La venue de ce conférencier a été rendue possible grâce au soutien financier du ministère de l'Agriculture, des Pêcheries et de l'Alimentation

" *New Opportunities for Soil and Crop Variability Management* "

Precision Farming: How-to Guide and Potential for the Planet

Jim Schepers
Soil Scientist (retired), USDA-ARS
Professor (emeriti), Univ. of Nebraska

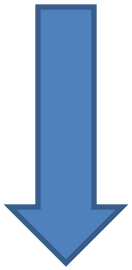
April 7-11, 2014

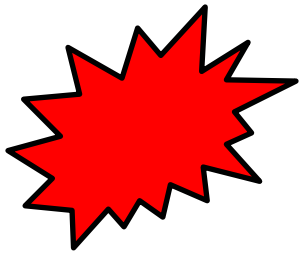
My Premise

The end users will endorse new technologies for reasons of :

Profitability
Convenience
Time / Labor
Regulations

OR





As scientists, we should focus on using new technologies to:

Enhance **yields**

Increase **input efficiency**

Facilitate **integration** / **interpretation**

Protect **environment**

Consider the sources of crop N :

N mineralization
Manure
Residual soil N (nitrate)
Legume credits
Nitrate in irrigation water
Precipitation
Fertilizers

} Most susceptible to spatial variability

→ *Variable Rate Applications*

How to assess spatial variability in fields ?

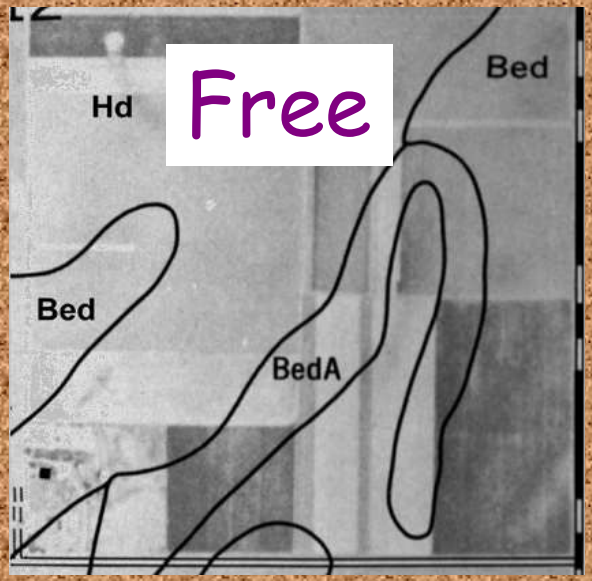
Soil testing *(grid or management zone sampling)*

Generate ***soil organic matter map*** *(soil sampling or remote sensing)*

Use the ***crop as a bio-indicator*** *(vigor, biomass, chlorophyll status)*

Intensive Soil Quality Assessment on a Field Scale

Sprinkler irrigated field in Central Nebraska



Soils Map

Aerial Photograph

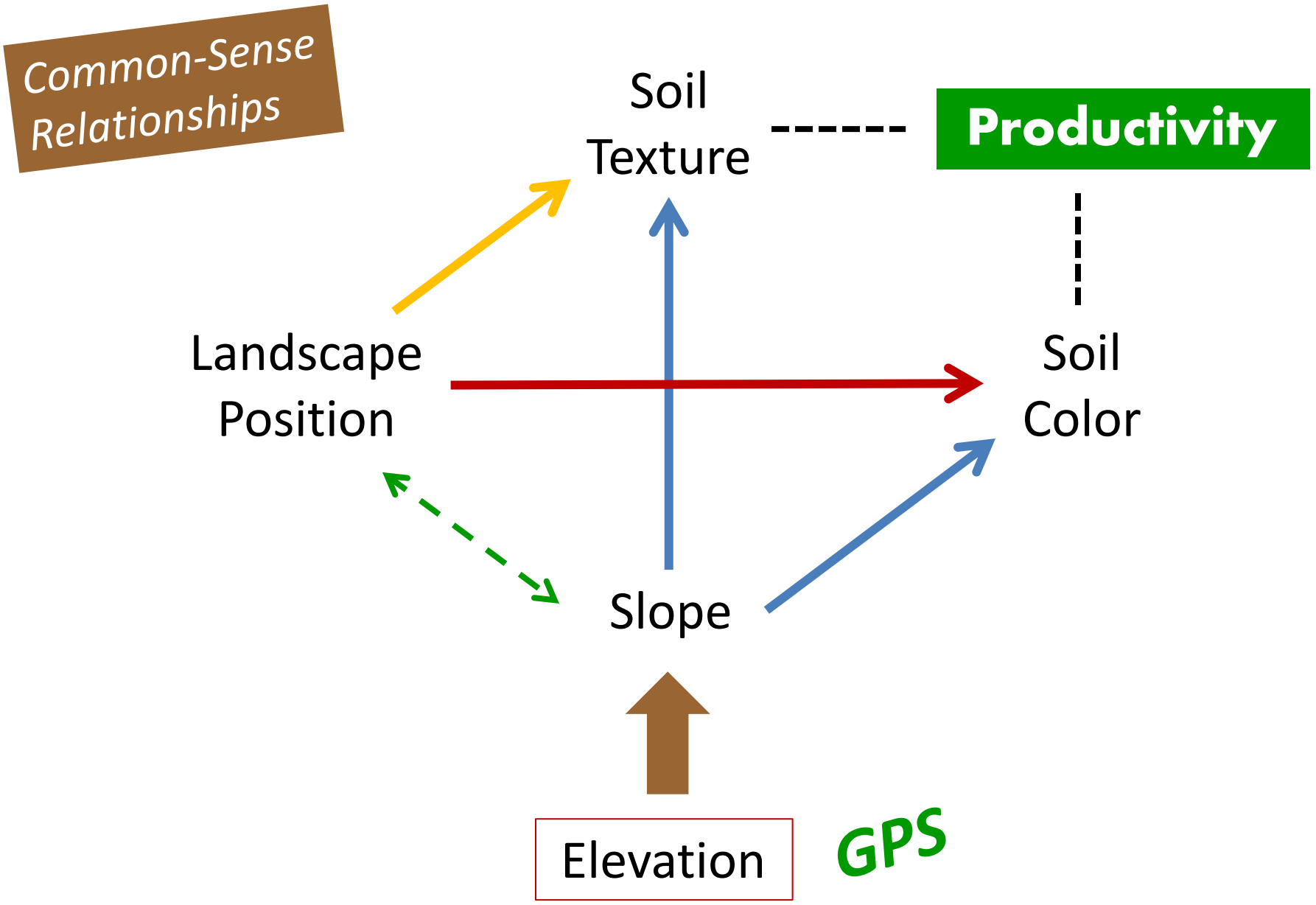
Grid Sampling

(40 x 80-ft grid)

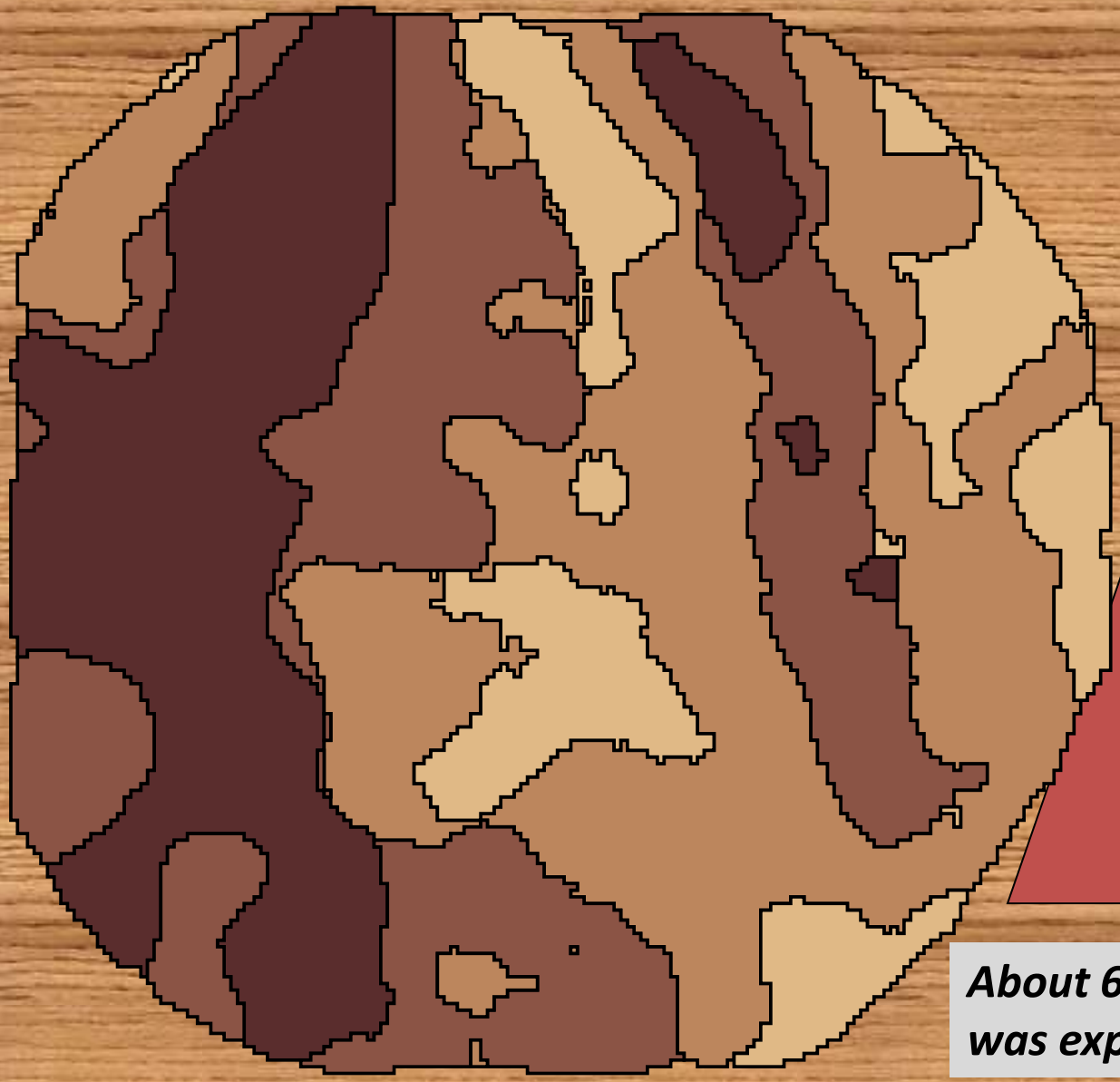
1.3 1.7 2.1 2.5 2.9 3.3

Organic Matter (%)

Management Zones


Common-Sense Relationships
Soil Texture
Productivity
Landscape Position
Soil Color
Slope
Elevation
GPS

Computer Generated Management Zones



Incorporating. . .

