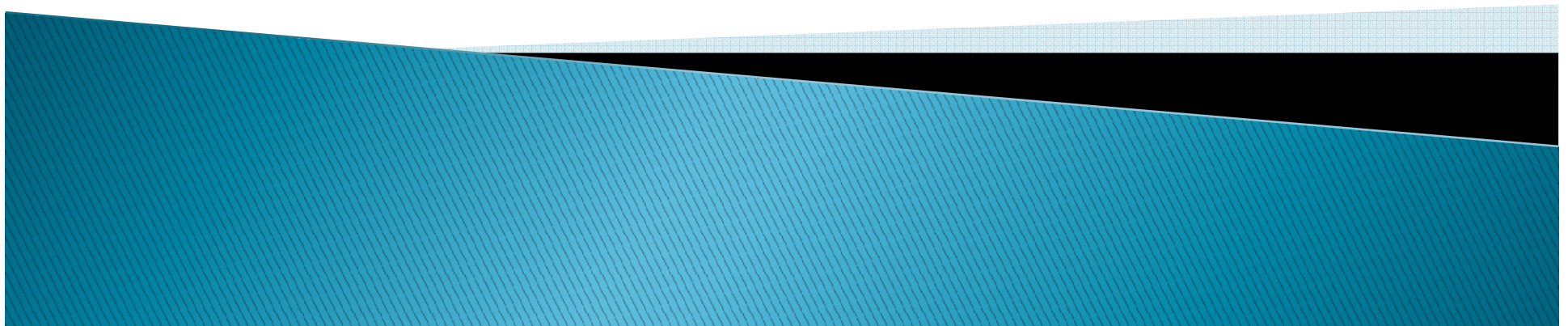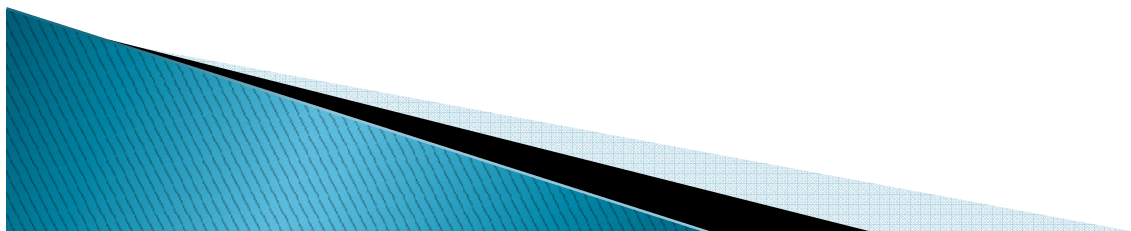# Sensor Algorithms 101

Brian Arnall
Oklahoma State University
Precision Nutrient Management

Algo 101

- Several Sensor Based N Rate Calculations exist.
- There are two distinct approaches to N rate calculations.
- Use of Yield Prediction and Response
- Use of Response only

