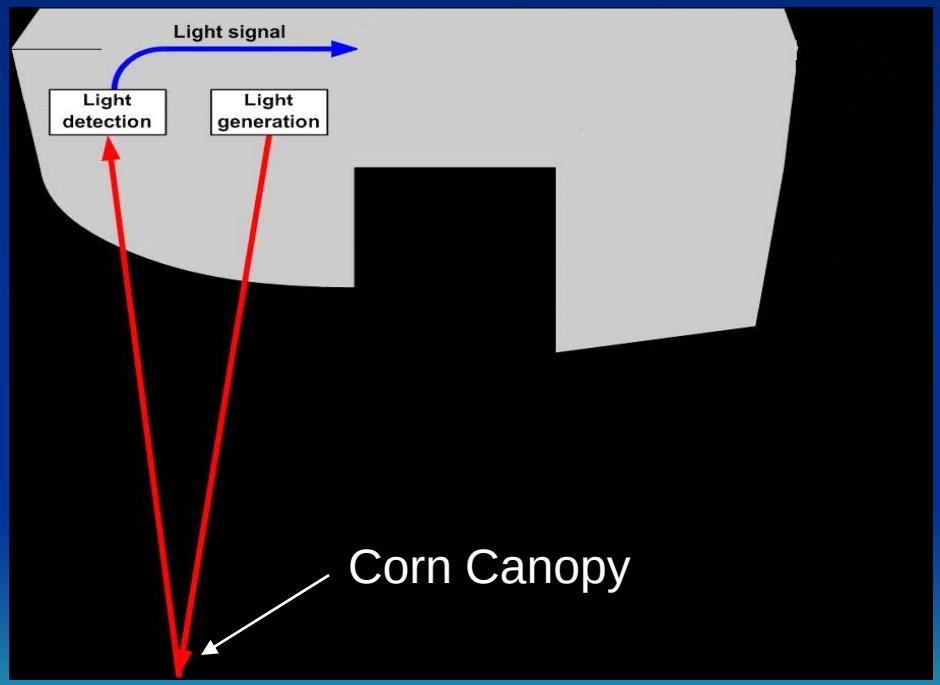
Active remote sensors to assess N status of corn and correlation with grain yield

T.M. Shaver, R. Khosla, and D.G. Westfall
Department of Soil and Crop Sciences
Colorado State University, Fort Collins, Colorado, USA.

- An important component of precision farming is identifying in-field variability.
- Remote sensing can determine N variability using Normalized Difference Vegetation Index (NDVI).
- NDVI correlates to leaf area index and green biomass, and is sensitive to photosynthetic efficiency.
- Several different ground based sensors are available.

Normalized Difference Vegetation Index (**NDVI):**

$$NDVI = \frac{\text{Near Infrared Band Reflectance} - \text{Visible Band Reflectance}}{\text{Visible Band Reflectance} - \text{Near Infrared Band Reflectance}}$$



Colorado State University

- The objective of this study was to evaluate the effect of :

  -Nitrogen fertility level (applied UAN N rate)

  -Plant growth stage

On the NDVI readings of three ground based remote sensors in corn under greenhouse & field conditions.

And to determine if NDVI readings and/or other ancillary variables were correlated with corn grain yield therefore aiding in N requirement estimates.

Colorado State University

Greenhouse Study:

Sensors:

