Use of Optical Sensors in Nutrient Management

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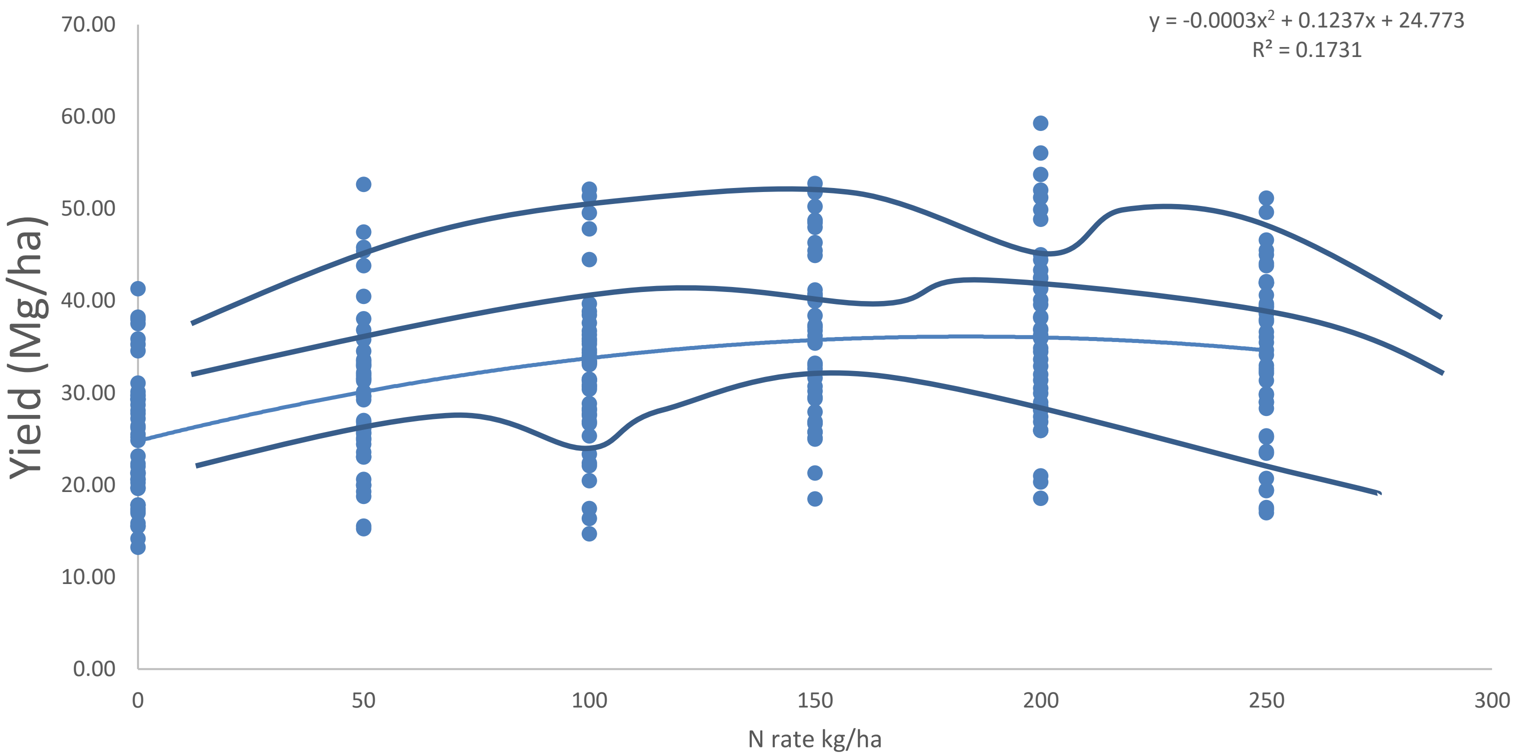
ROLE OF NITROGEN