Algo 101

- This Workshop
- Will walk through the published Algorithms built by 5 institutions. All are used/available in Commercial systems.
- We are not going to compare specific N rates applied.
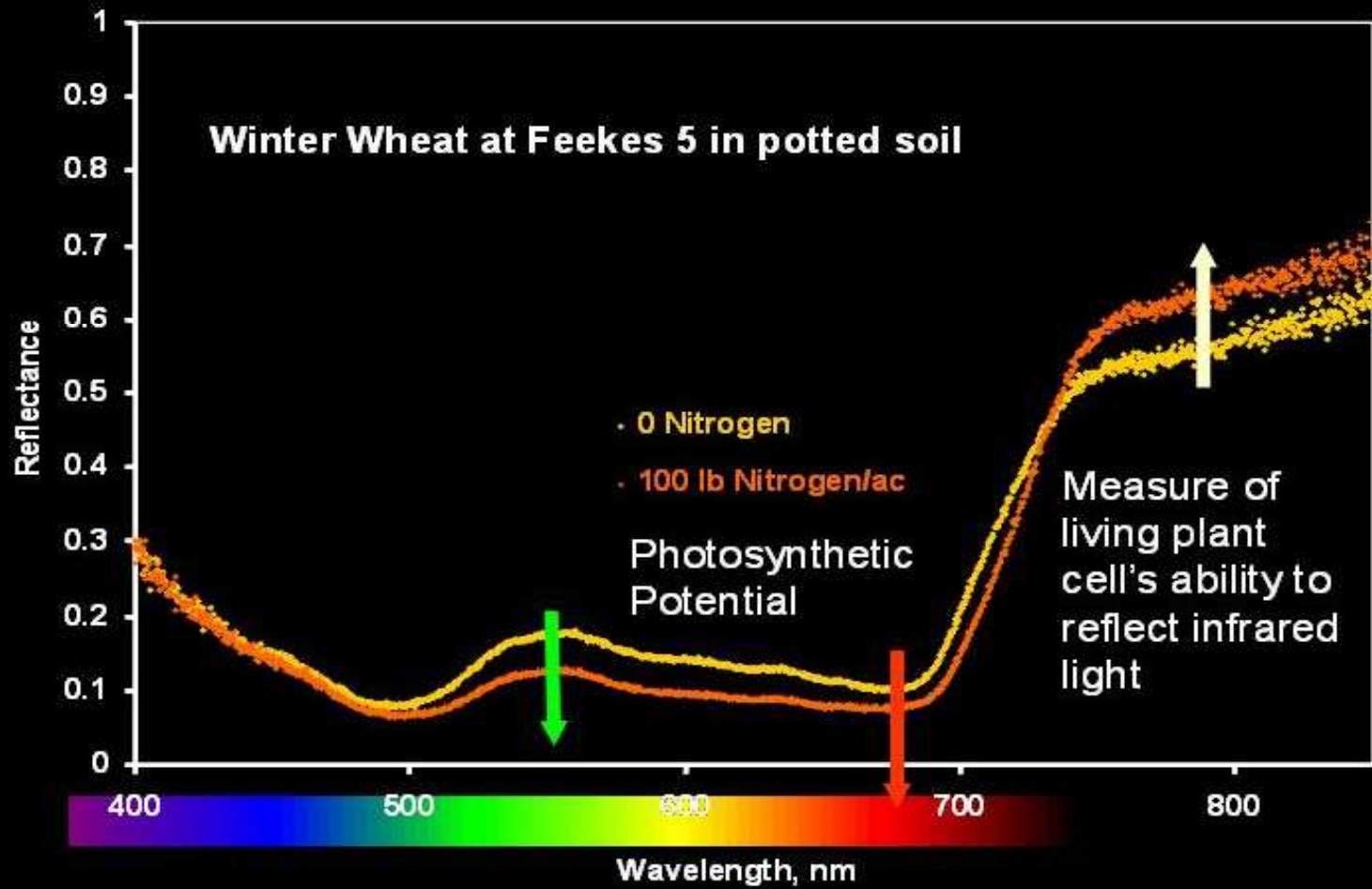- We are going to look and the Metrics and Agronomics behind each.
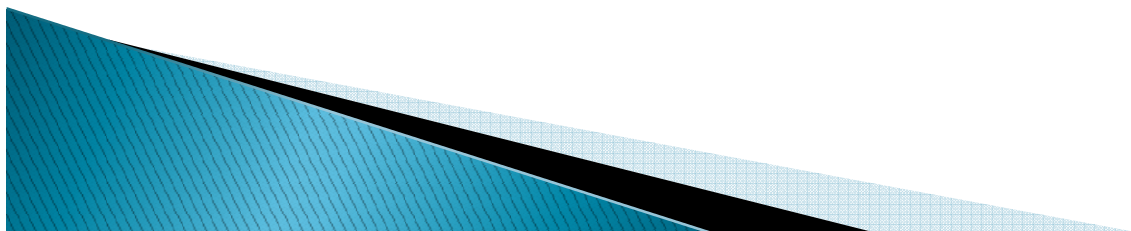
Optical Sensor Values

- NDVI
  - Regardless of sensor is essentially a measure of biomass.
  - NDVI = (NIR-VIS)/(NIR+VIS)
- Simple Ratio
  - SR = NIR/VIS
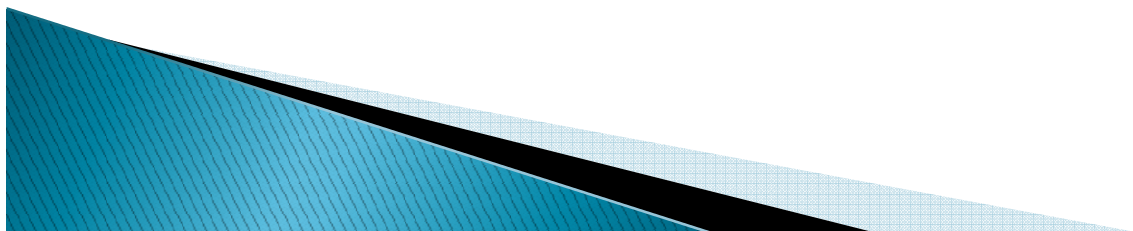- Red-edge: Chlorophyll measurement
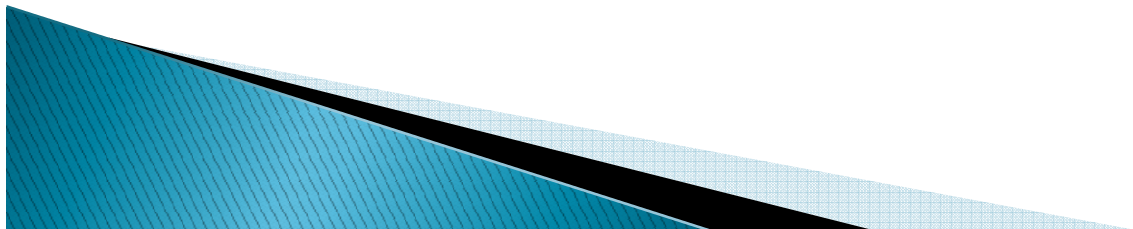
Reflectance

