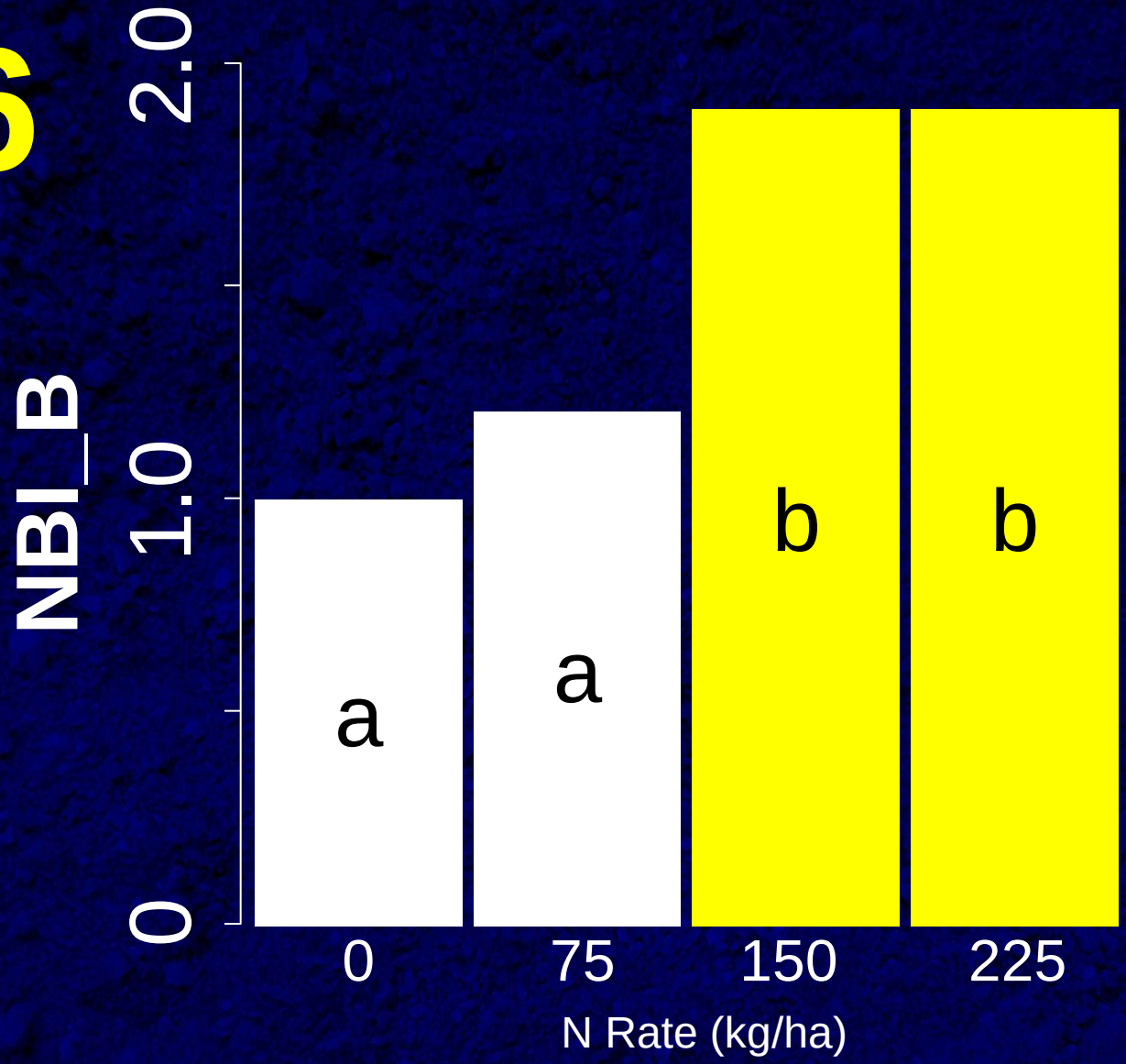


V4

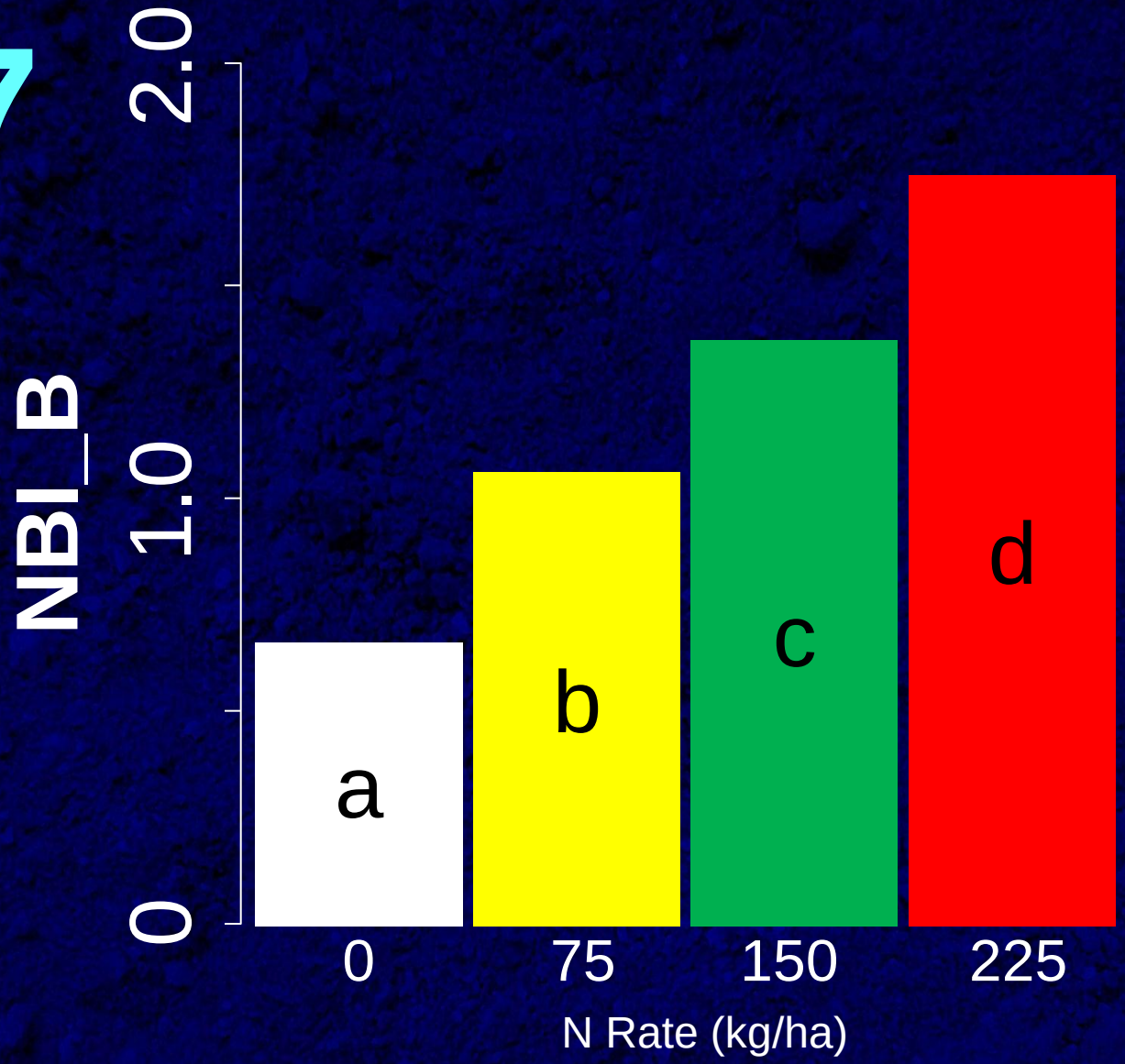



V5
NBI_B
2.0
1.0
0
a
b
b
c
0
75
150
225
N Rate (kg/ha)