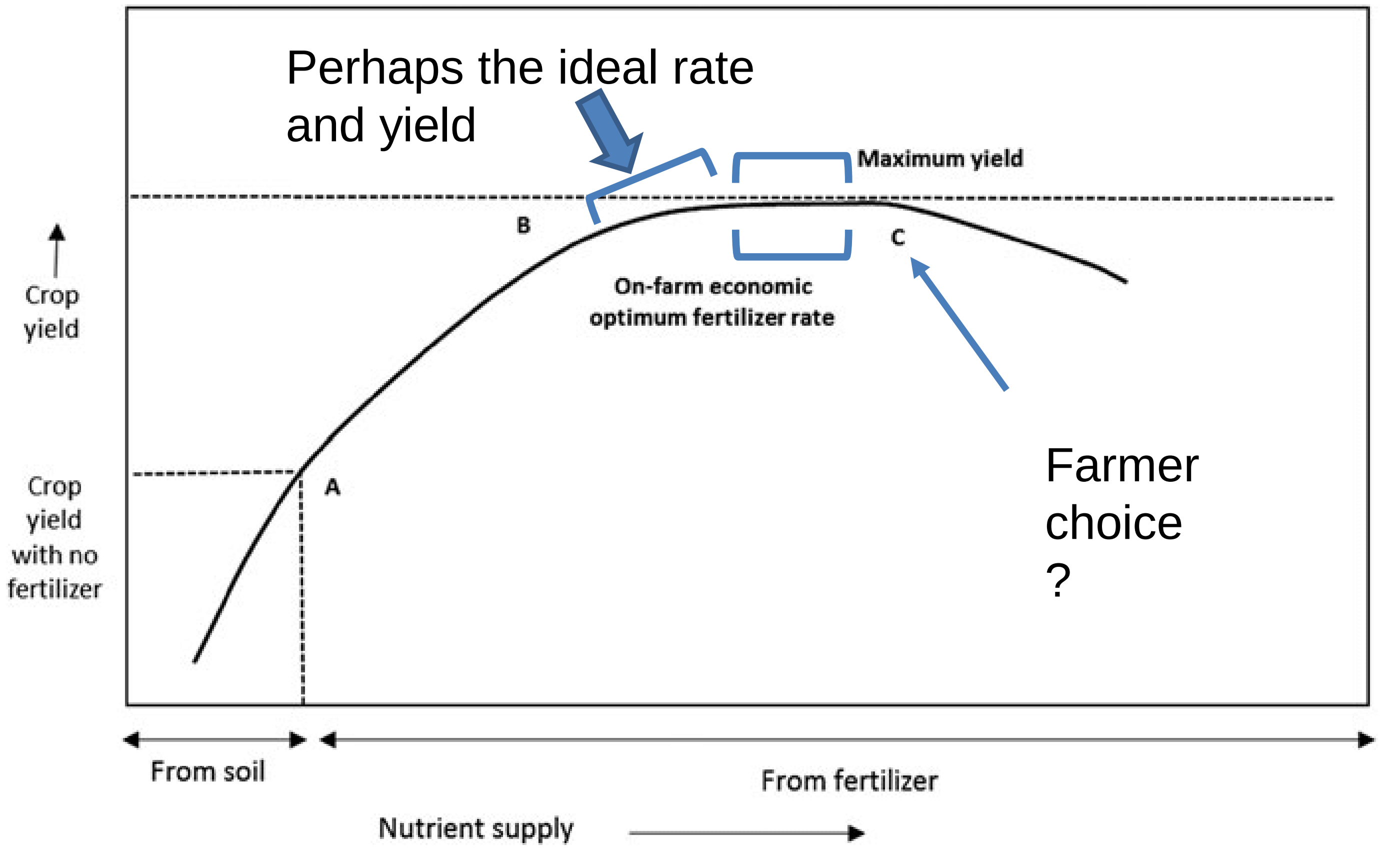
- Structural, genetic and metabolic compounds
- Amino acids
- Enzymes
- Part of chlorophyll, Photosynthetic activity
- Yield

Current Recommendation

- **Current Recommendation**
  - Yield expectations
  - Modified by soil test nitrate analysis before planting
  - Crops that typically have an N benefit if corn follows them in the rotation.
- **Recommendation omits**
  - Regional climate
  - Cultural practices.
  - Temporal variability
  - Spatial Variability



y = -0.0003x2 + 0.1237x + 24.773
R² = 0.1731
Yield (Mg/ha)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
50
100
150
200
250
300
N rate kg/ha


Perhaps the ideal rate and yield
Maximum yield
B
C
On-farm economic optimum fertilizer rate
Crop yield
Farmer choice ?
Crop yield with no fertilizer
A
From soil
From fertilizer
Nutrient supply