Response

- Response is thought of in two ways.
  - RI: Increase above standard pre-plant high/low >1
    - Increase in yield due to N
    - RI 1.2, Expect an increase in yield of 20% w/ N
  - SI: Percent of high level low/high <1.0
    - Sufficiency of standard practice
    - Typically uses a Base N rate
    - SI of .75, Expected N need 200 FP = 150
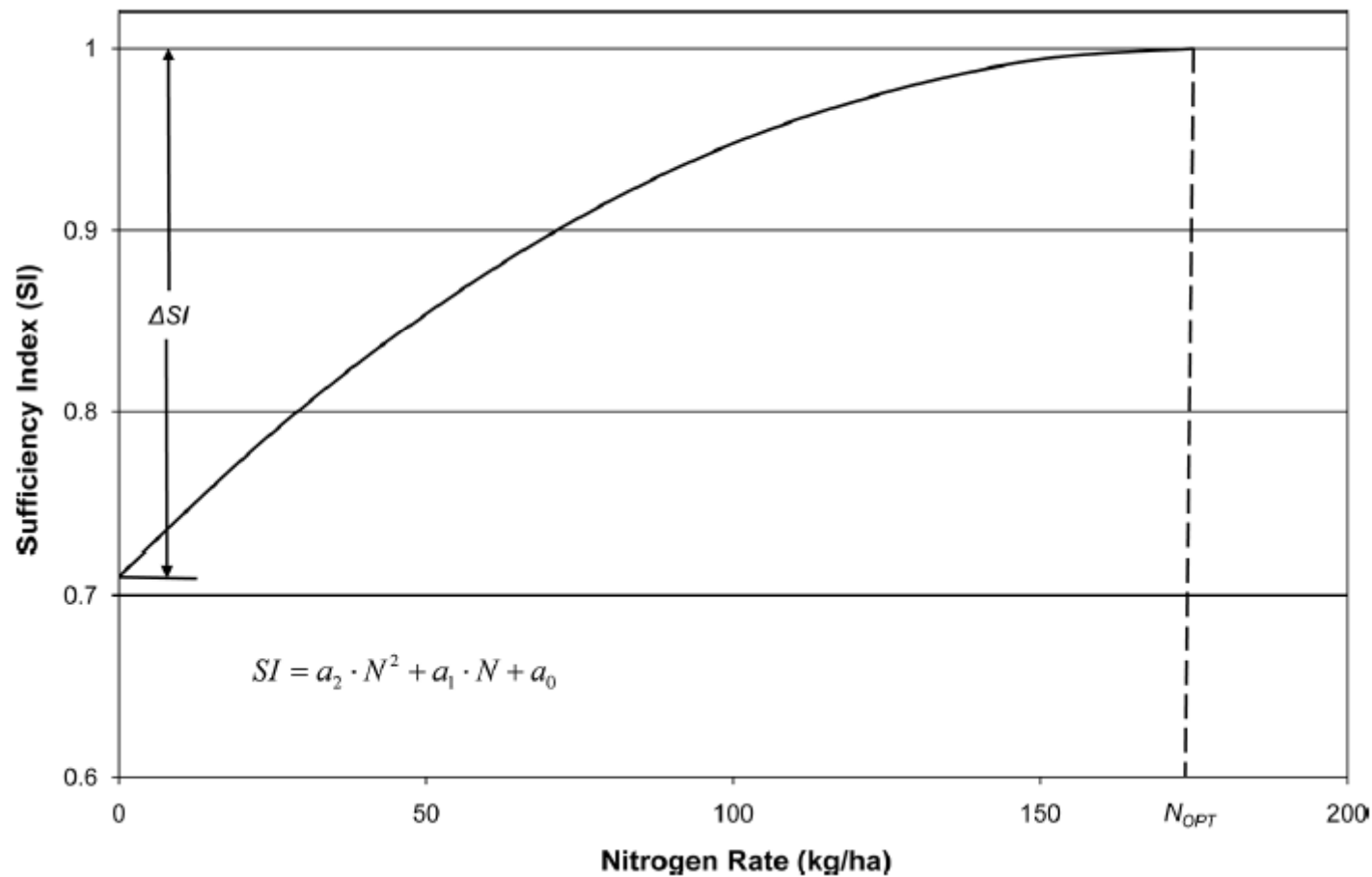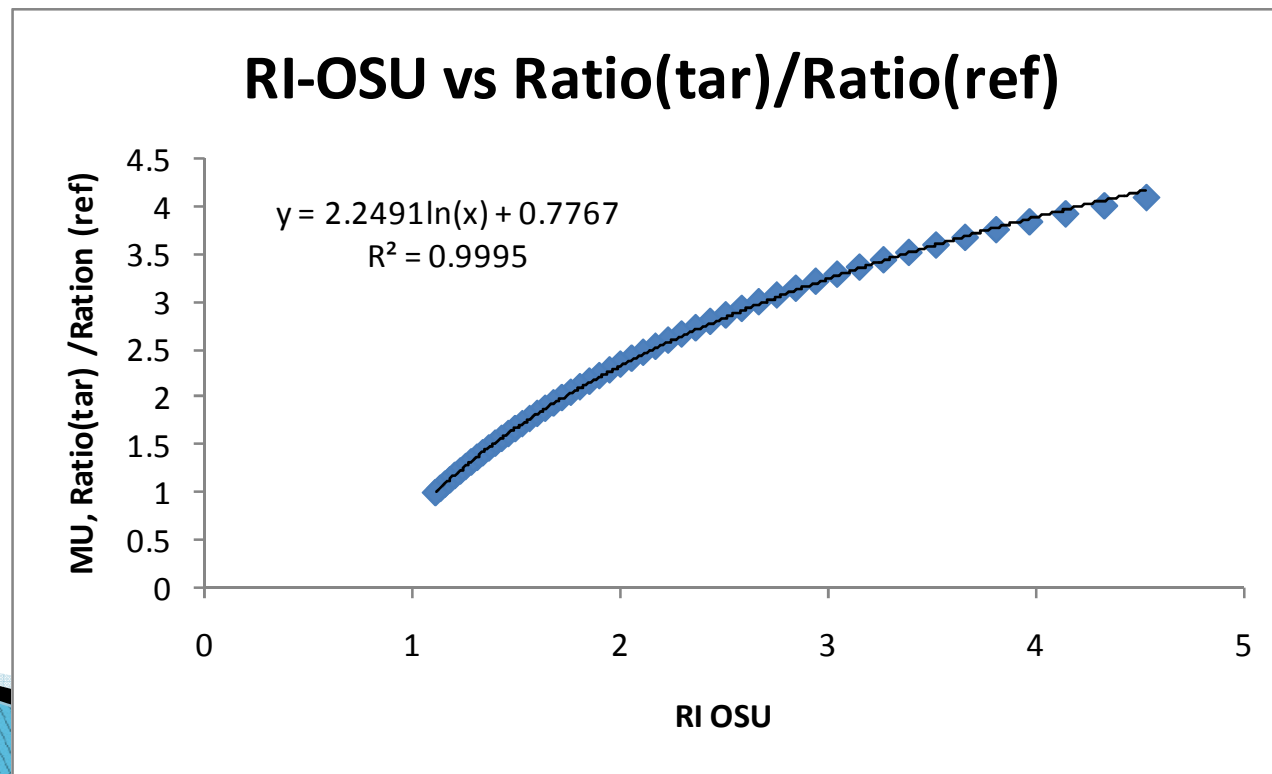- Can be calculated using NDVI or SR