NTech's GreenSeeker™ red and green units

Holland Scientific's Crop Circle™

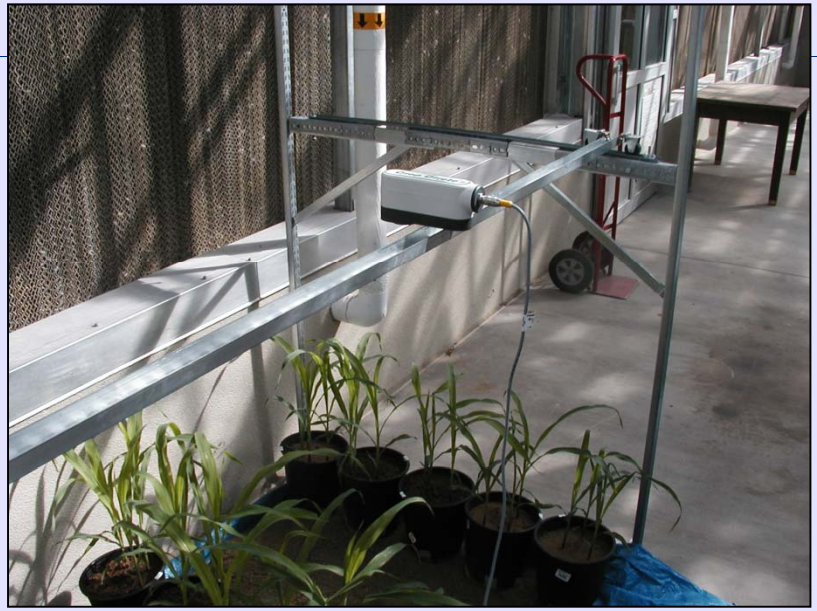
Readings at growth stages:	N rates (lbs/ac):
V8	0
V9	75
V10	150
V11	225
V12	

Colorado State University

Greenhouse Study:

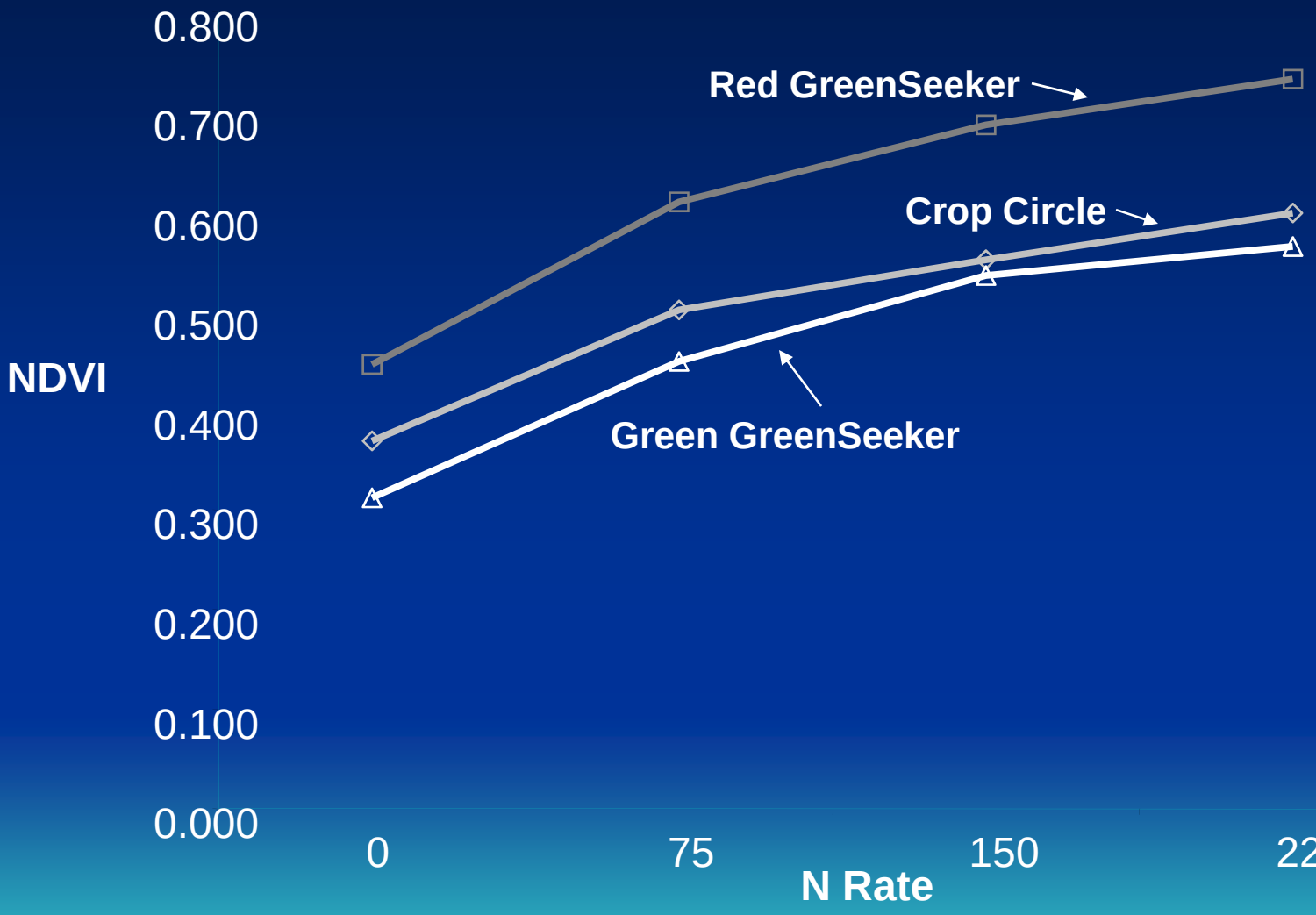
Colorado State University

Greenhouse Results