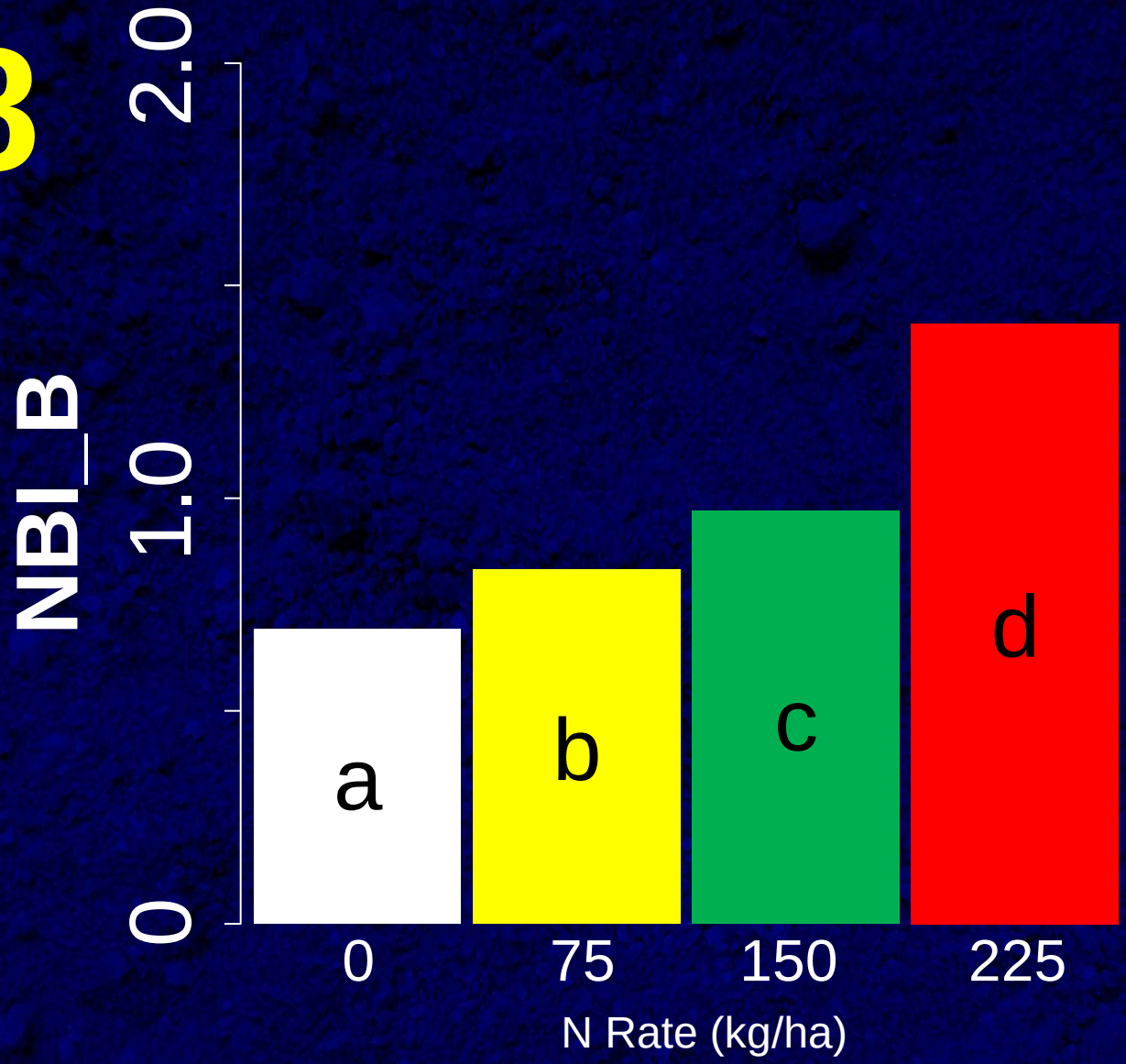
V6



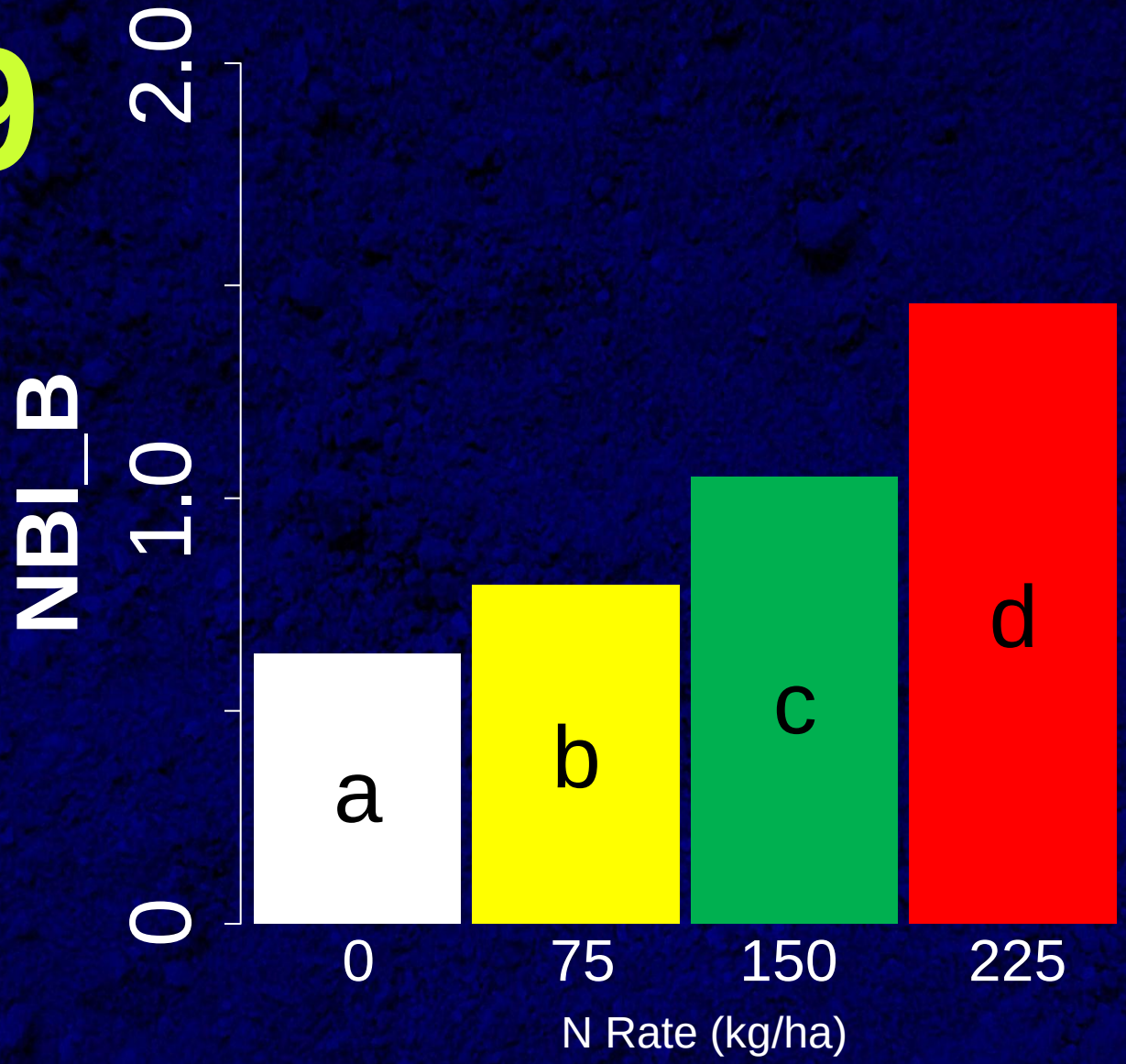
V7

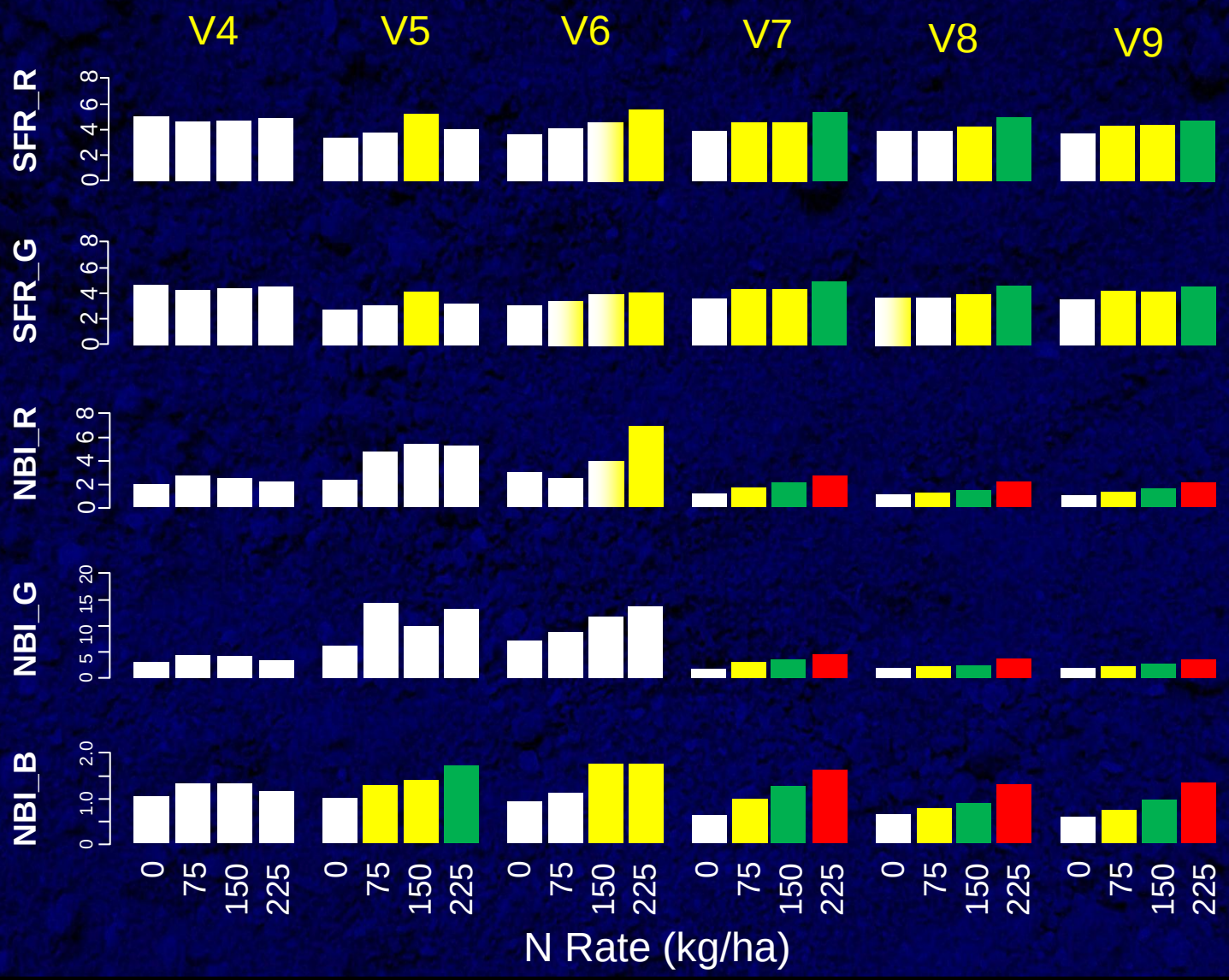


V8

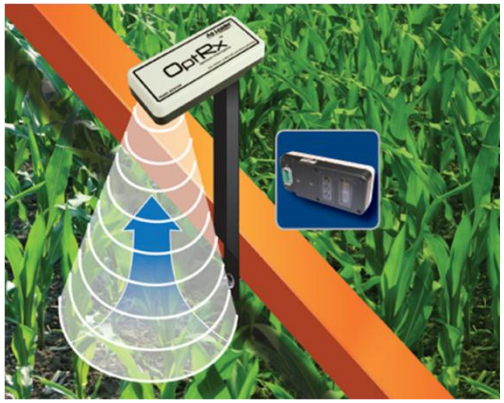


V9




V4
V5
V6
V7
V8
V9
SFR_R
SFR_G
NBI_R
NBI_G
NBI_B
0 2 4 6 8
0 2 4 6 8
0 2 4 6 8
0 5 10 15 20
0 1.0 2.0
0 75 150 225
N Rate (kg/ha)

Crop Sensors (ver 1.01)



- Currently it is not feasible to differentiate the nutrient deficiency of "iron" versus "nitrogen" in a corn field using sensing technology,