N Rate Calculator

Select Region — ◉ Central Aroostook ○ North Aroostook

Organic Matter — ○ Below 2 ◉ Between 2 and 4 (inclusive) ○ Above 4

Cover Crop — ◉ Yes ○ No

Potato Price ($/cwt) — 2.2

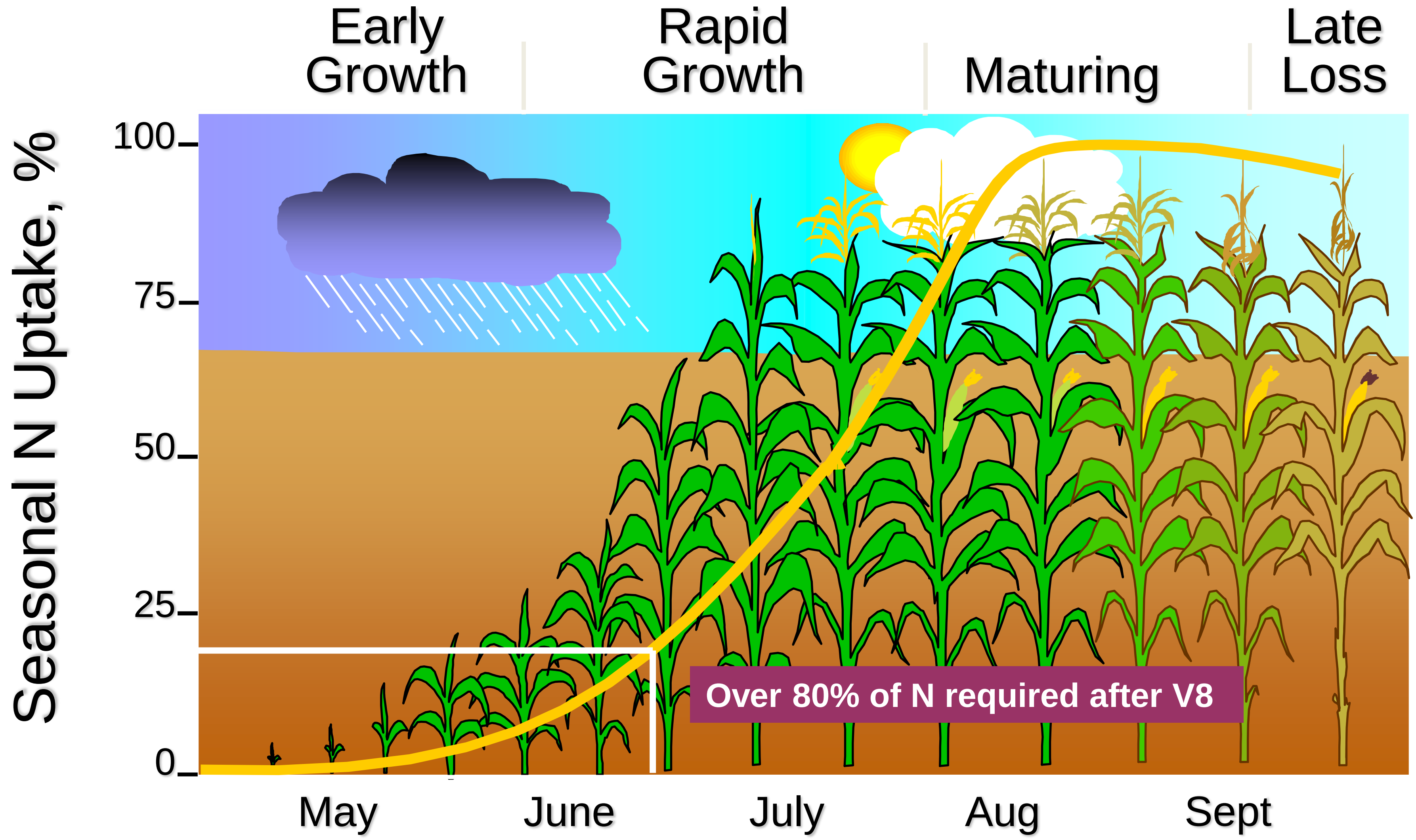
Nitrogen Cost ($/lbs) — 0.22

N Rate 174

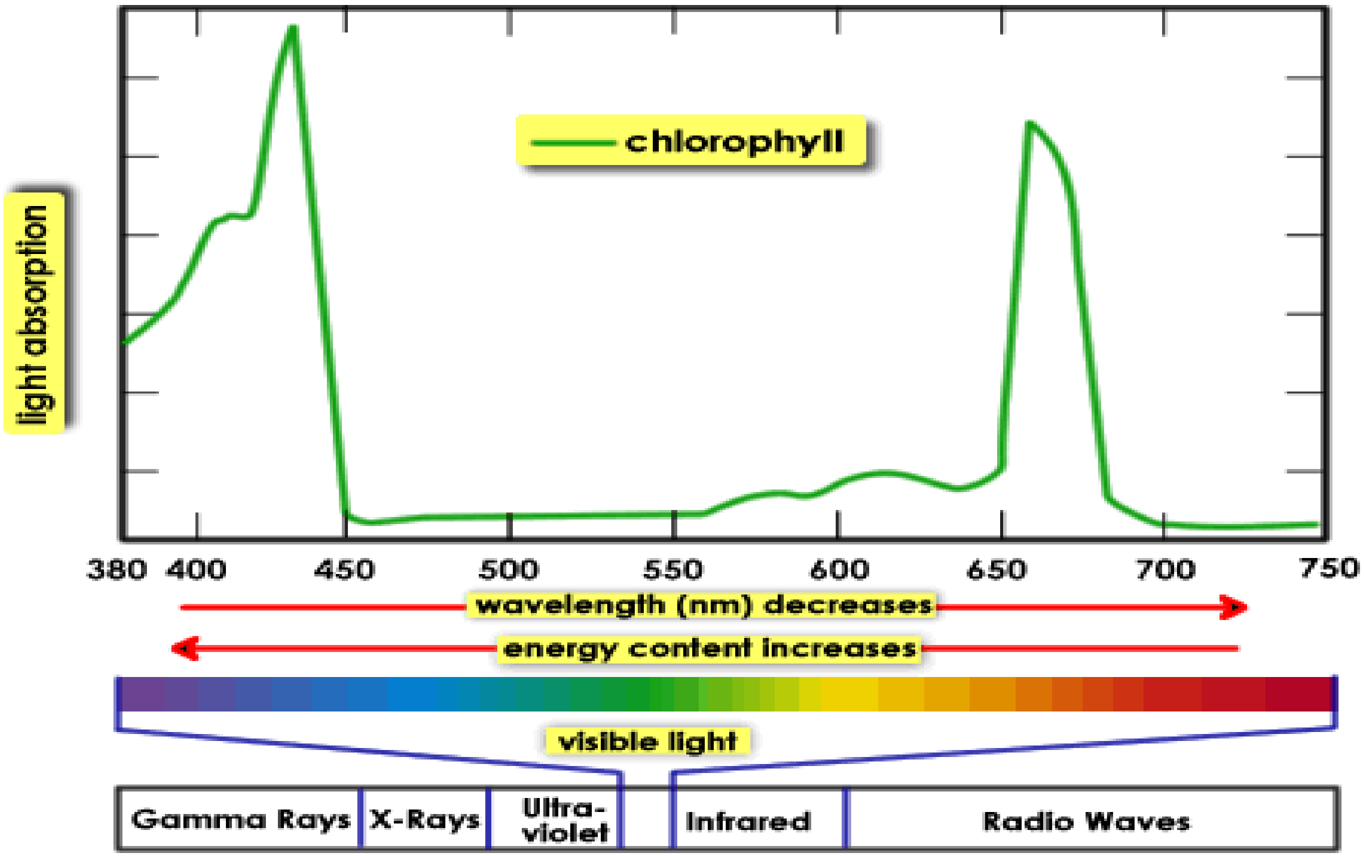
Calculate Reset

https://rishabhrrk.github.io/nrate/

The first 6 weeks of growth, little N is needed



Source: Dr. Jim Schepers, NUE conference presentation, Fargo-http://nue.okstate.edu/Nitrogen_Conference2012/North_Dakota.htm



- ❑ Major components of visible light spectrum are violet, blue, green, yellow, orange and red
- ❑ Blue and red are used in photosynthesis

http://childofthecornx.livejournal.com/23964.html

- **Red wavelength-Green leaves have a reflectance of 20 percent or less in the 500 to 700 nm range (green to red).**

- **Red ... ngth- 60 per ... (near infr...**

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Development of the GreenSeeker, at Oklahoma State University