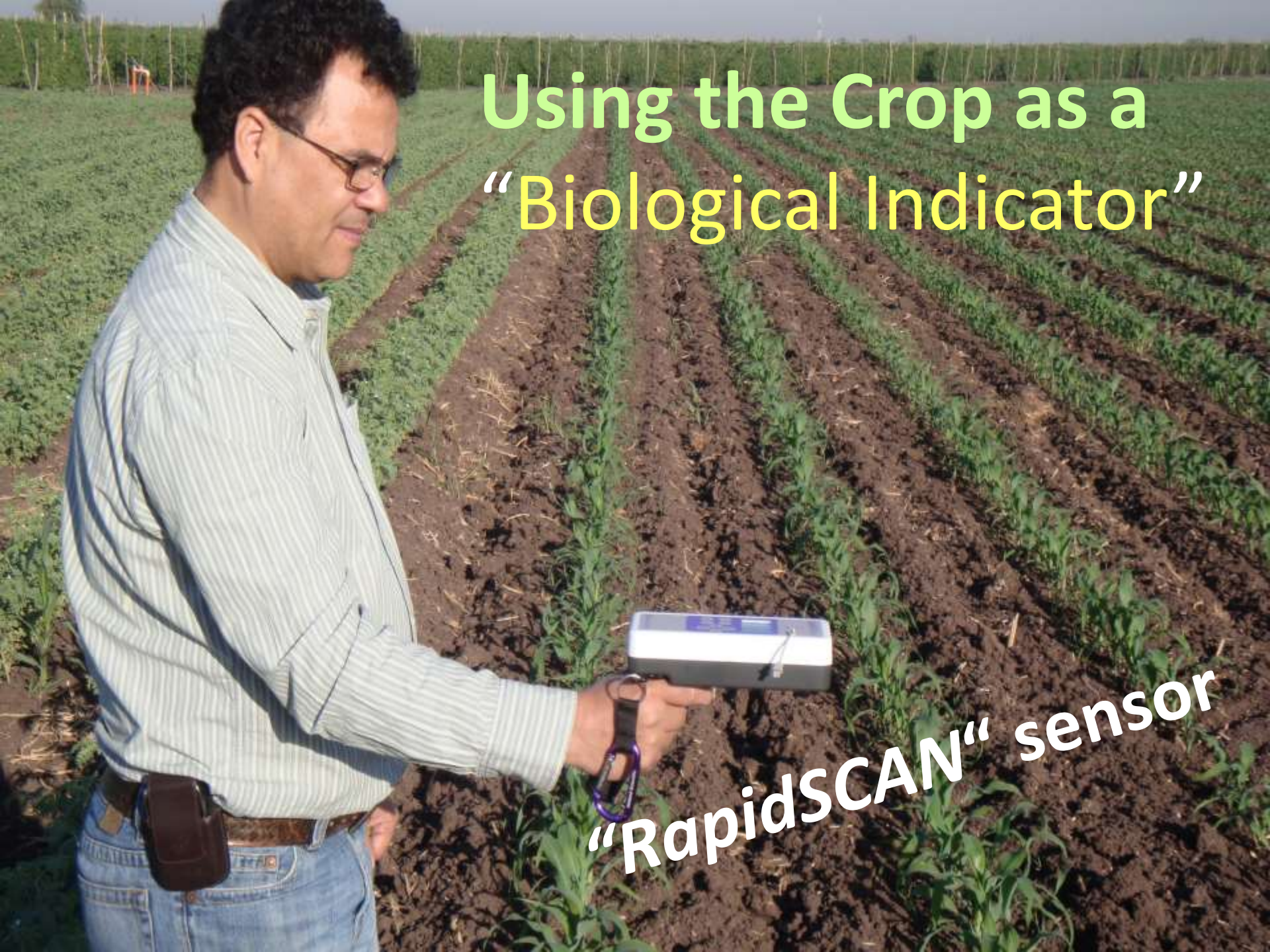
Bare Soil Image

Elevation

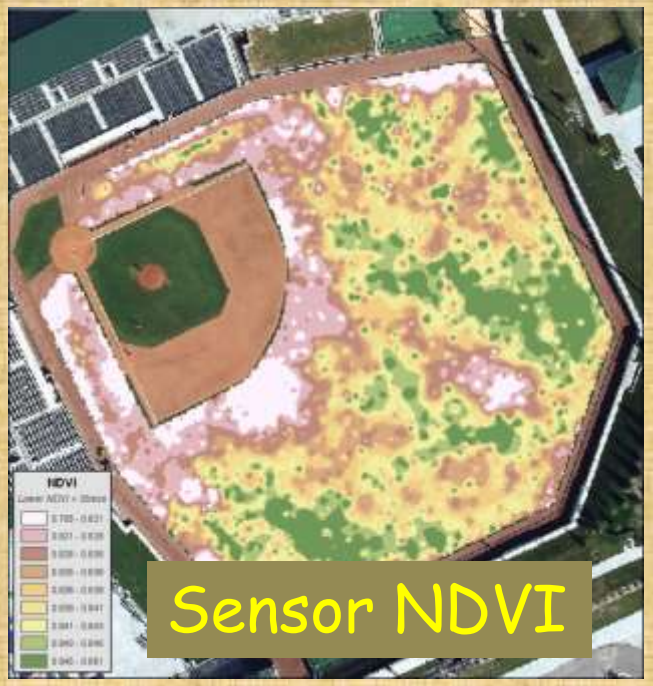
Slope

EM-38

About 65% of yield variability was explained by bare-soil color


Using the Crop as a
"Biological Indicator"
"RapidSCAN" sensor

Crop sensing for " in-season " N application

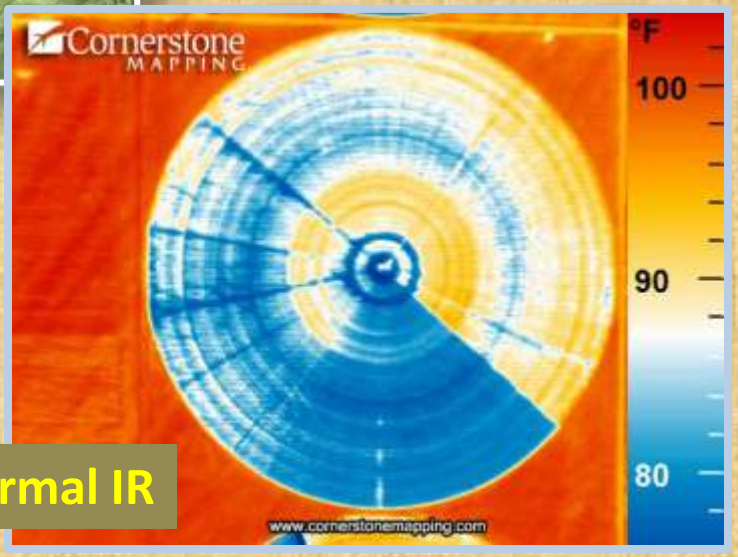

NDVI
Sensor NDVI

Wow !


Color


Color IR


Bare Soil


Cornerstone
MAPPING
°F
100
90
80
Thermal IR
www.cornerstonemapping.com

What is the likelihood that soil residual N will be significant before planting ? ? ?

Depends on :

Mineralization (temperature)

Excess precipitation ***Can Be Like***

- Flu-u-u-sh -

Perhaps spatial variability in mineralization potential after planting will be significant ?

- as such -

NO_3 gradually becomes available

NO_3

“ No correlation between looks and yield “

Henry A. Wallace

Mg/ha *or* ***Bu/acre***

Premise – in-season differences in **crop vigor** will be ***p r o p o r t i o n a l*** to **yield** at harvest