Graph of SI

The equation shown on the graph:

$$SI = a_2 \cdot N^2 + a_1 \cdot N + a_0$$

Axis labels: Sufficiency Index (SI) on the vertical axis; Nitrogen Rate (kg/ha) on the horizontal axis. The curve shows ΔSI and N_{OPT}.

Figure from Holland and Schepers: 2010 Agronomy Journal.

Response

▸ Correlation between OSURI ndvi of RI Ratio

RI-OSU vs Ratio(tar)/Ratio(ref)

$y = 2.2491\ln(x) + 0.7767$
$R^2 = 0.9995$

*MU, Ratio(tar) /Ration (ref)*

RI OSU

RI NDVI and RI Harvest

- A few of the groups have determined that the relationship RI of NDVI and RI of yield is not a 1 to 1 relationship.
- Therefore some algorithms use adjusted RI based on research. Calculation differs across crops and environments (great plains vs east coast).
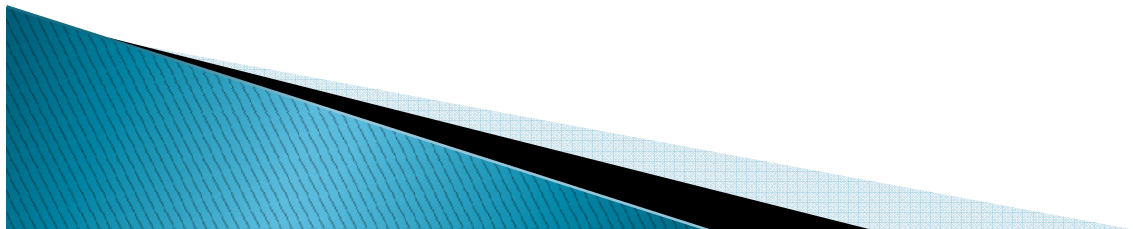
N-Rich / Reference Strip

- **What:** A high rate of N applied in, across, through, over or under each and every field (NR).
- **How Much:** Rate significantly higher than standard practice (Farmer Practice FP).
- **How and Where:** 10 to 100 ft wide, anywhere representative.
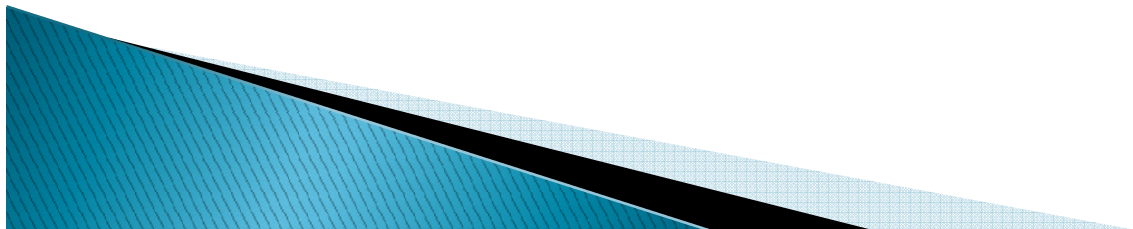- **Timing:** Crop and Environment specific
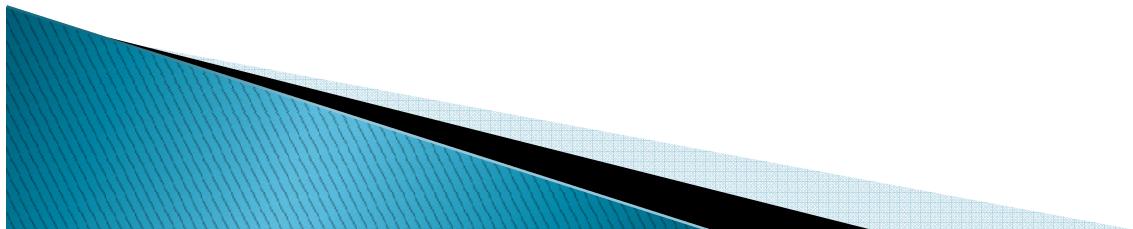
N-Rich / Reference Strip