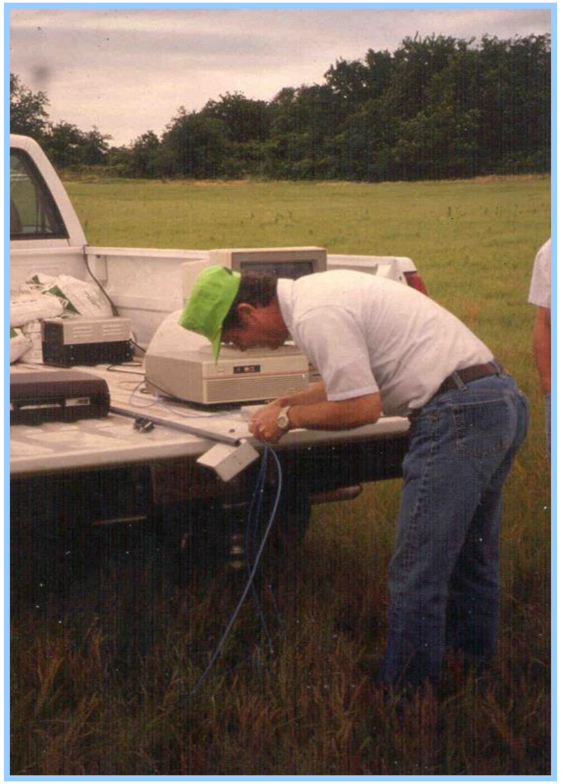
Initial sensor research focused on detecting and spraying weeds.

In the summer of 1992, a first-order bindweed detection/sprayer was evaluated for fall applications.

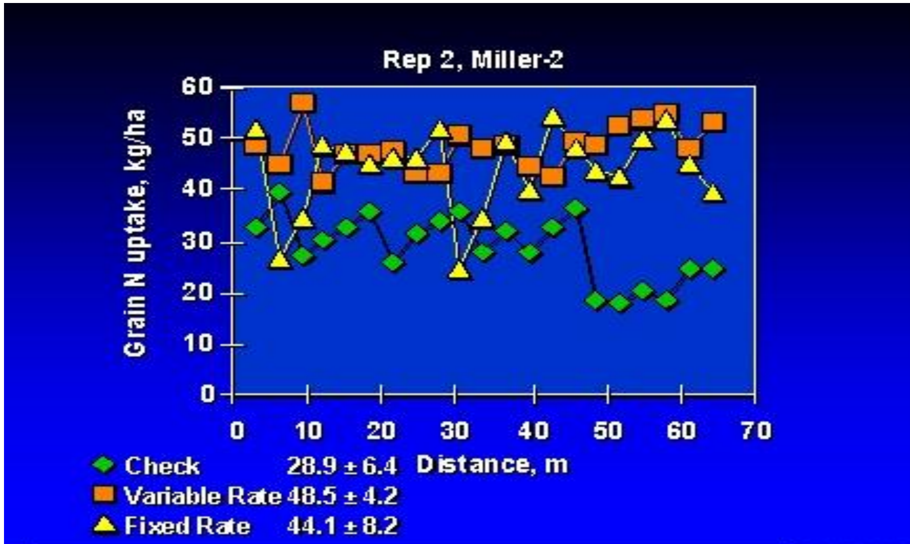
1992

First discussion between the Departments of Plant and Soil Sciences and Biosystems and Agricultural Engineering concerning the possibility of sensing biomass in wheat and bermudagrass. Biomass was to be used as an indicator of nutrient need (based on removal).

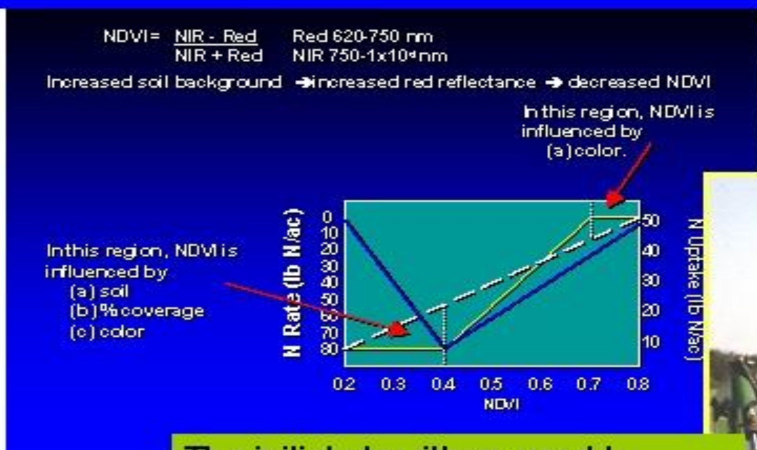
Ongoing sensor readings in bermudagrass, N rate * N timing experiments with NFS at Oklahoma. Results were promising to continue work in wheat.



Dr. Marvin Stone adjusts the fiber optics used in early bermudagrass N rate studies, 1994.