≈

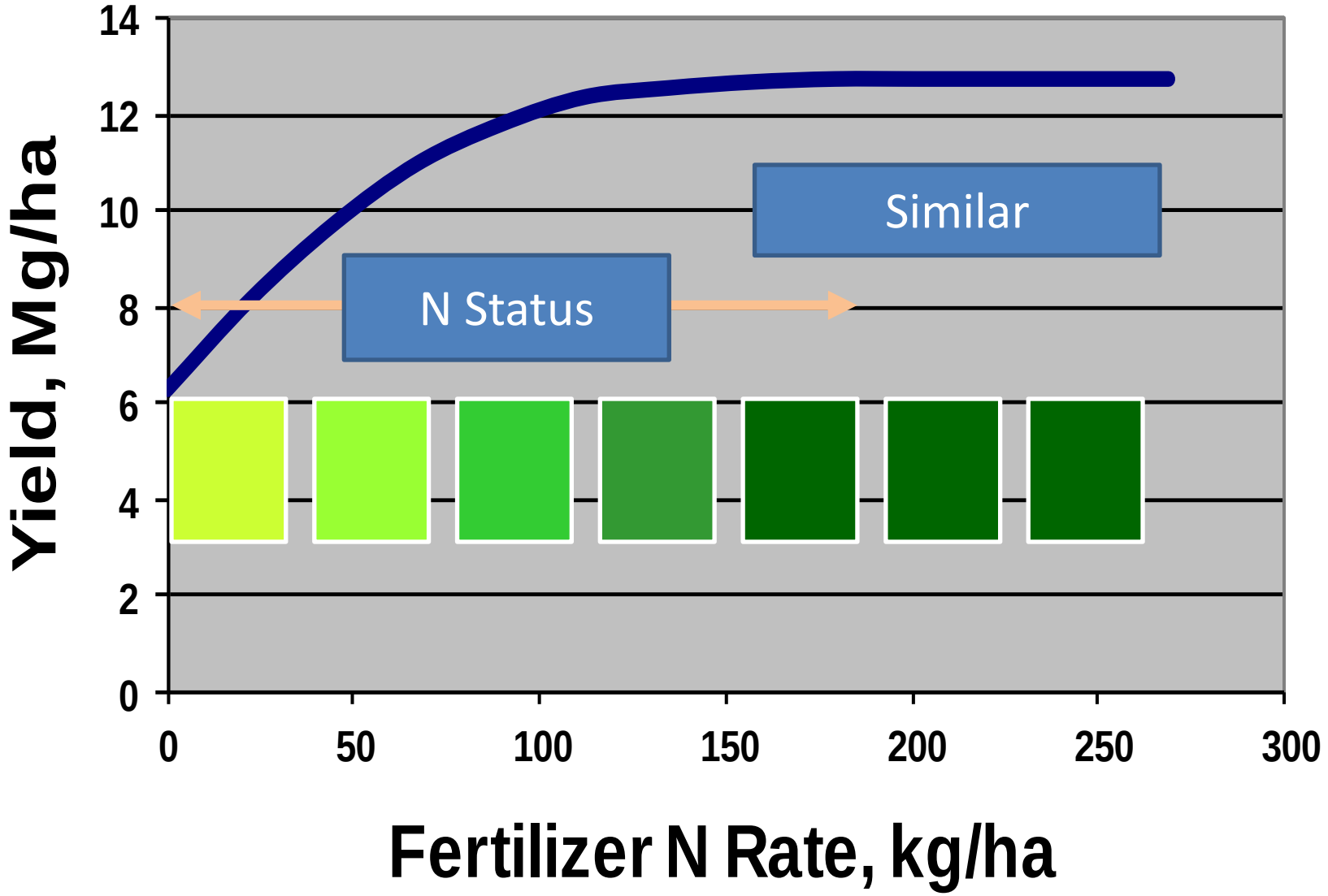
In-Season N Management

Crop vigor during the growing season

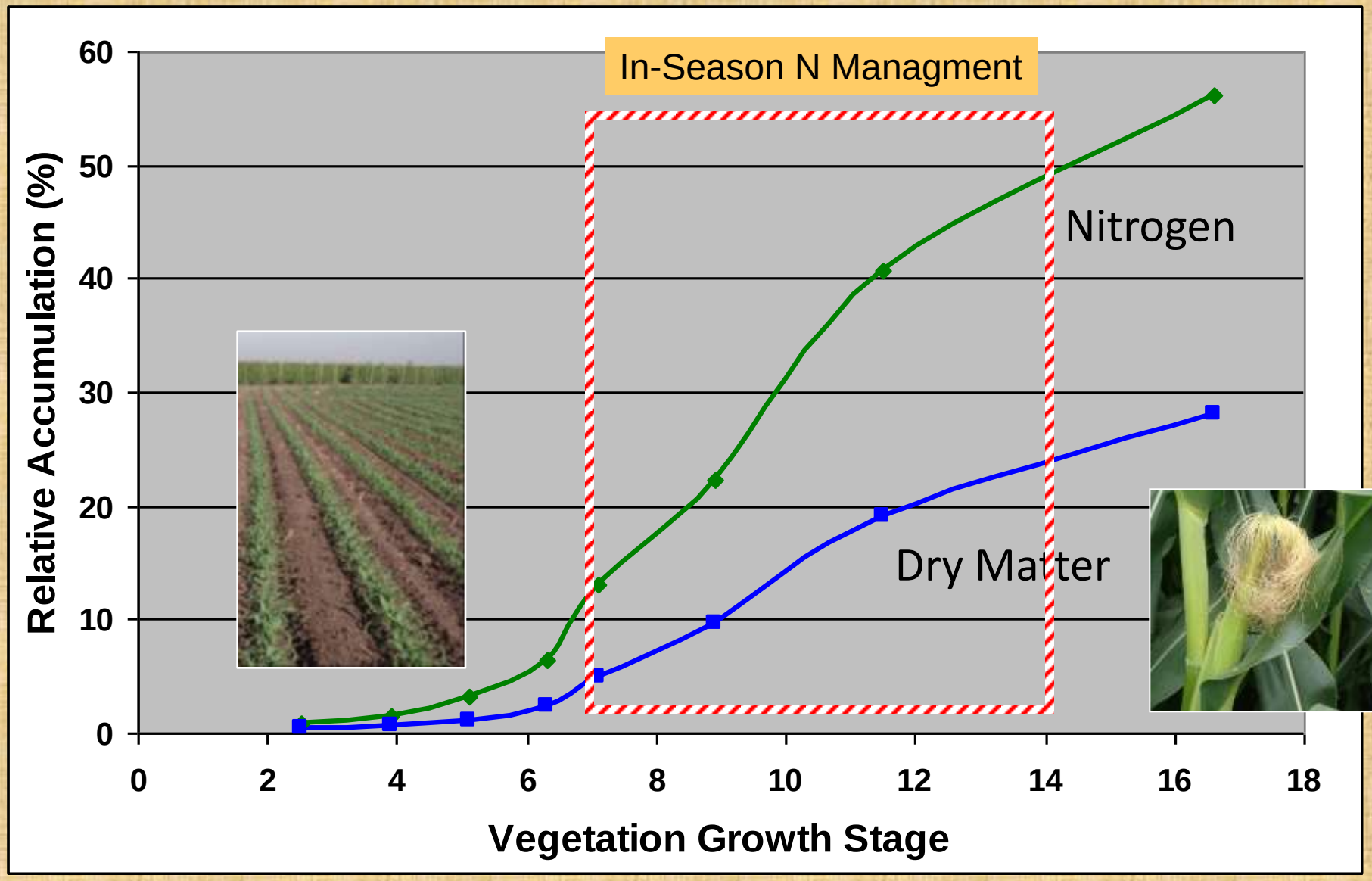
is **proportional** to

yield at harvest

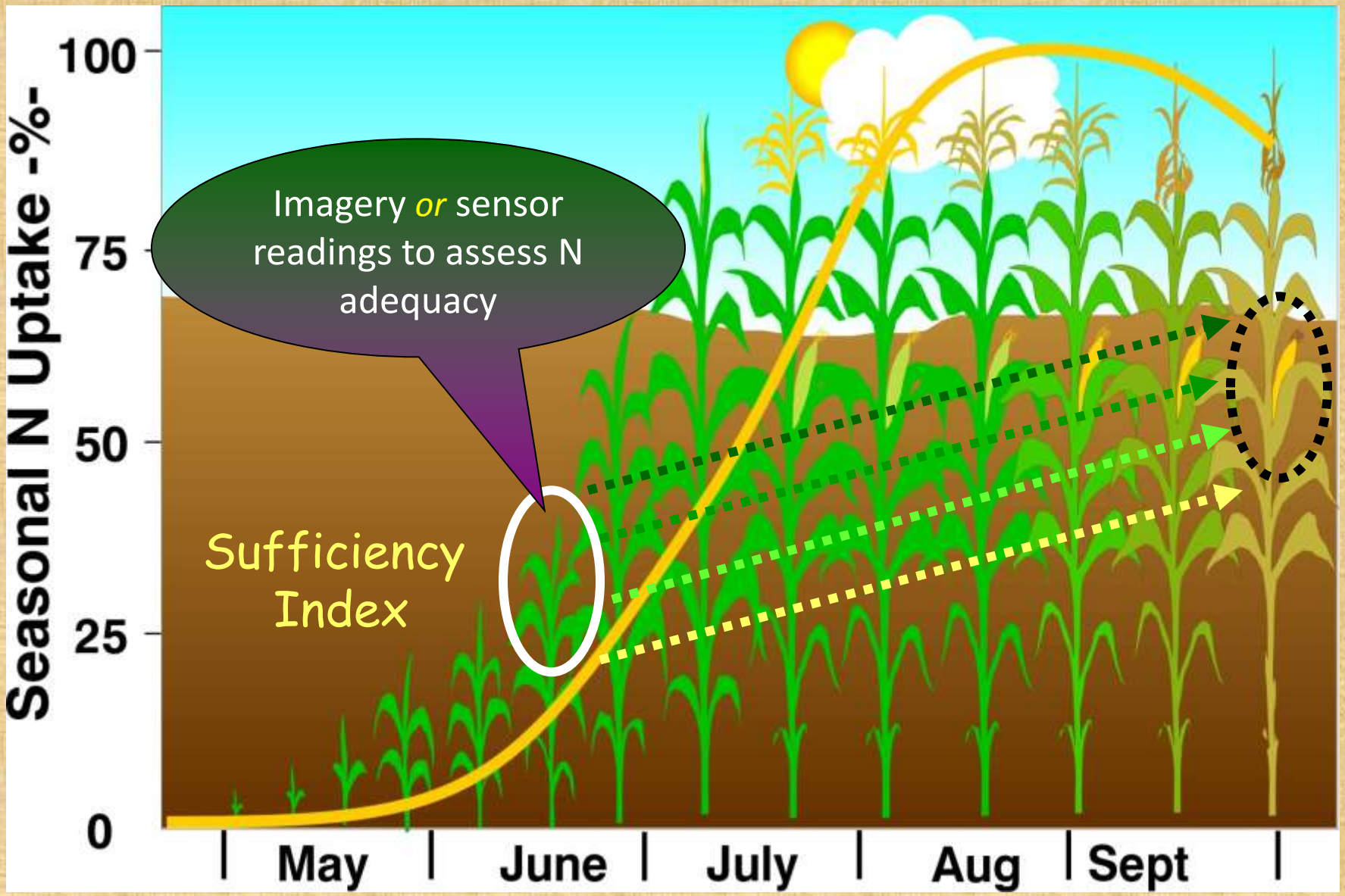
Canopy sensors can not quantify excess N