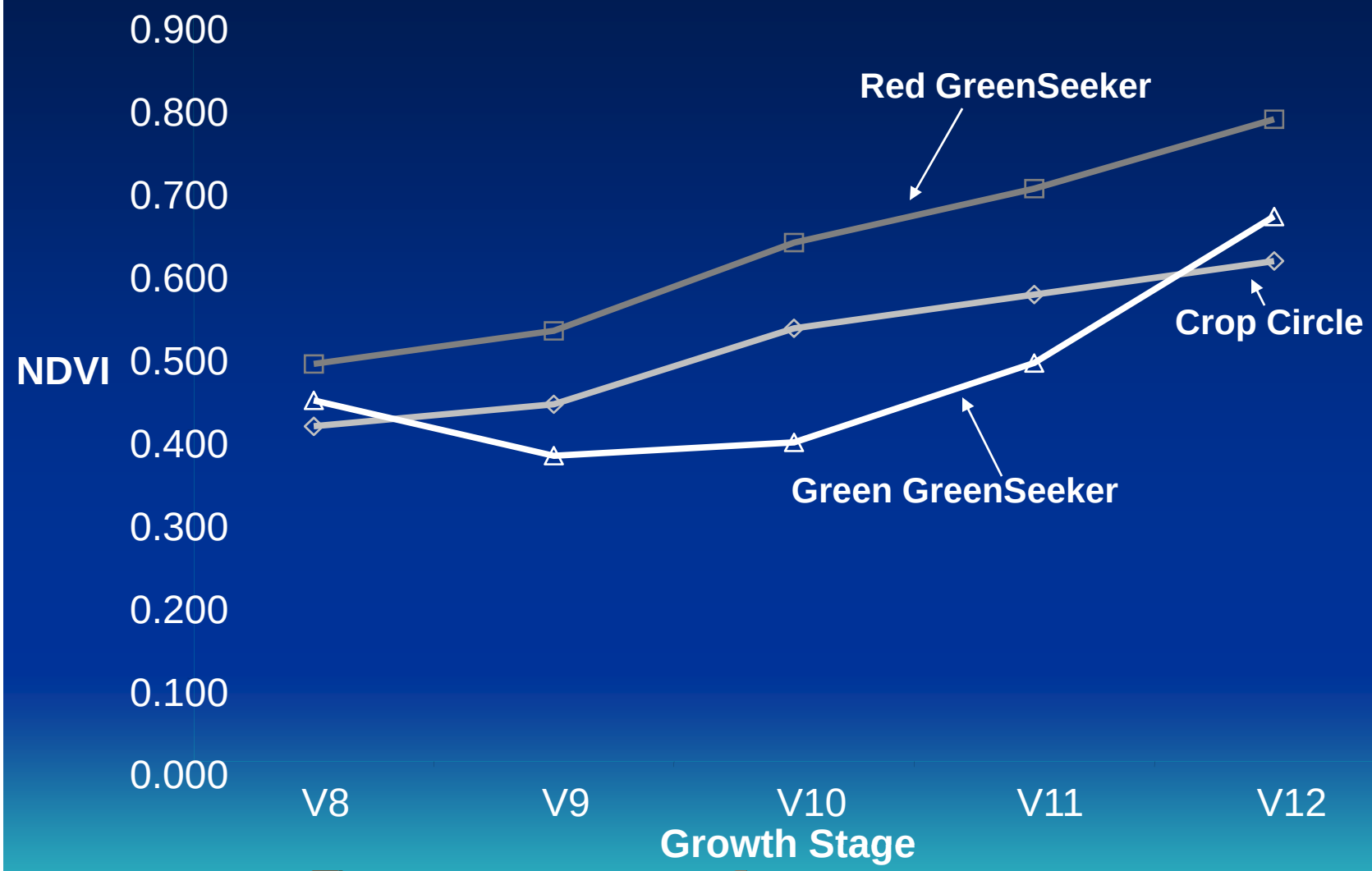
Colorado State University

Sensor NDVI by N Rate:



Colorado State University

Sensor NDVI by growth stage:



Colorado State University

Greenhouse Summary:

- Crop Circle™ and Red GreenSeeker™ sensors:

  -NDVI readings correlated with N rate and growth stage and were significantly different at each level.

- Green GreenSeeker™ sensor:

  -NDVI readings were significantly different and correlated with N rate.

  -NDVI readings did not correlate with growth stage.

Field Study:

Sensors:

NTech's GreenSeeker™ red and green units

Holland Scientific's Crop Circle™

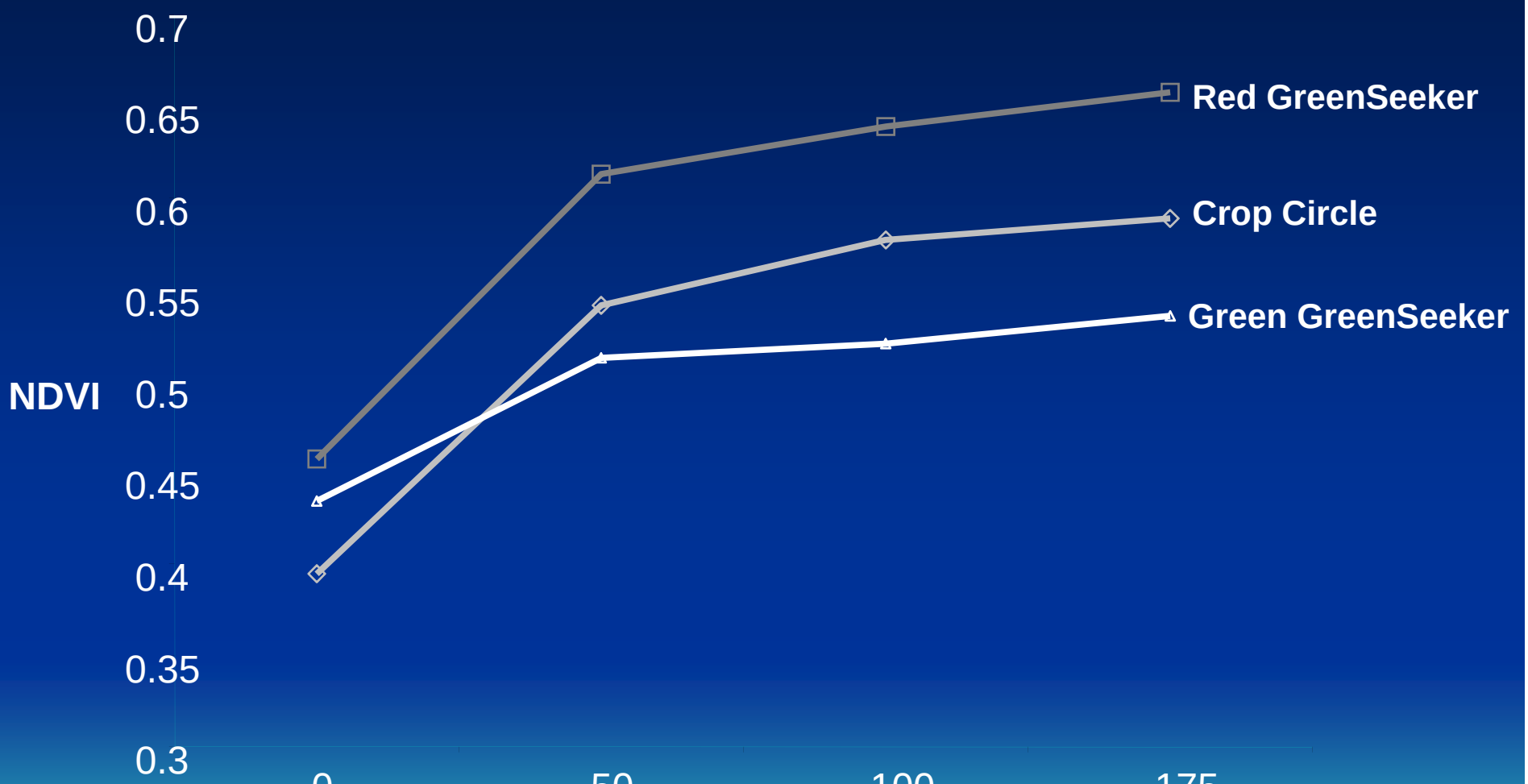
Readings at growth stages:	N rates (lbs/ac):
V8	0
V10	50
V12	100
V14	175