In the fall of 1993, variable N rates using an inverse N-rate, NDVI scale were attempted at Miller-2. Using this approach, N rates were cut in half with no differences in grain yield compared to fixed rates. Grain N uptake levels using VRT across a 70 meter transect were less variable when compared to the fixed rates (left).



The initial algorithms used to spatially treat N deficiencies in wheat and bermudagrass employed an inverse N Rate-NDVI scale. Later, critical NDVI levels were established (both min and max) resulting in a plateau-linear-plateau function.

In the summer of 1994, John Ringer and Shannon Osborne collected sensor readings and later applied variable N fertilizer rates based on an initial bermudagrass algorithm developed by TEAM-VRT.

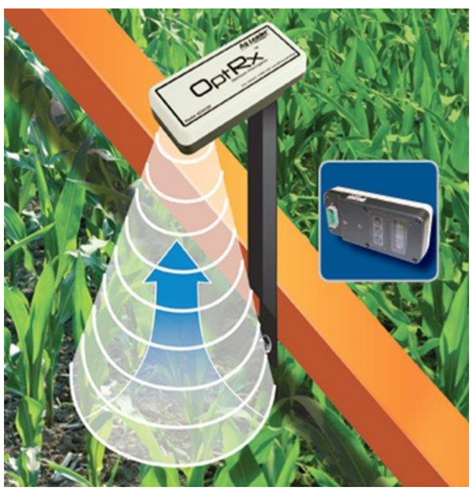
- Samples collected every 1 square foot.
- Experiments showed that each 4ft^2 in agricultural fields need to be treated as separate farms.