Zero N Strip Low N

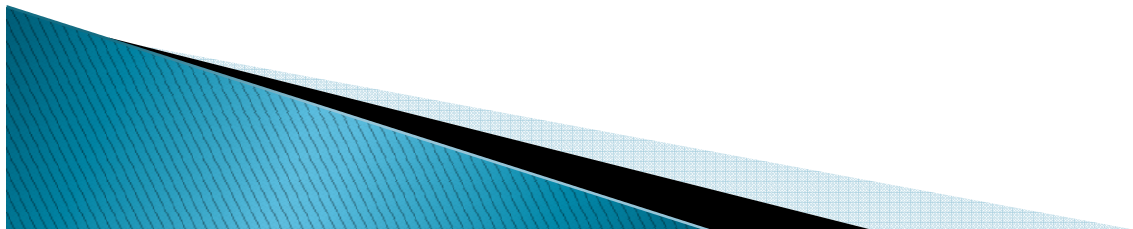- Used in Several areas and algorithms.

RI calcs

- OSU $1.64 * (NR/FP) + .5287$
- tOSU $-1.5926*((1-LN)/(1+LN))/(1-NR)/(1+NR))+2.6557$
- VT NR/LN

Yield with N, YPN

- OSU $YPN*RI$
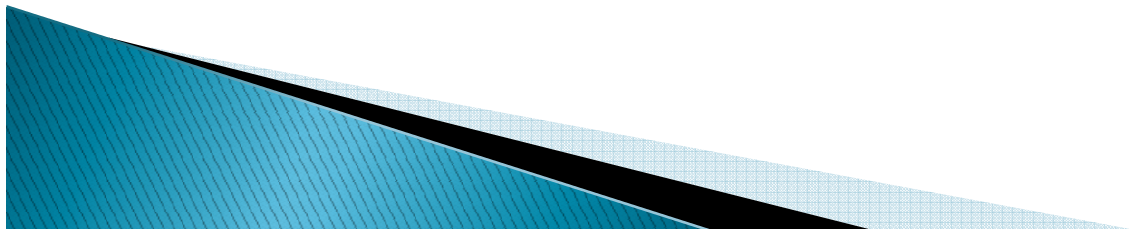- tOSU $20*\exp(-.06 *((1-FP)/(1+FP))*DFP)*100*2.2/56/2.47*YP0$
- VT $3500*\exp((FP*(NR/LN)/DFP$

Virtual RI

- Measurements from the greenest area of the field for N-Rich value
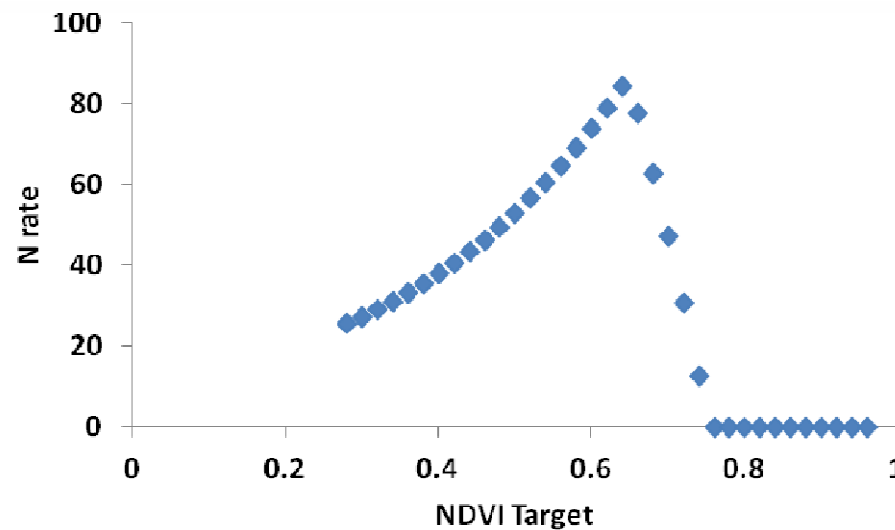- Used with SI on On-The-Go sensors.