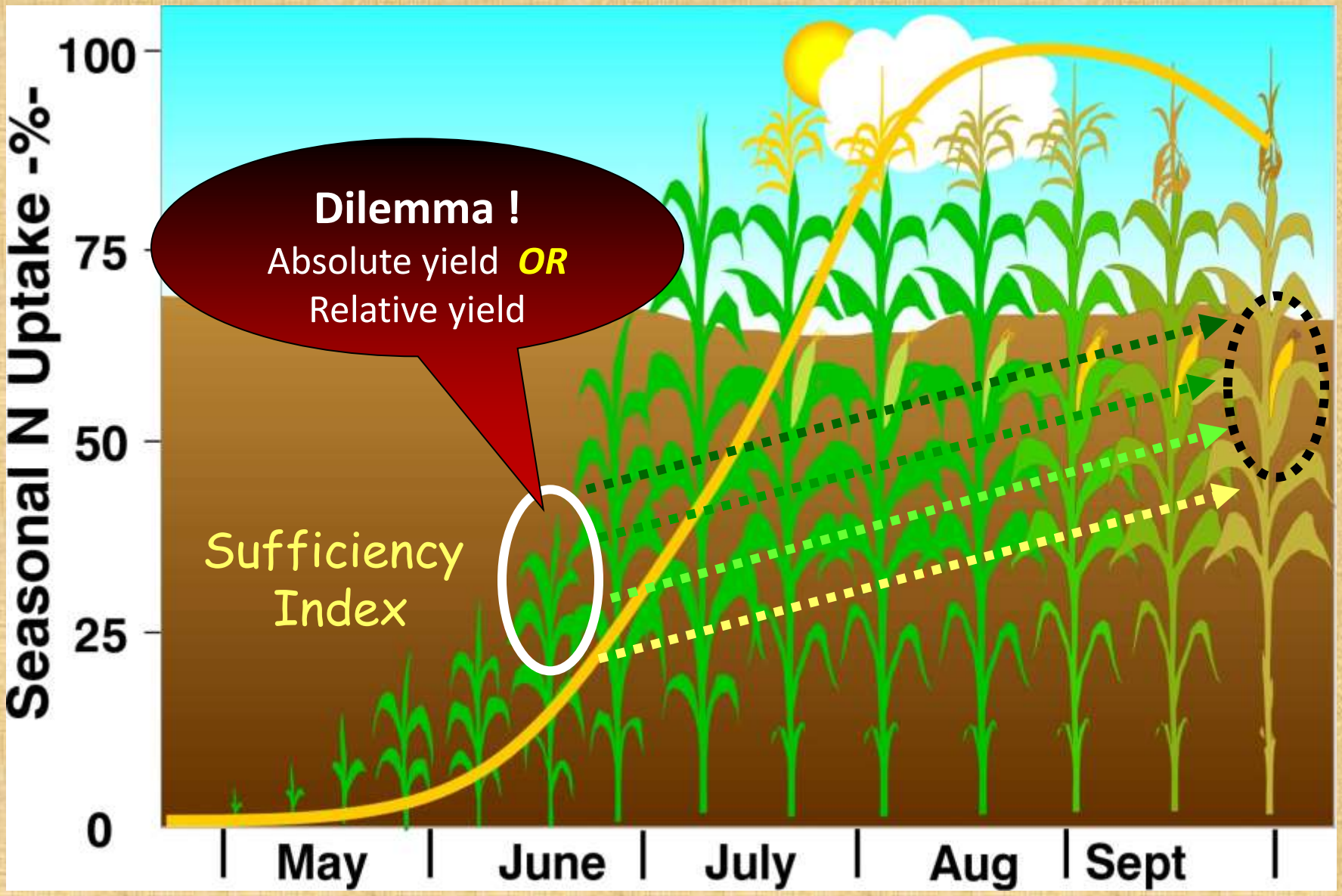
Corn Growth Patterns & Opportunities



Where Does **Adaptive Management** *Fit ?*



Where Does ***Adaptive Management*** *Fit ?*



Sufficiency Index

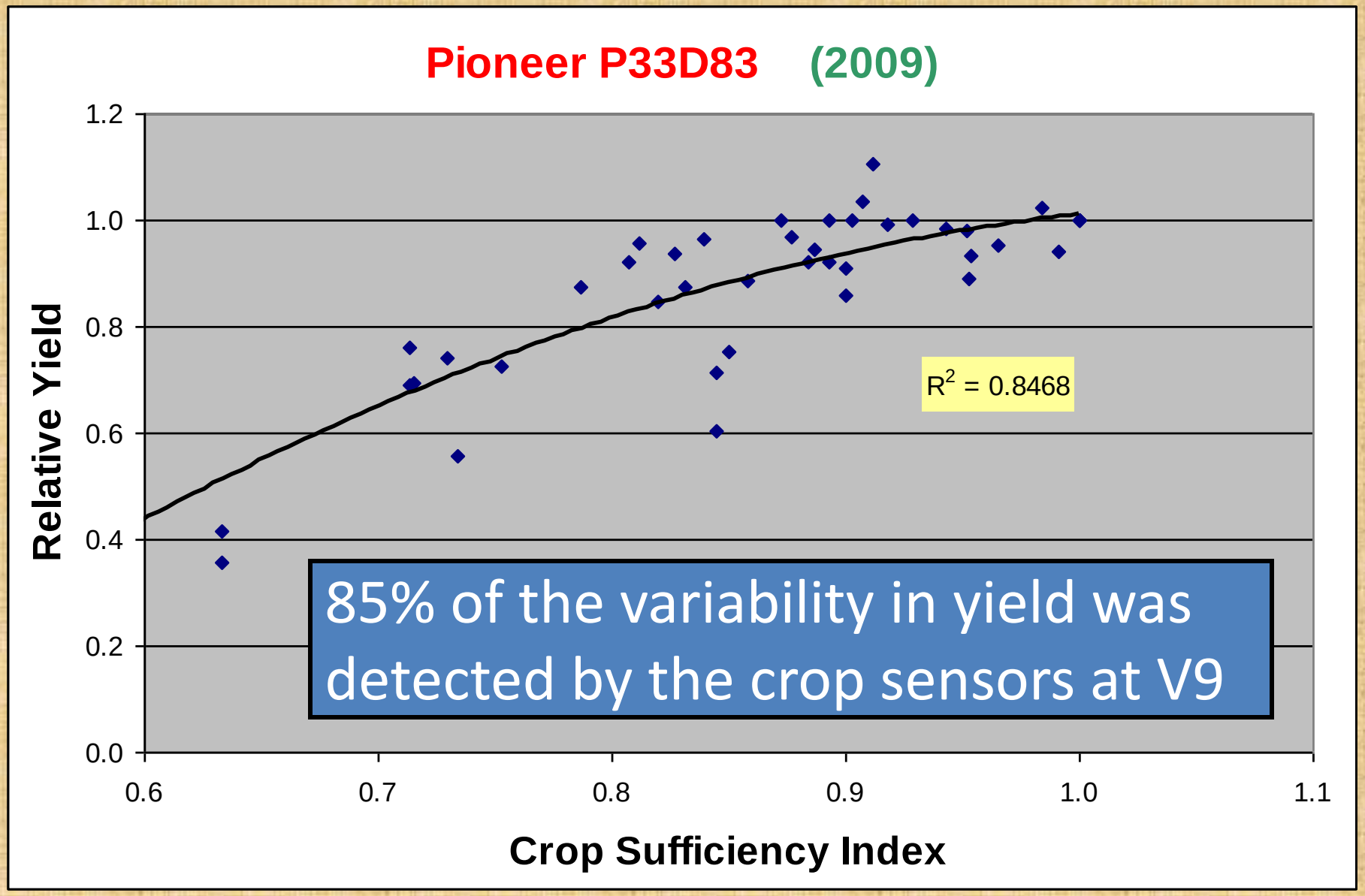
Relative "**Vigor**"
(i.e., 92% adequate)

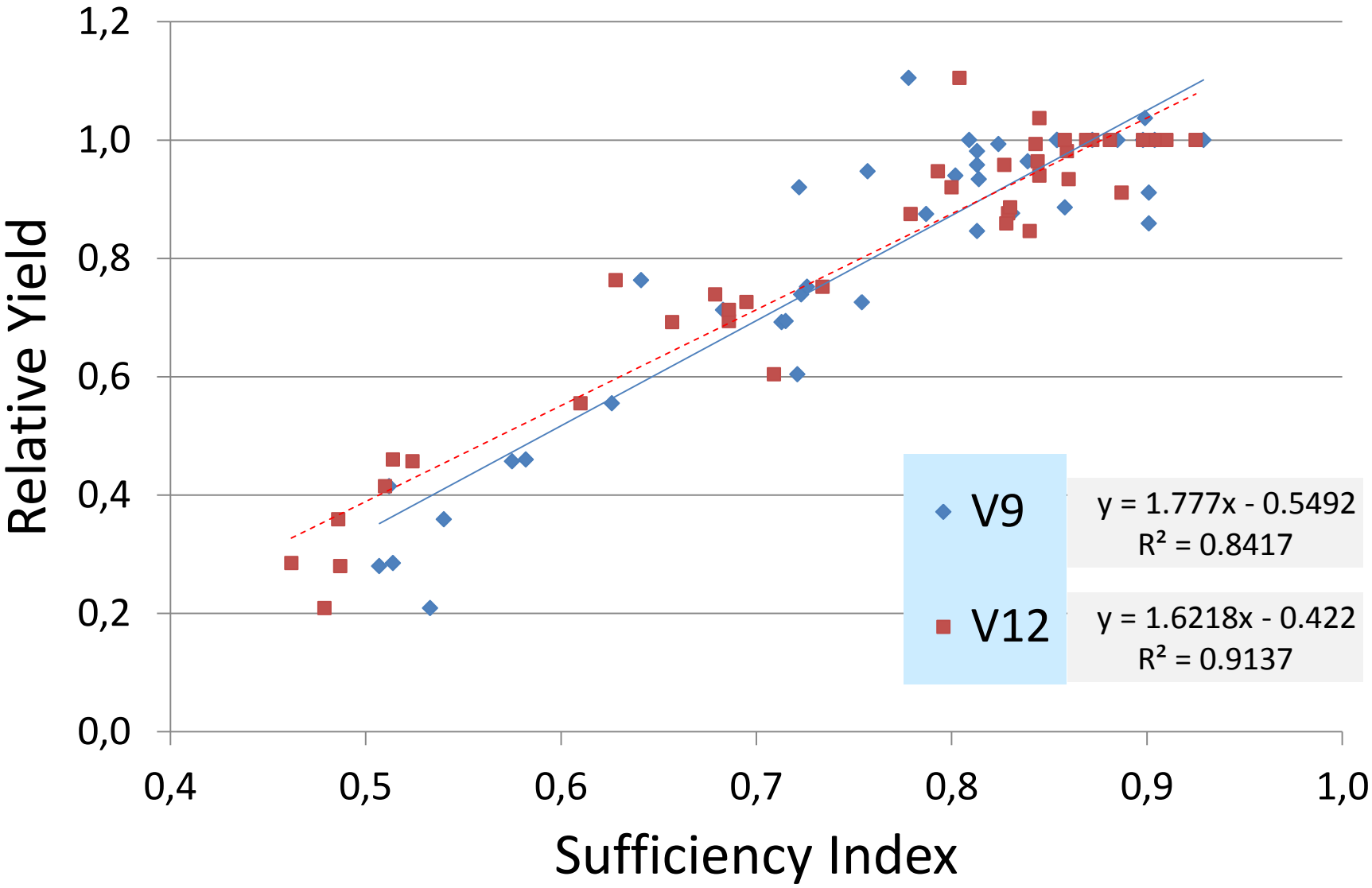
"X"
Reference

= "Managed Crop" / "Happy Crop" = SI

Normalize by field, cultivar, growth stage, and crop history

Irrigated Corn (V9)