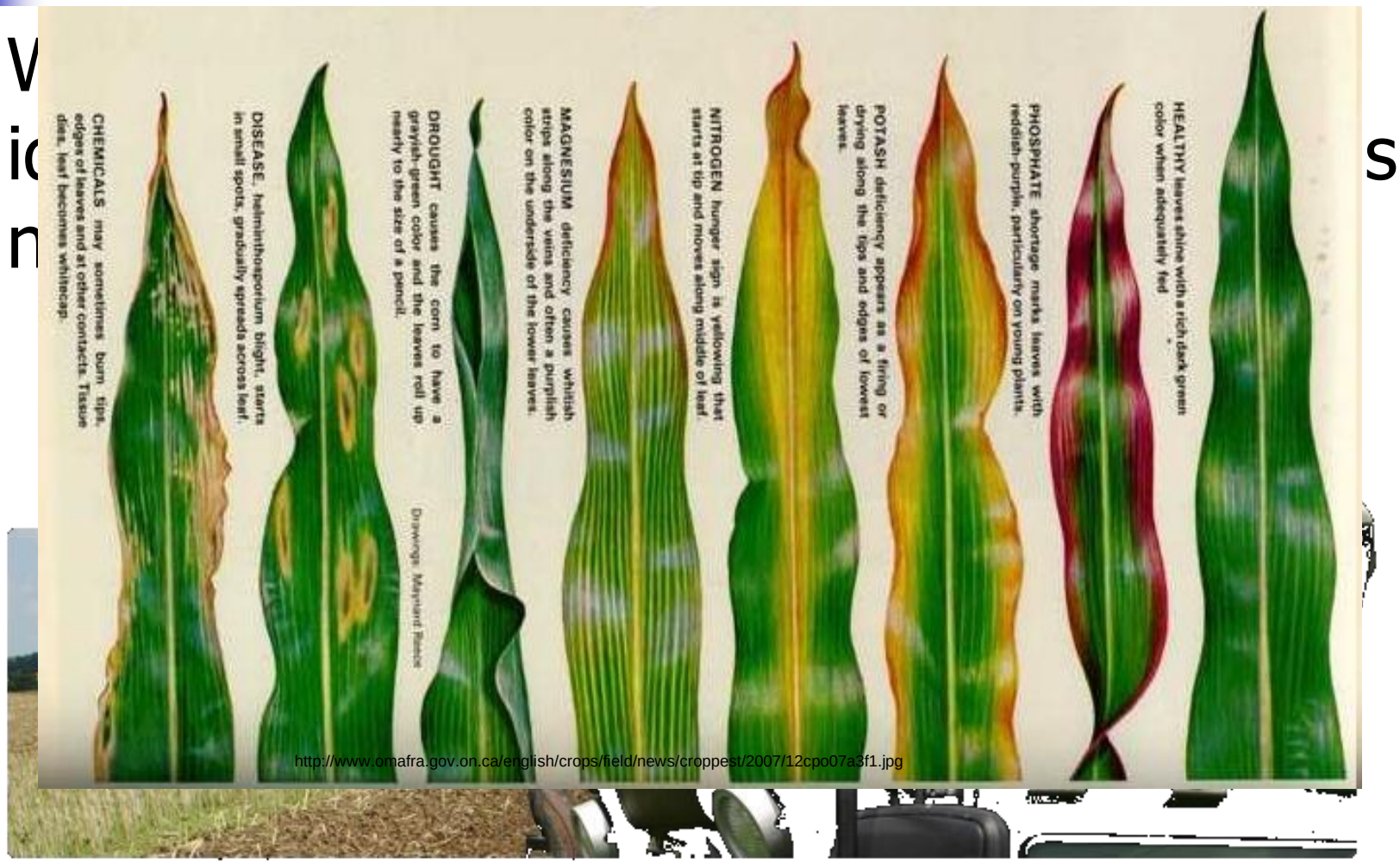
[Iron deficiency]

http://www.bcg.org.au/cb_pages/images/images/StripeRust_640.jpg

Image: IPNI website [N deficiency]