- http://www.agleader.com/products/directcommand/optrx/

Yield with N YPN

- OSU YPN*RI
- tOSU $20 \cdot \exp(-.06 \cdot ((1-FP)/(1+FP)) \cdot DFP) \cdot 100 \cdot 2.2/56/2.47 \cdot YP0$
- VT $3500 \cdot \exp((FP \cdot (NR/LN)/DFP$

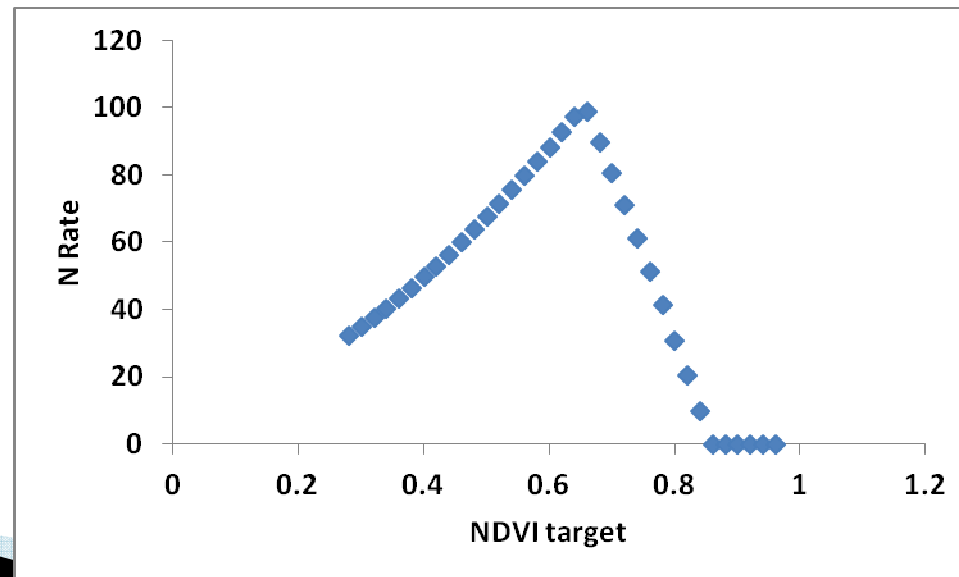# OSU/Canada/KSU/LSU

- Uses Yield Prediction and RI (OSU) in ex.
- If (YP0*RI<YPNR, YPN*RI, YPNR)-YP0 *56lb/bu *.0125 %N / .60%NUE