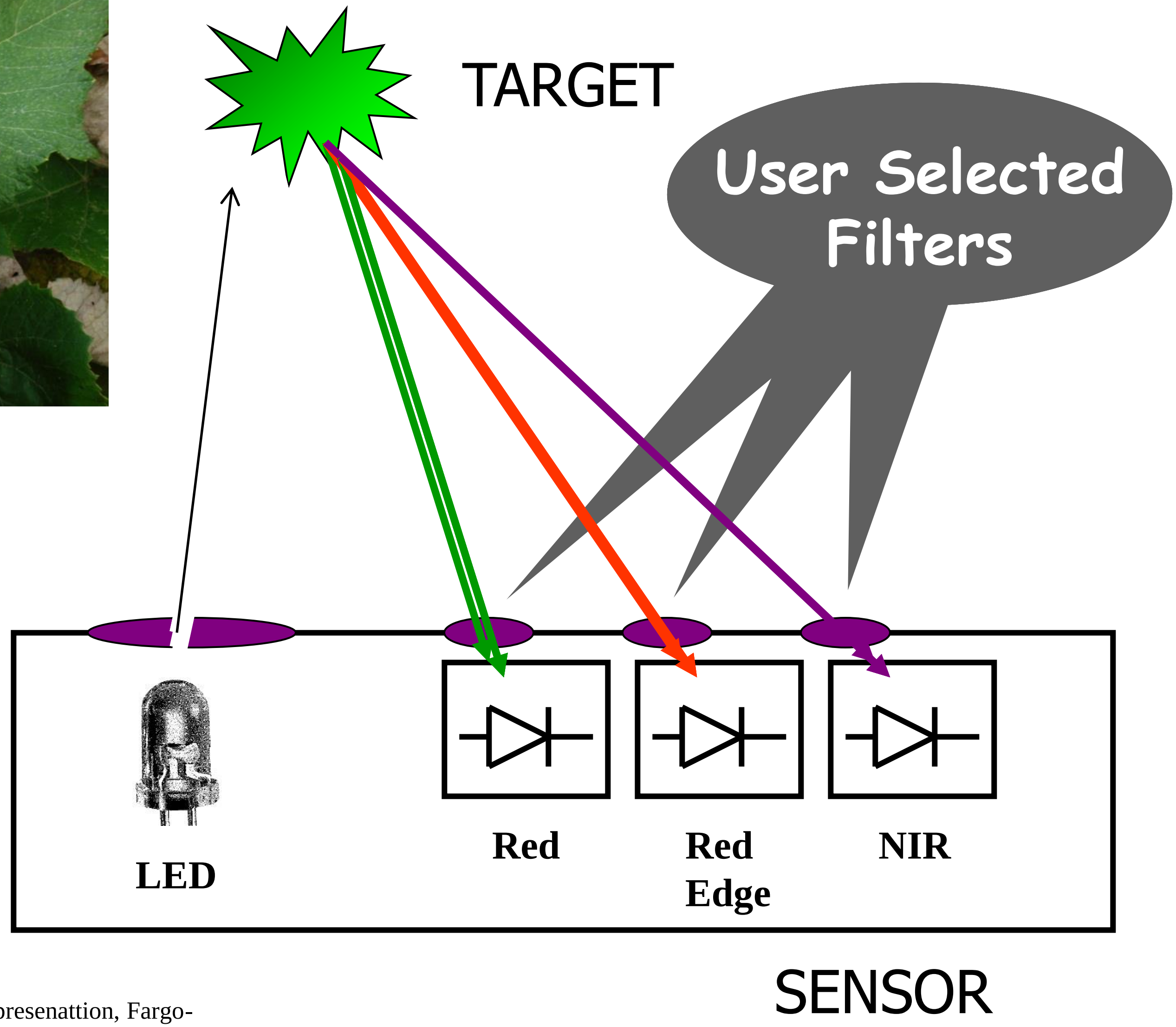
1995

Experiments looking at changes in sensor readings with changing, growth stage, variety, row spacing, and N rates were conducted.


2008

Holland Crop Circle-470





ACS-470

Source: Dr. Jim Schepers, NUE conference presenattion, Fargo-
http://nue.okstate.edu/Nitrogen_Conference2012/North_Dakota.htm

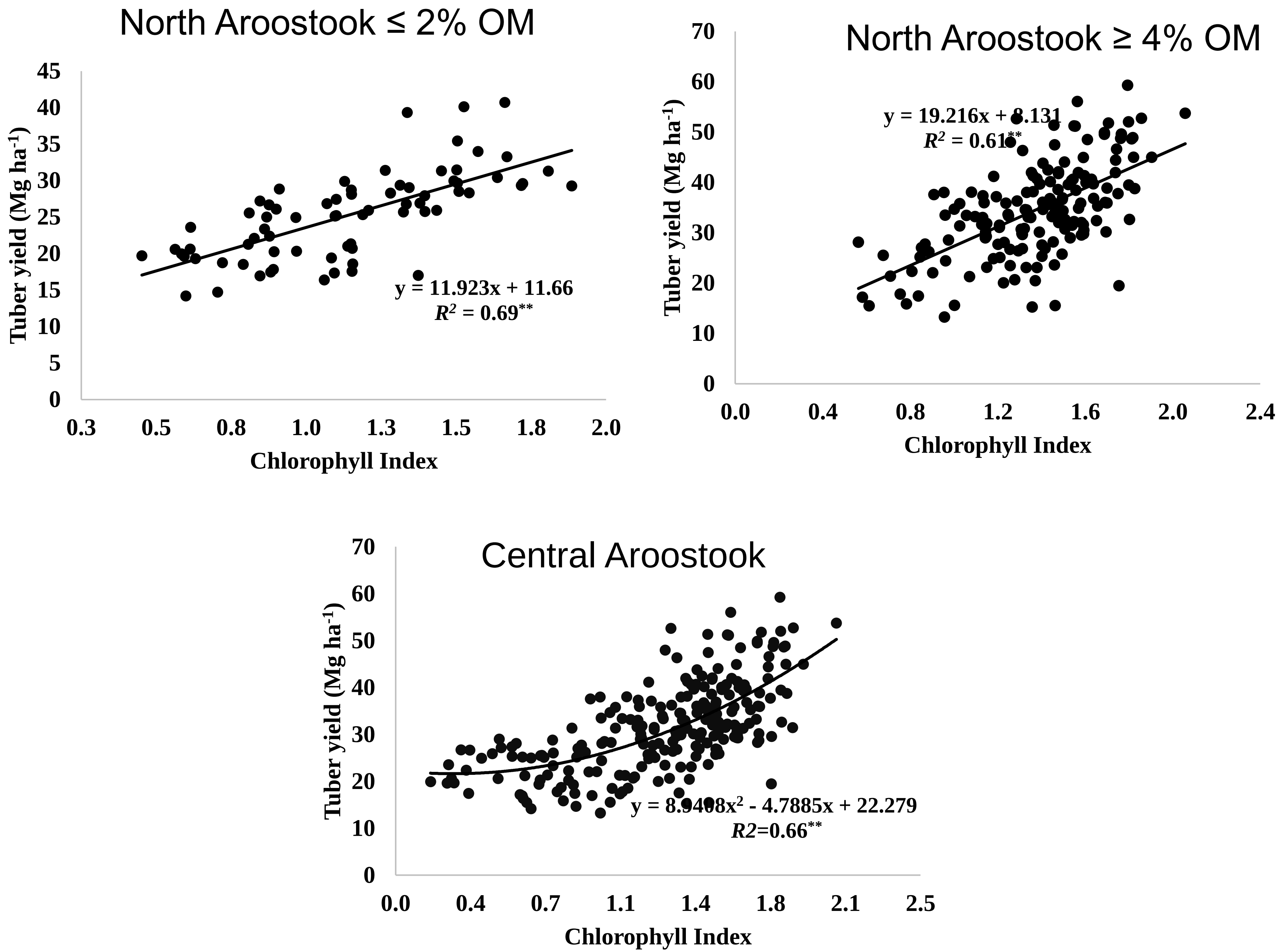
Algorithms will not use sensor readings by themselves.