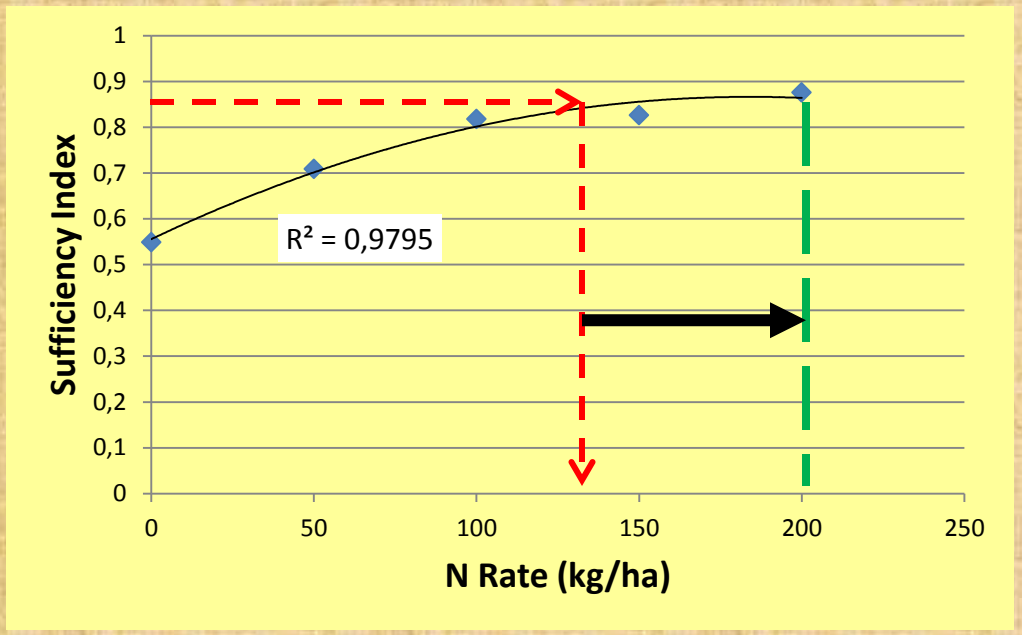


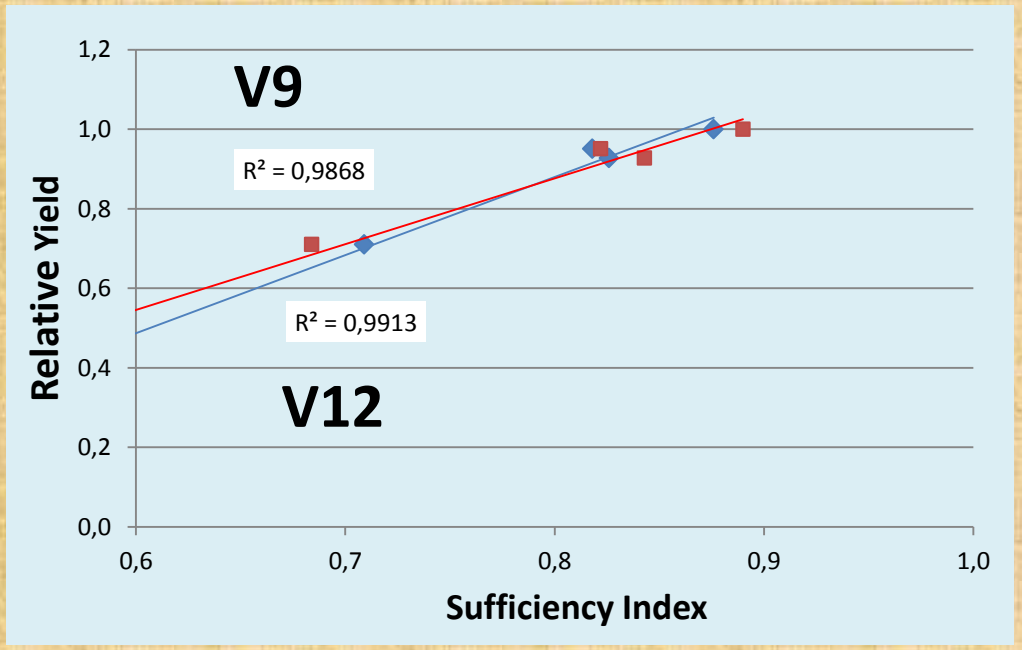


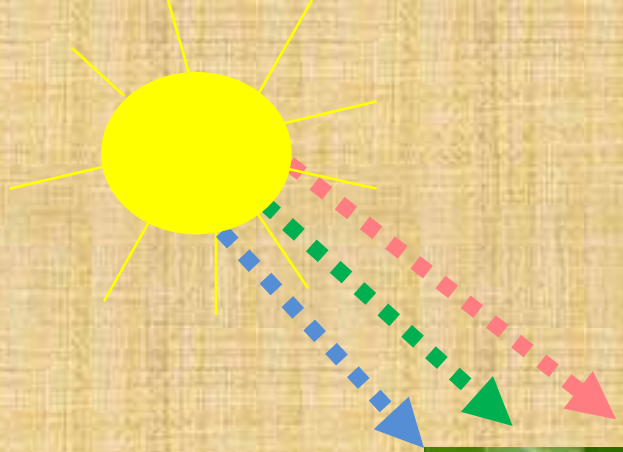
Irrigated Corn - 2009

Fertilizer N Rates
influence crop vigor
(sufficiency index)

Crop **Sufficiency Index**
is directly related to
Relative Yield







Photosynthesis

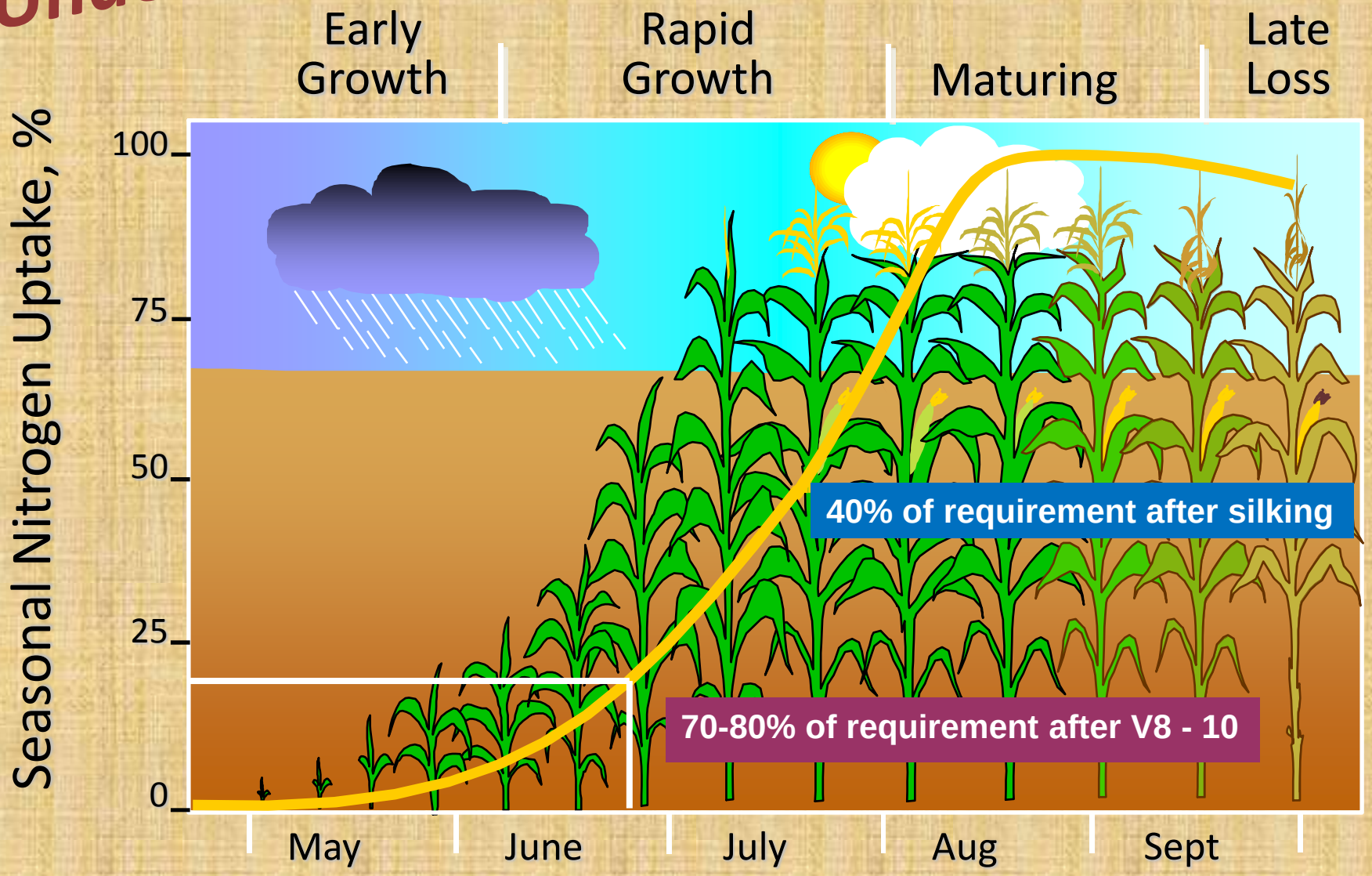
Chlorophyll

Biomass

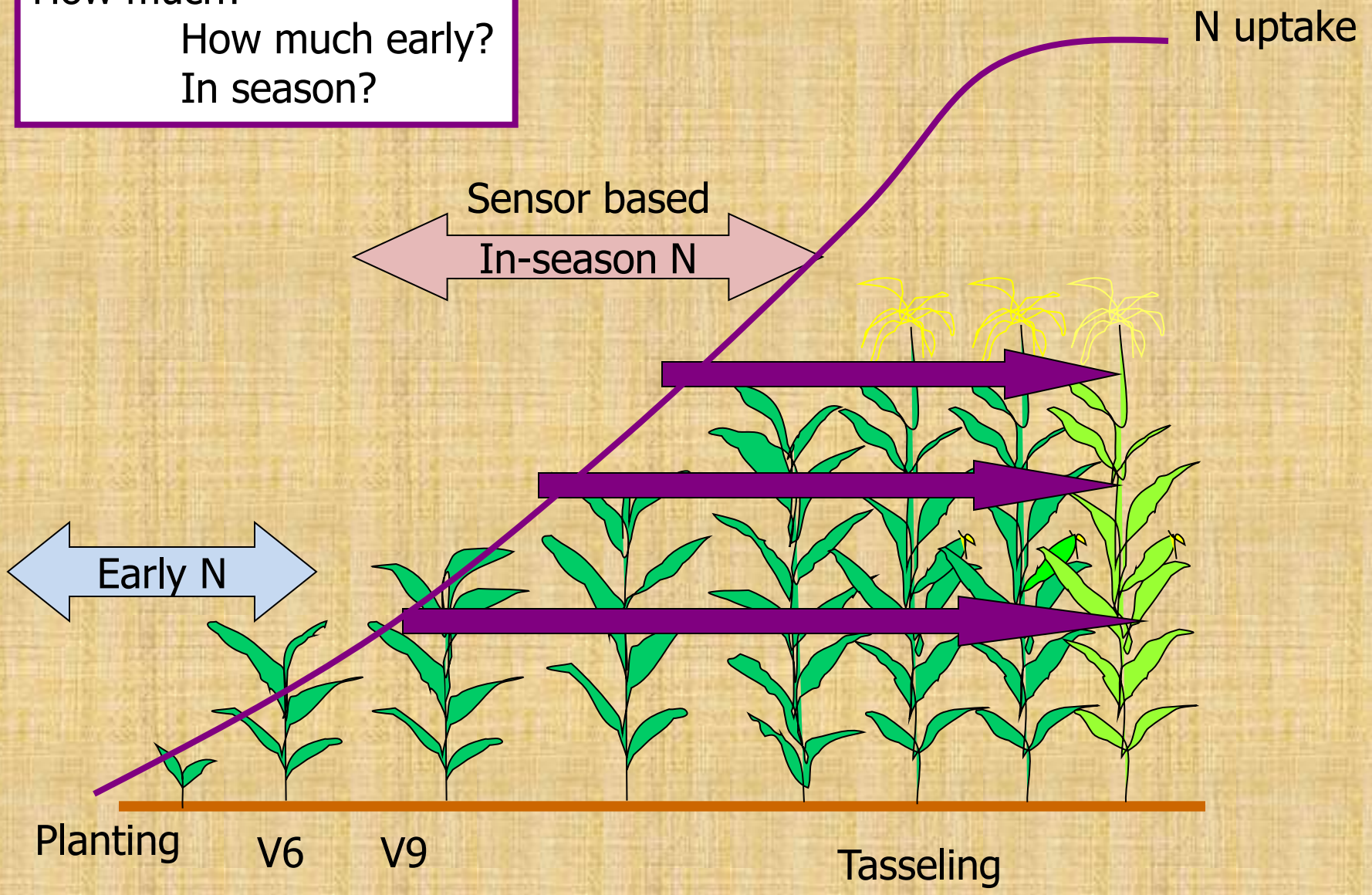
Productivity (yield) is proportional to :

Chlorophyll Content **X** ***Incoming Radiation***

Understanding the Crop



When?
How much?
How much early?
In season?