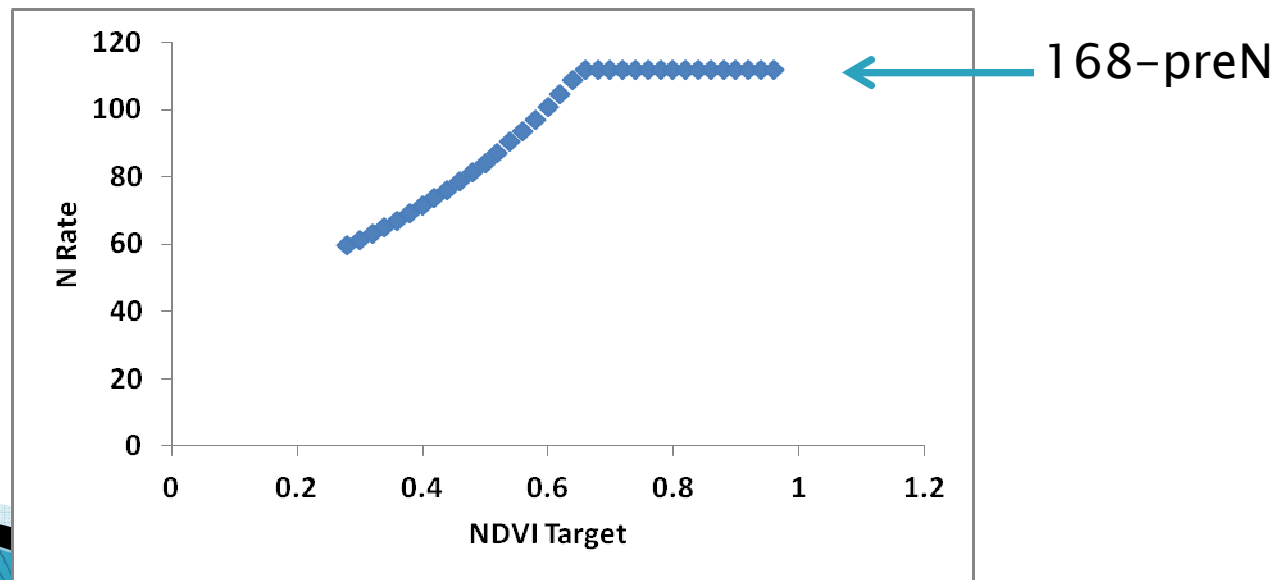# The OHIO State tOSU

- Uses Yield Prediction and RI(tOSU) LowN
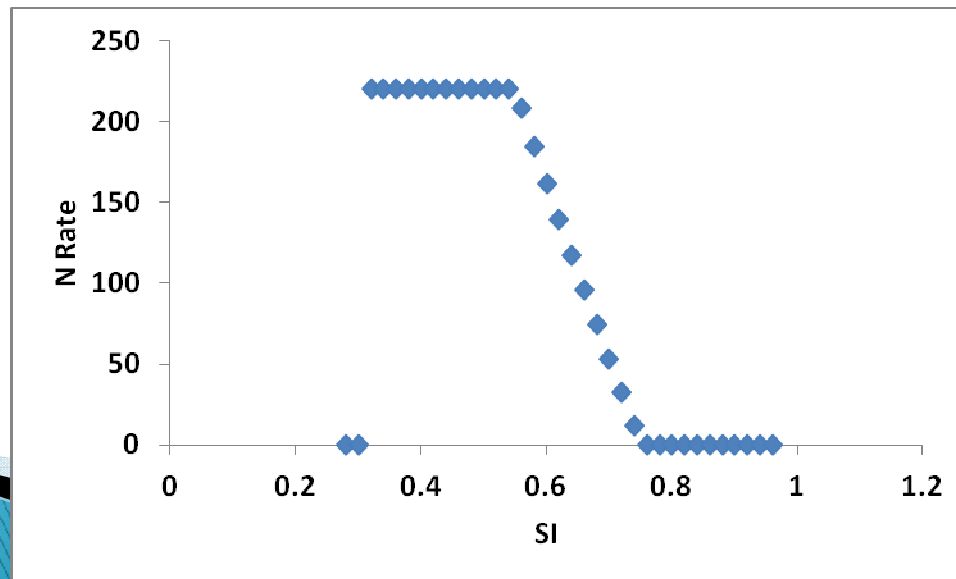- Min: (YP0*RI, Max Yld) – YP0 *65*.0125/.60

Virginia Tech

- Uses Yield Prediction and RI(tOSU) LowN
- Min {((.0125/.6)*(YPN–YP0)+100–PreN)), 168–PreN} 100=Sidedress Base Rate 168= Max N.

U of Missouri

- Sufficiency Index and Max N
- Min ((Max N-SI)-Index Ceiling, Max N)
  - Max N Changes by stage V6-V7 & V8-V10
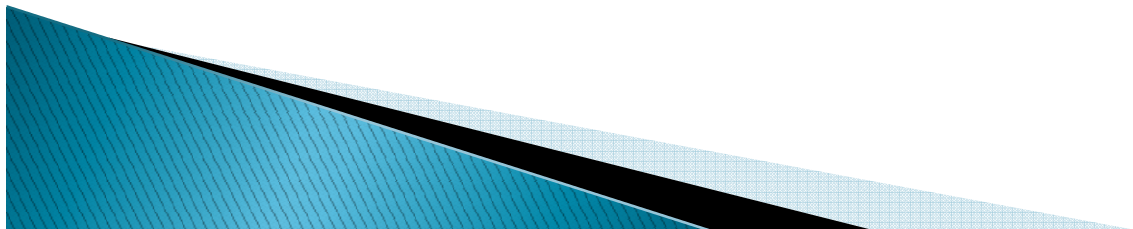 - Index Ceiling change by sensor and stage

Min SI used in GS

UNL Solari

- Uses SI and Optimum N Rate
- Based on a Chlorophyll Meter Algo.
- Min(317*SPRT(.97-SI), OptN)
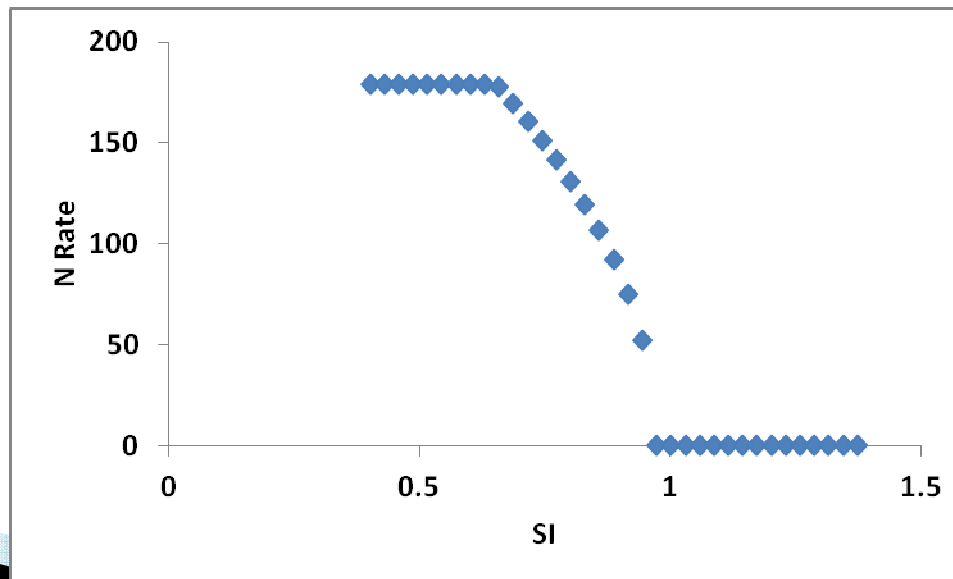
Holland Sci

- SI, Delta SI, Nopt
- (OPTN-Npre-Ncred+Ncomp)*

SQRT (1-SI)/(Delta SI *(1+.1*exp (backoff* (SIthreshold-SI))

  ◦ Delta SI is .3+/-.1 or FP/RI
  ◦ Backoff 0,10, 20, 50. controls N dec w/ dec SI
    • Adjust based on ability of crop to recover.
  ◦ SI theshold .7