Colorado State University

Field Results

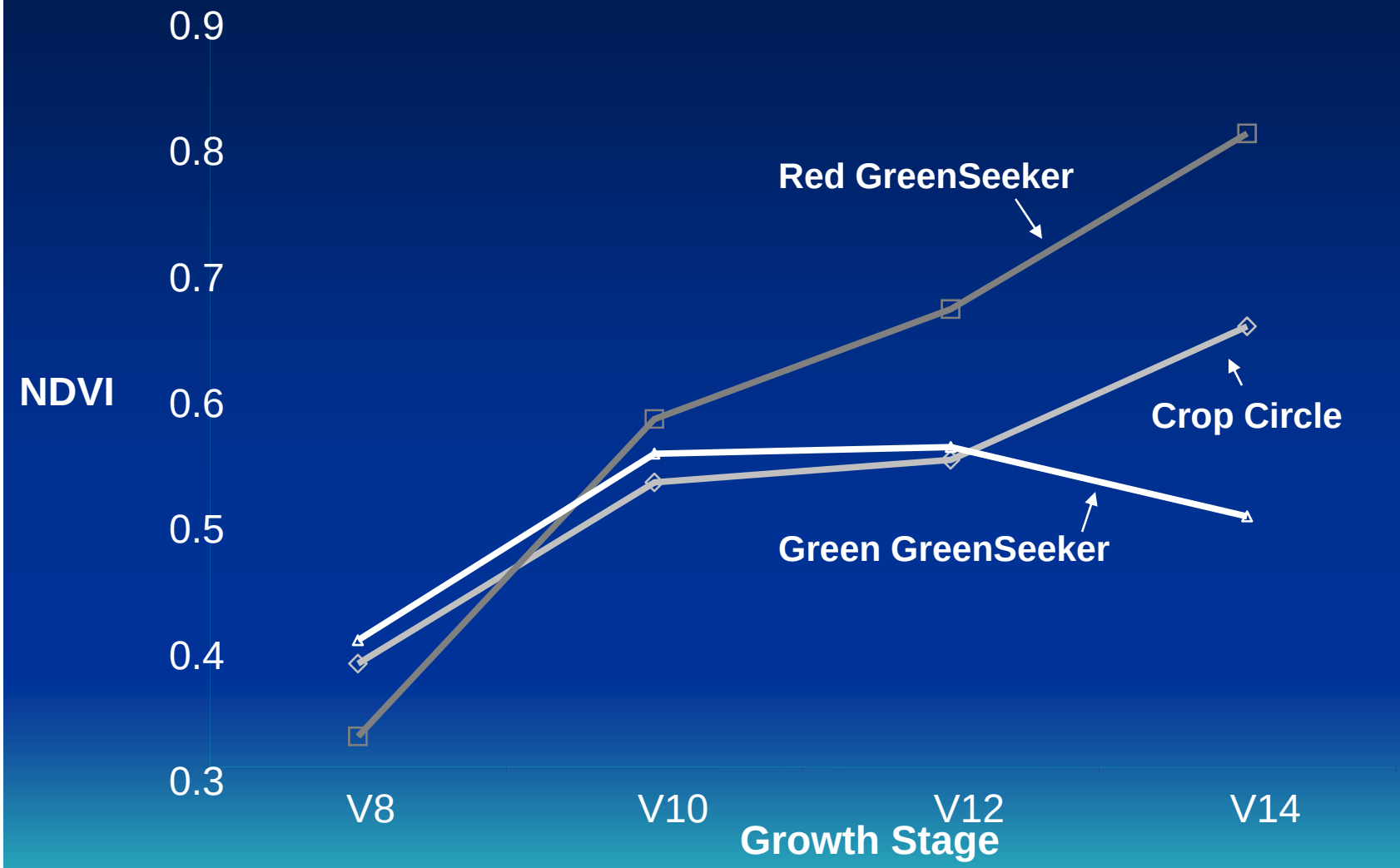
Colorado State University

Sensor NDVI by N Rate:



Colorado State University

Sensor NDVI by growth stage:



Colorado State University

Field Study Summary:

- Crop Circle™ sensor:

  -NDVI was significantly different and correlated with all N rates.

  -Sensor did not significantly distinguish V10 and V12 growth stages.

- Red GreenSeeker™ sensor:

  -NDVI was significantly different and correlated with all N rates and growth stages.

Colorado State University

Field Study Summary:

- Green GreenSeeker™ sensor:

  -NDVI was only significantly different when comparing the 0 lbs/ac N rate. The sensor did not differentiate the 50, 100, or 175 lb/ac rates.

  -Sensor did not significantly distinguish V10 and V12 growth stages and there was a significant drop in NDVI at the V14 growth stage.

Ancillary Sampling:

- Soil N concentration by N rate and growth stage (0-8 inch depth)
- Plant leaf N concentration by N rate and growth stage (most mature leaf) and chlorophyll content (SPAD)
- Plant height by N rate and growth stage
- Corn grain yield (plot combine with yield monitor)

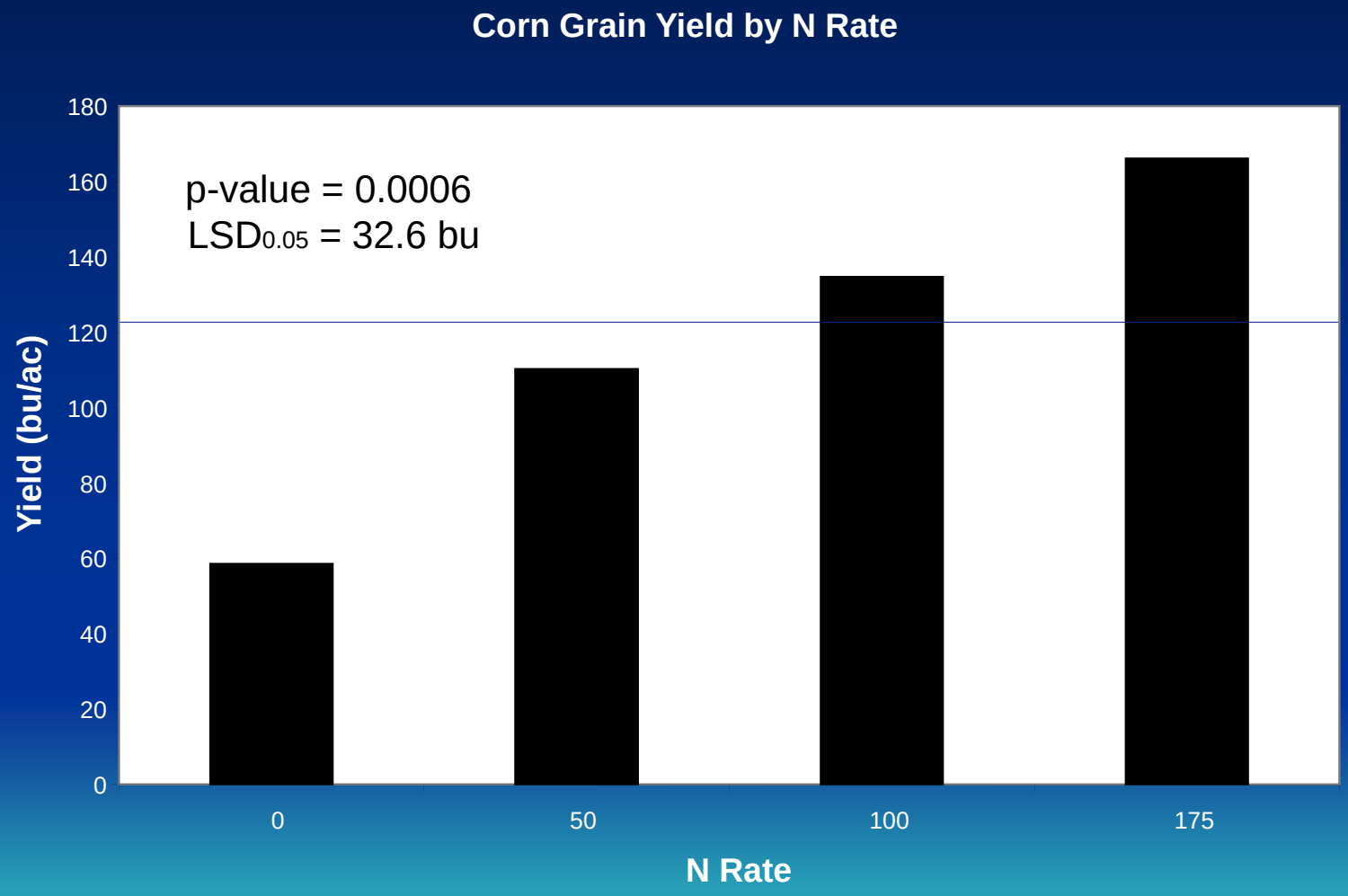
Colorado State University

Analysis:

- Stepwise regression of:
  - Sensor NDVI (Red GreenSeeker and Crop Circle)
  - Soil N content
  - Plant leaf N concentration
  - Leaf chlorophyll content
  - Plant Height

With corn grain yield to determine correlation

Corn Grain Yield:



Colorado State University

V8 Corn Growth Stage:

Correlation With Yield:	R-square
Crop Circle NDVI	0.51
GreenSeeker (Red) NDVI	0.49
SPAD	0.39
Soil N	0.31
Leaf N	0.64
Plant Height	0.45
Multiple Regression	----------

Colorado State University

V10 Corn Growth Stage:

Correlation With Yield:	R-square
Crop Circle NDVI	0.59
GreenSeeker (Red) NDVI	0.66
SPAD	0.59
Soil N	0.05
Leaf N	0.74
Plant Height	0.62
Multiple Regression	----------

Colorado State University

V12 Corn Growth Stage:

Correlation With Yield:	R-square
Crop Circle NDVI	0.69
GreenSeeker (Red) NDVI	0.66
SPAD	0.57
Soil N	0.10
Leaf N	0.74
Plant Height	0.49
Multiple Regression	0.84 (Soil N + Leaf N)

Colorado State University

V14 Corn Growth Stage:

Correlation With Yield:	R-square
Crop Circle NDVI	0.71
GreenSeeker (Red) NDVI	0.75
SPAD	0.43
Soil N	0.27
Leaf N	0.50
Plant Height	0.61
Multiple Regression	----------

Colorado State University

Correlation Summary:

- NDVI and soil & crop variables generally respond linearly to applied liquid N fertilizer rate.
- No multiple regression improved the R^2 for leaf N at the V8, V10, and V12 growth stages or the NDVI R^2 at the V14 growth stage.
- Leaf N and NDVI explained a significant portion of the variability in grain yield but not a high enough level to use for in-season N requirement estimates.
- This study provides a good ground work for successive studies attempting to increase the accuracy of N estimates in corn.

Colorado State University

Overall Conclusions:

- The red GreenSeeker™ was very effective showing significant differences across all growth stages and each level of N fertility.
- The Crop Circle™ sensor was also effective in distinguishing variability across N rates but did not show significant in-field differences between the V10 and V12 corn growth stages.
- The green GreenSeeker™ unit did not correlate with growth stages or applied N rate.

Colorado State University

Overall Conclusions:

- NDVI and soil & crop variables such as leaf N content and plant height explained a significant portion of the corn grain yield variability and respond to applied N rate linearly.

- However, the correlations were not great enough to increase N need estimates for optimal corn growth.

Colorado State University

Questions

???

Colorado State University

Thank You

Tim Shaver
timothy.shaver@colostate.edu

Raj Khosla
raj.khosla@colostate.edu

Dwayne Westfall
dwayne.westfall@colostate.edu

Colorado State University