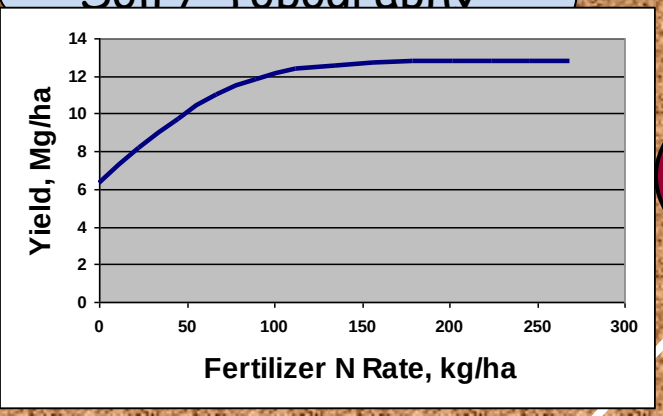
EONR
Producer Optimum

N Credits
Preplant N

Field
Reference

Sufficiency Index

Spatial
Soil / Topography



Algorithm

N Accumulation
(based on growth stage)

Back-Off Strategy
SI to start cutback
SI to cut-off

No calibration coefficients

Basic Algorithm

Holland K.H. and J.S. S… variable rate nitrogen a… fertilization of corn. Ag… 1424.

Caution :
Mineralization* and *Immobilization are embedded within **SI**

$$N_{appl} = (N_{opt} - N_{cred}) \sqrt{\frac{(1 - SI)}{\Delta SI}}$$

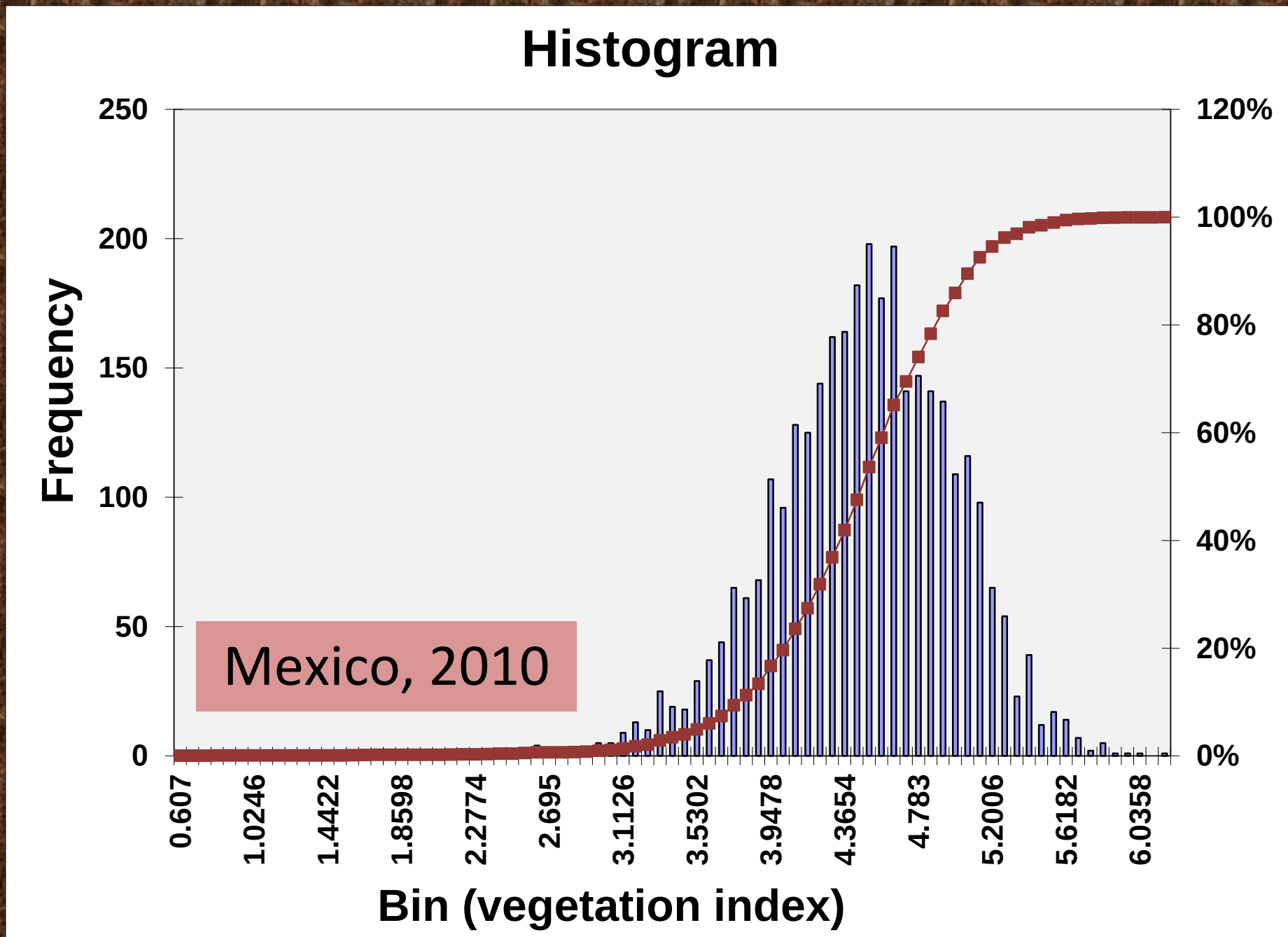
Farmer Rate
or N_{EONR}

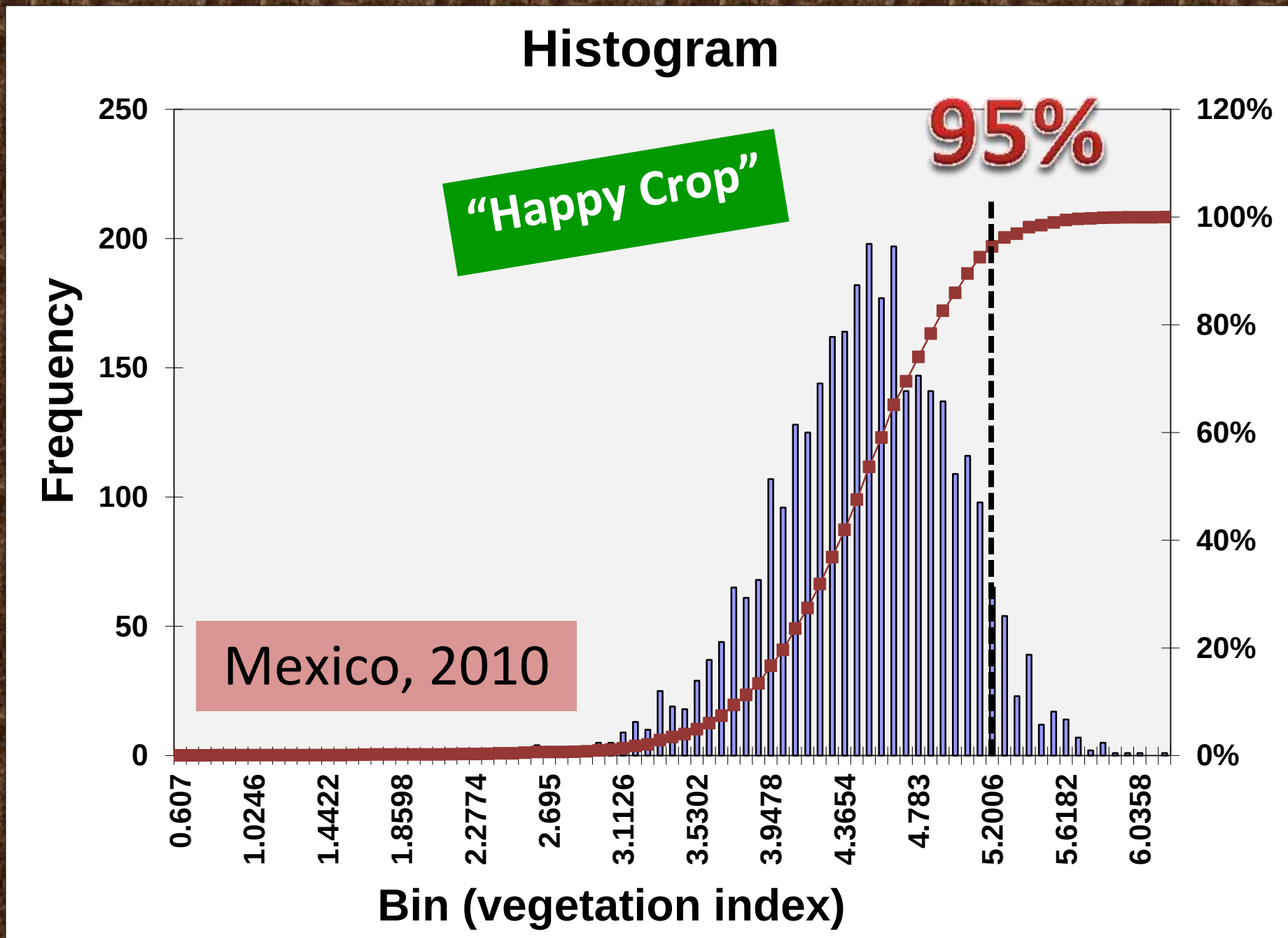
Virtual Reference Concept :

- **N-Rich concept** was developed to calibrate SPAD meter readings in plot studies
- **Excess N** can inhibit mycorrhizal infection of roots
- Corn plants at the V6-V10 growth stage have <30% of N total uptake at harvest, therefore **modest planting-time N** application will provide adequate N at the time of sensing

Strategy :

- Apply 30-50% of typical N fertilizer at or before planting ***(sensing at V6-V10 will not be responsive to soil N availability at higher preplant N* rates)**
- Travel through a field to monitor spatial variability in vegetation index and then construct a histogram to determine reference value ***(extract 95-percentile value)***
- Use **reference vegetation index** value to calculate **sufficiency index (SI)** for all locations in field. The SI value is used to calculate real-time N application rate.