Back off
None
Intermediate
Aggressiv
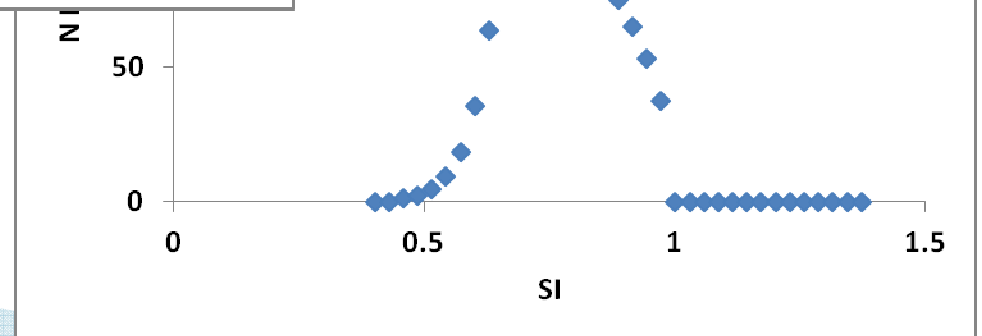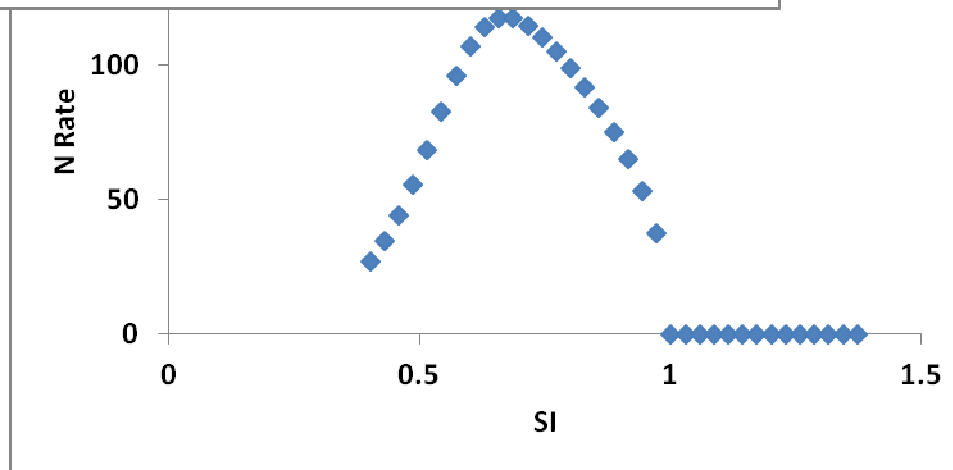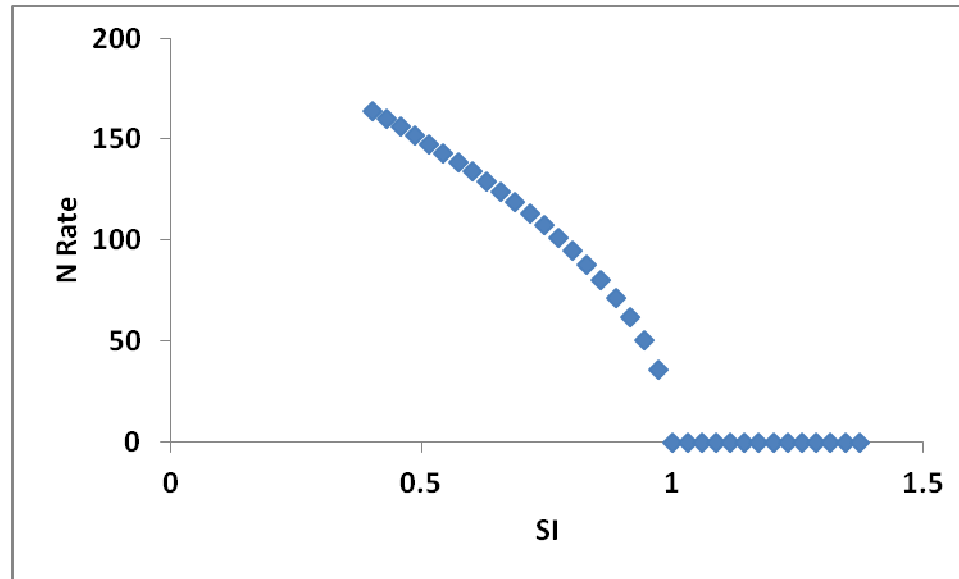
References

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- Holland and Schepers. 2010. Derivation of a variable rate nitrogen application model for in-season fertilization of corn. Agron. J. V102 5:1415-1424
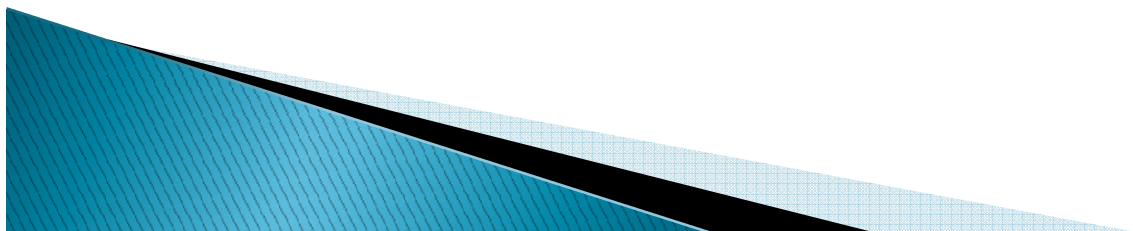
Thank you!!!

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Facebook Fan Page
www.facebook.com/osunpk
YouTube Channel: OSUNPK