We used a normalization concept developed by Oklahoma State Univ. during their development of the GreenSeeker

INSEY-
In Season Estimate of Yield

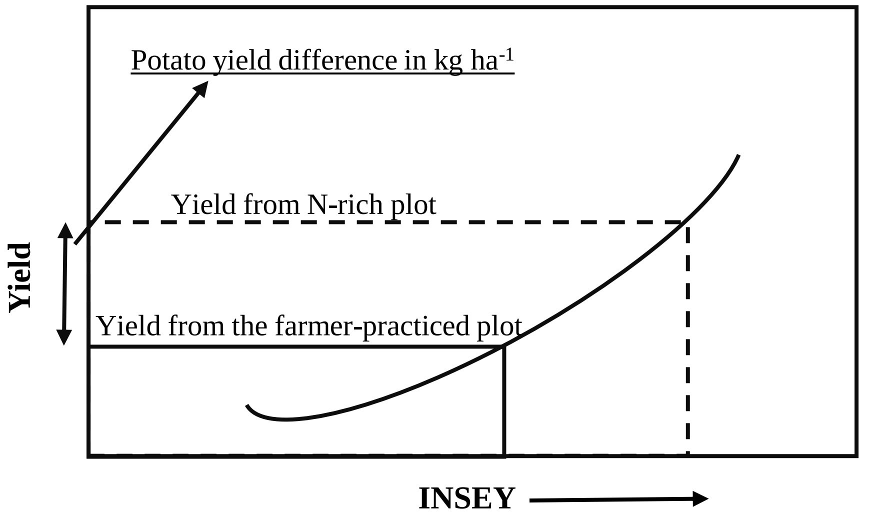
Sensor reading / growing degree days from planting date

To develop an in-season estimate of yield


North Aroostook ≤ 2% OM
Tuber yield (Mg ha-1)
Chlorophyll Index
y = 11.923x + 11.66
R2 = 0.69**
0 5 10 15 20 25 30 35 40 45
0.3 0.5 0.8 1.0 1.3 1.5 1.8 2.0
North Aroostook ≥ 4% OM
Tuber yield (Mg ha-1)
Chlorophyll Index
y = 19.216x + 8.131
R2 = 0.61**
0 10 20 30 40 50 60 70
0.0 0.4 0.8 1.2 1.6 2.0 2.4
Central Aroostook
Tuber yield (Mg ha-1)
Chlorophyll Index
y = 8.9408x2 - 4.7885x + 22.279
R2=0.66**
0 10 20 30 40 50 60 70
0.0 0.4 0.7 1.1 1.4 1.8 2.1 2.5

Develop an algorithms for use in directing in-season nitrogen rates for corn

$$\text{NUE} = \frac{(\text{Crop yield in N fertilized plot} - \text{Crop yield in no N plot})}{(\text{Quantity of N fertilizer applied in N fertilized plot})}$$



Example-

280 lb/acre = Reference yield predicted- 315 CWT
120 lb/acre = In-field yield estimated- 290 CWT

difference = 25 CWT X 112 lb N/CWT
= 2800 pounds
X 0.018 = 50 lb N
50 /0.63 efficiency factor = 79 lb N
at that location.

Farmer Rate = 225 pounds/acre
Our rate = 120 + 79 = 199 pounds/acre

Saving = 225 – 199 = 26 x $0.92/pound of N = $23.92 x 800 acres = $19,136

N saving total = 26 pounds/acre x 800 acres = 20,800 pounds/farmer

Summary……

- **Experiment sites divided by Soil types, cultivation system, and climate zone helps to improve nutrient recommendations**

- **Some sensor better than other so pick the one that works with your crop**

- **As leaf stages advances red wavelength get saturated**