Histogram
250
200
150
100
50
0
120%
100%
80%
60%
40%
20%
0%
Frequency
Mexico, 2010
0.607
1.0246
1.4422
1.8598
2.2774
2.695
3.1126
3.5302
3.9478
4.3654
4.783
5.2006
5.6182
6.0358
Bin (vegetation index)


Histogram
95%
"Happy Crop"
Mexico, 2010
Frequency
250
200
150
100
50
0
120%
100%
80%
60%
40%
20%
0%
0.607
1.0246
1.4422
1.8598
2.2774
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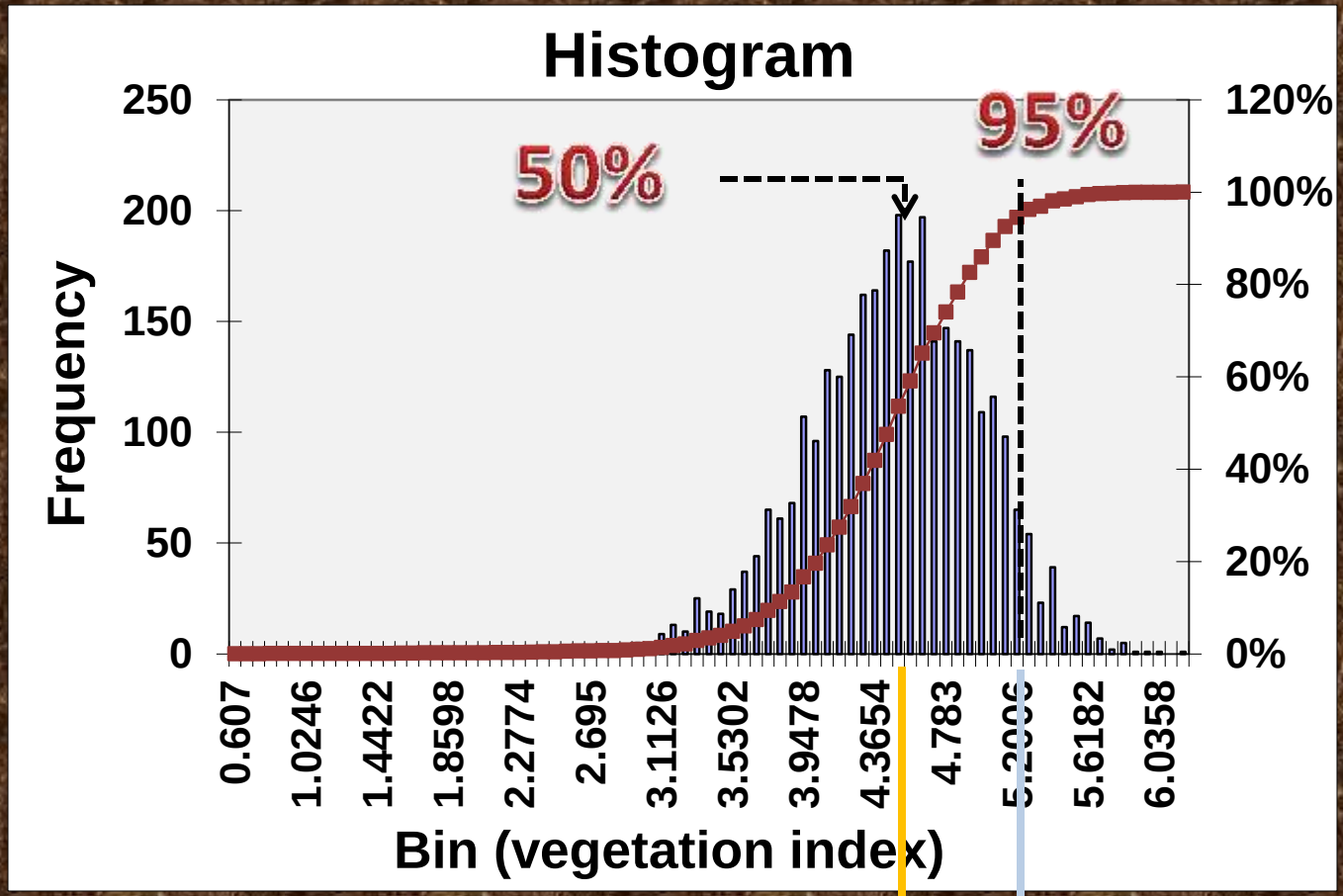
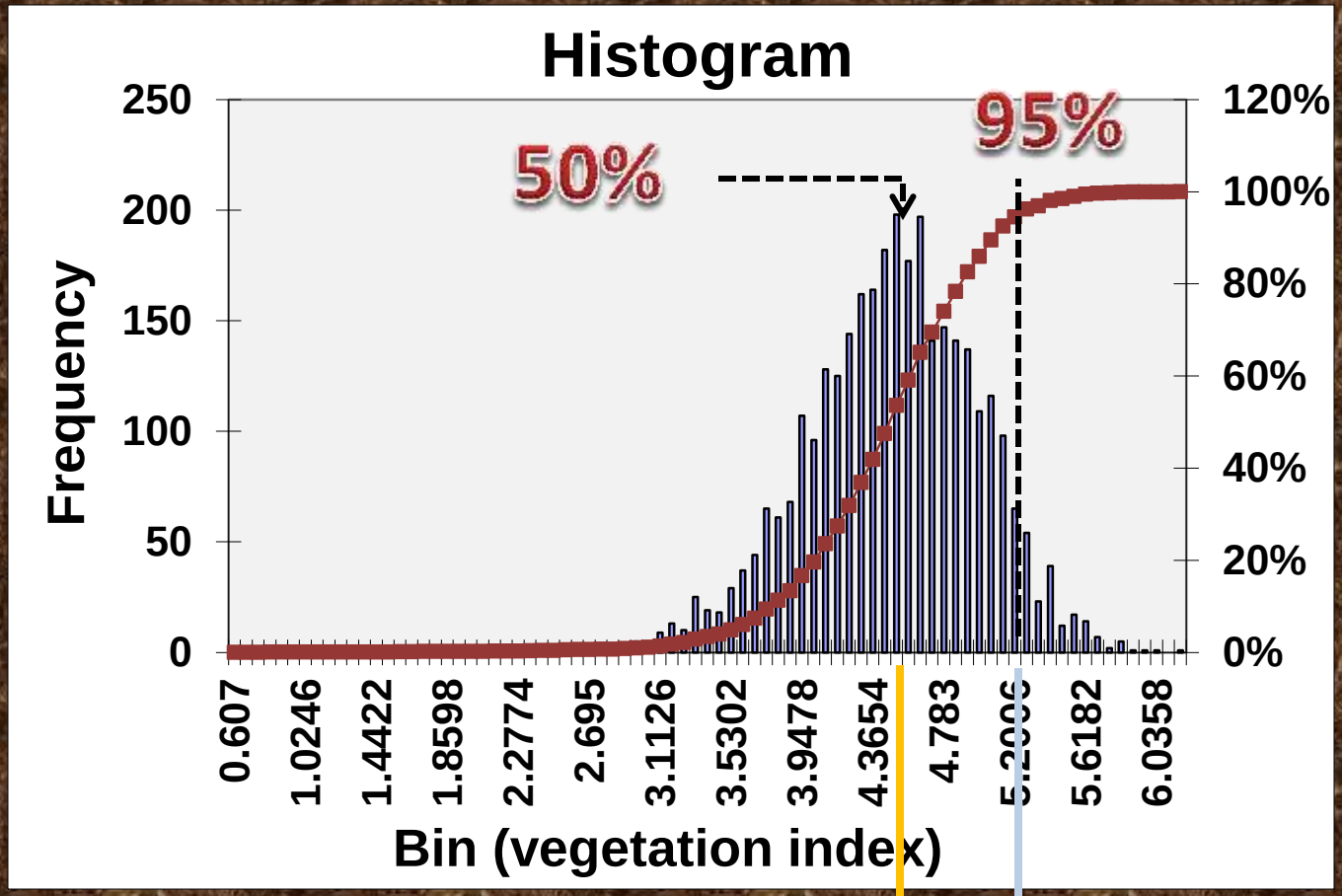


$$SI = \frac{4.47}{5.21} = 0.85$$

" Sufficiency Index "



$$RI = \frac{5.21}{4.47} = 1.17$$

"Response Index "

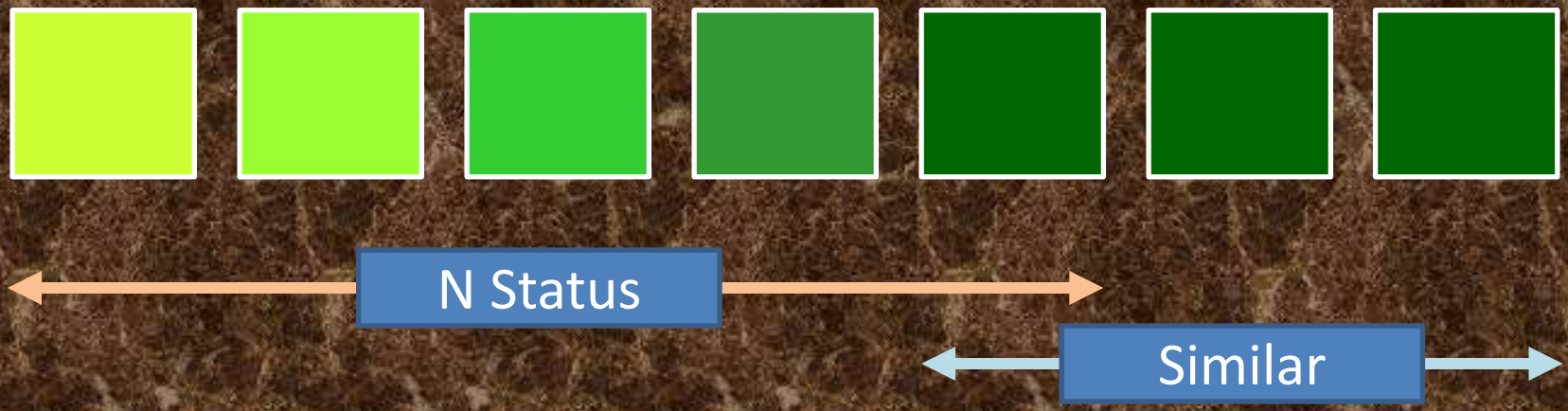
Sensors **only Measure** Bulk Reflectance

- Many factors can influence leaf chlorophyll content -

Remember - - - -

Canopy sensors respond to ***"living biomass"*** and ***"chlorophyll content"***

Treatments / N-rates



Canopy sensors can not quantify excess N

AND

Soil background reduces sensitivity

Attributes of Related Data

Are there grow stage / location / year differences ?