- Either one gives a lower NDVI value

- V
  i
  n
  s

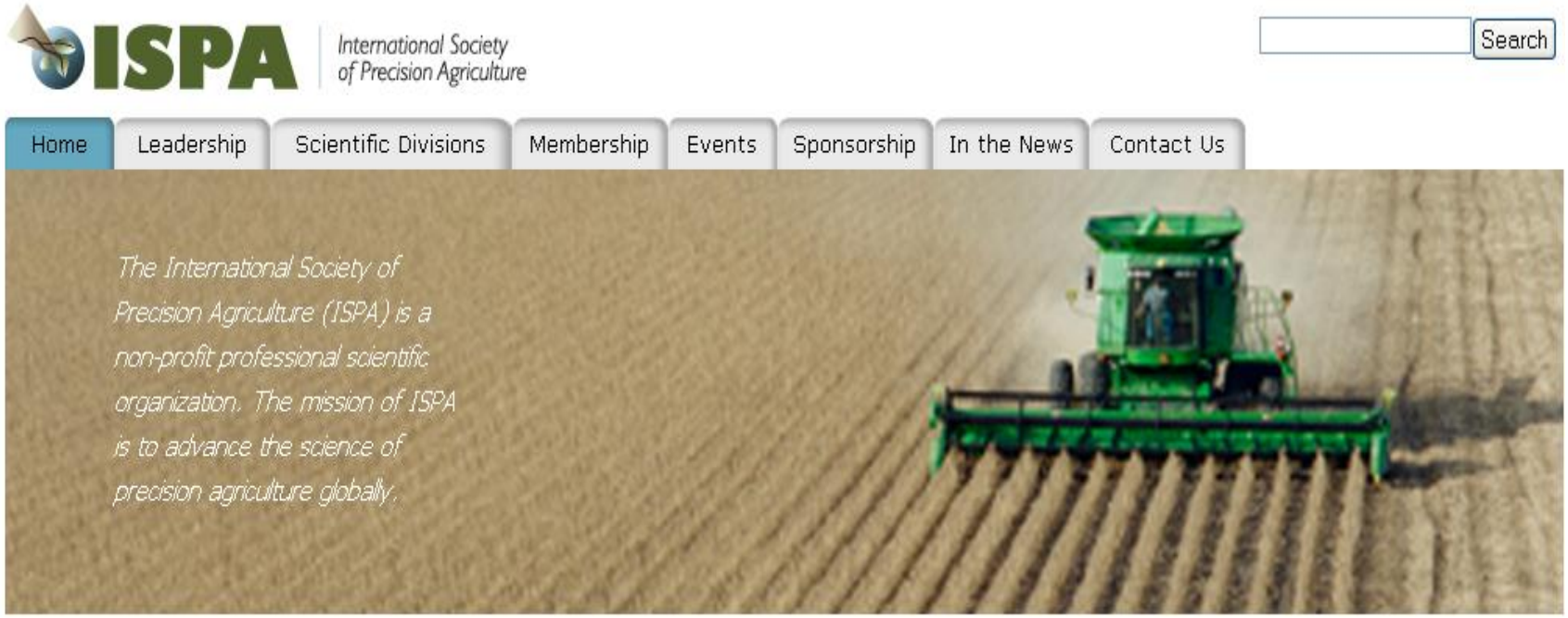


http://www.omafra.gov.on.ca/english/crops/field/news/croppest/2007/12cpo07a3f1.jpg

http://agricon.typo3dev.de/uploads/media/00_agricon_yaransensor_01.png

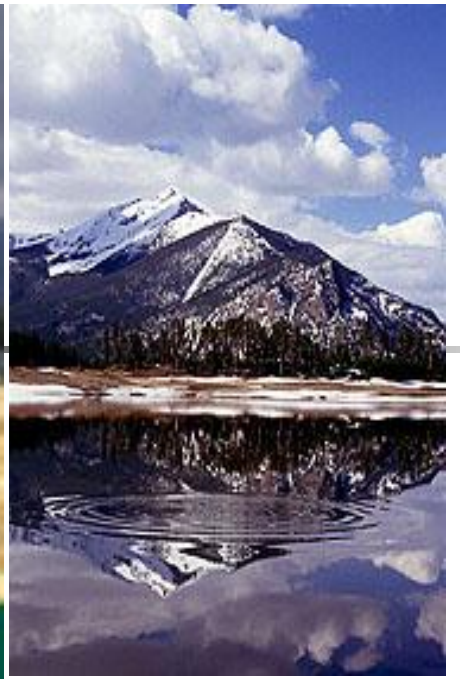
Summary

- Fluorescence based sensor has potential to detect early nitrogen deficiency in corn
- Soil background noise is minimal
- Can it differentiate between N and K deficiency?
- Or deficiency of nutrients vs pest/disease infestations?



11th International Conference on Precision Agriculture

- Hyatt Regency, downtown, Indianapolis
- July 15-18th, 2012



THANK YOU

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