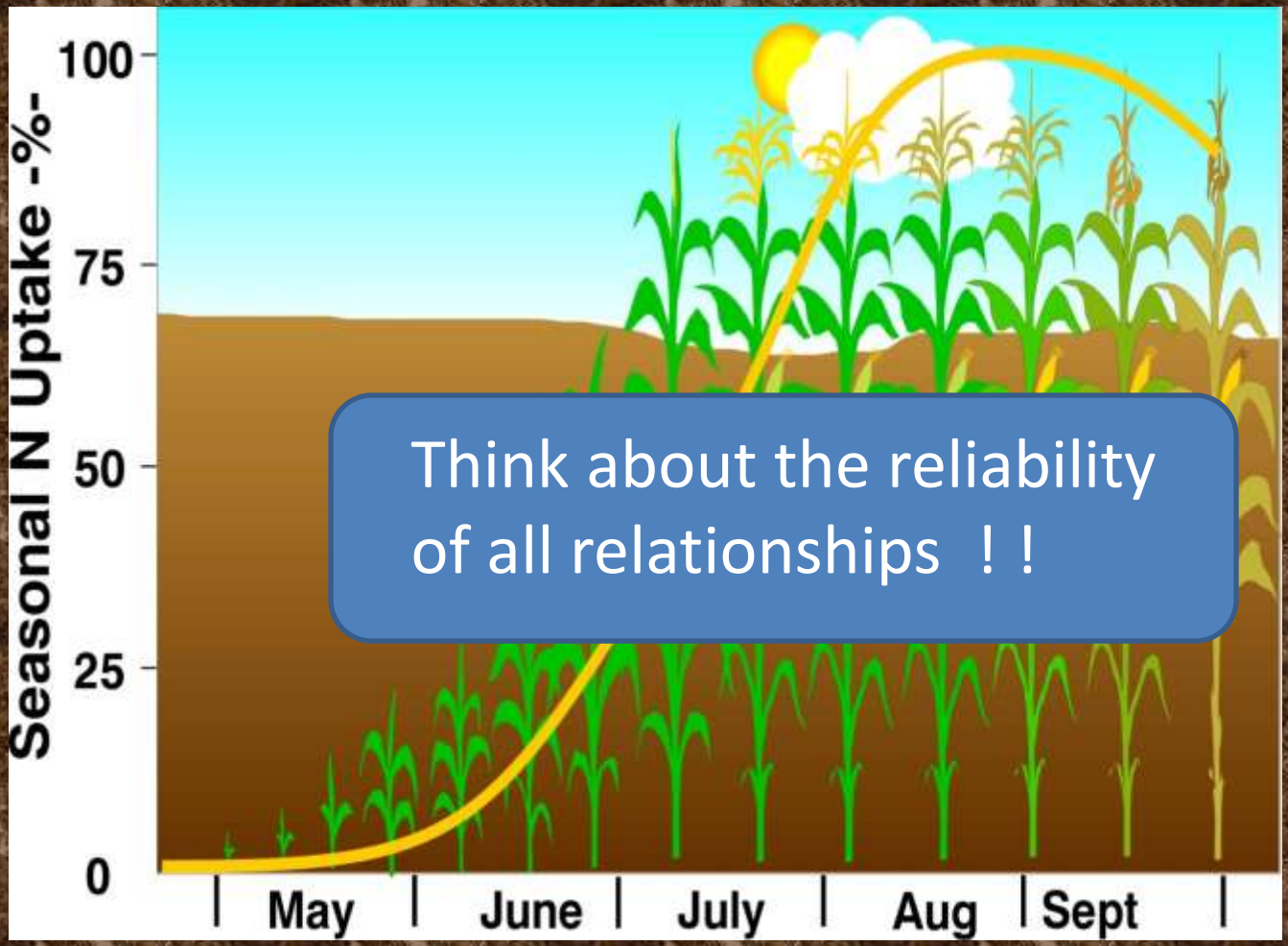
Sensor data

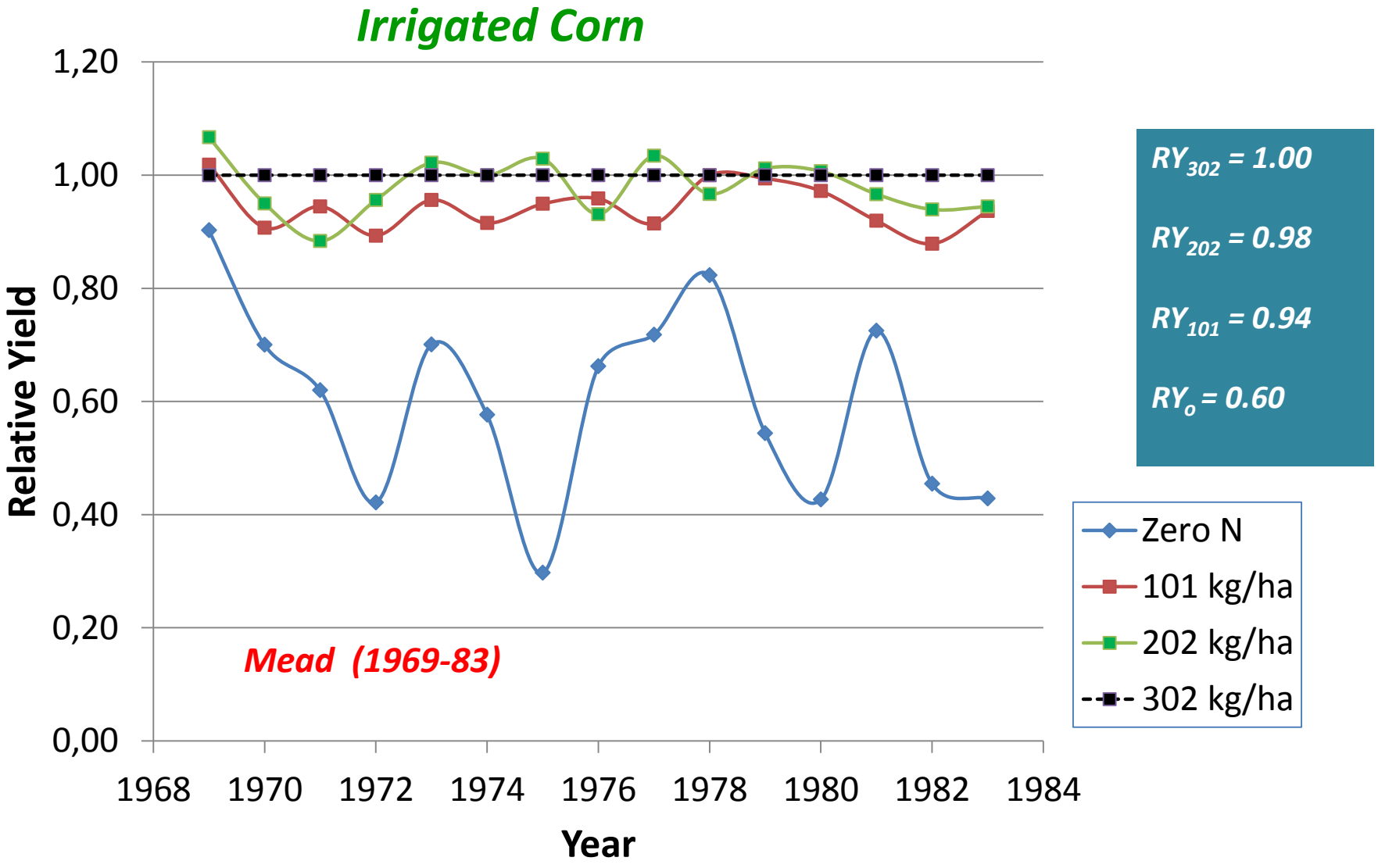
SPAD meter

LAI

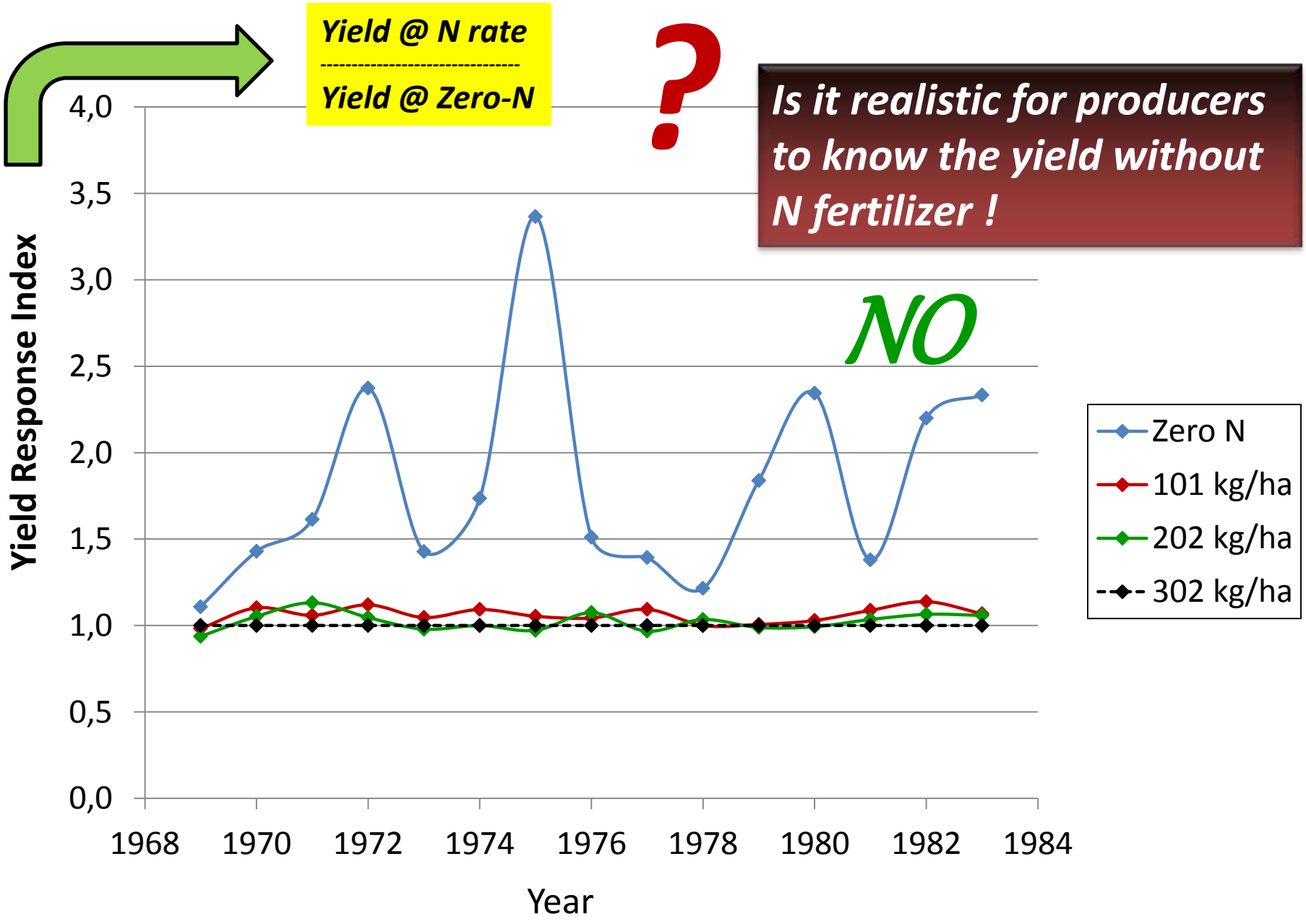
N Uptake

Yield





Conclusion : ***Relative yield*** was generally correlated with N rate, but **varied by year.**



Yield Response Approach *is based on ability to accurately predict yield !*

Role of Precision Agriculture in:

Global Climate Change and *Environmental Issues*

- Nitrous oxide losses to the atmosphere are proportional to residual N (nitrate) concentrations in soil under anaerobic conditions.

  *Where will **mineralization potential** be high (includes manure) ?*

  *Where does **soil texture** facilitate nitrate leaching ?*

therefore

- Plan fertilizer N management strategies to use mineralized soil N first, then supplement with fertilizers.
- Minimize carry-over N in soil after harvest.

however

- Using **denitrification** to reduce nitrate concentrations in leachate (tile drain discharge) and runoff transfers part of the problem to the atmosphere.

N_2 or NO_x

Little Publicized Facts :

- Crops remove CO_2 from the atmosphere during photosynthesis
- Crops release O_2 via photosynthesis

Jim Schepers

402-310-6150

james.schepers@gmail.com