# New Information for Explaining How Humic Products Benefit Crops

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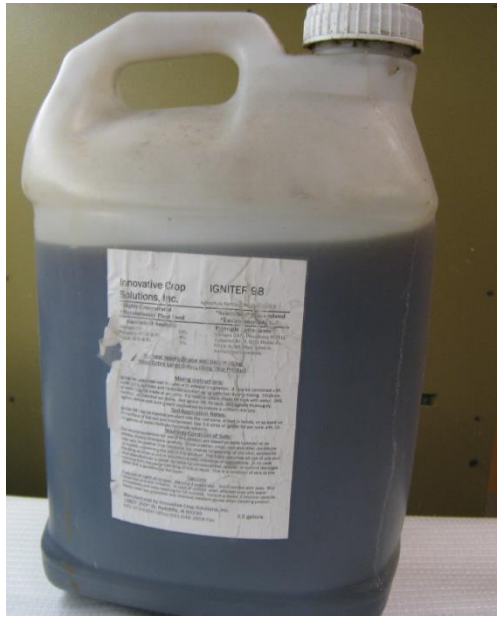
# What are humic products?




Extracts of immature coals (leonardite, oxidized lignite), peats, composts.
Super-finely ground solid

Humic acid (HA), soluble in base but not acid. and/or fulvic acid (FA), soluble in both base and acid]

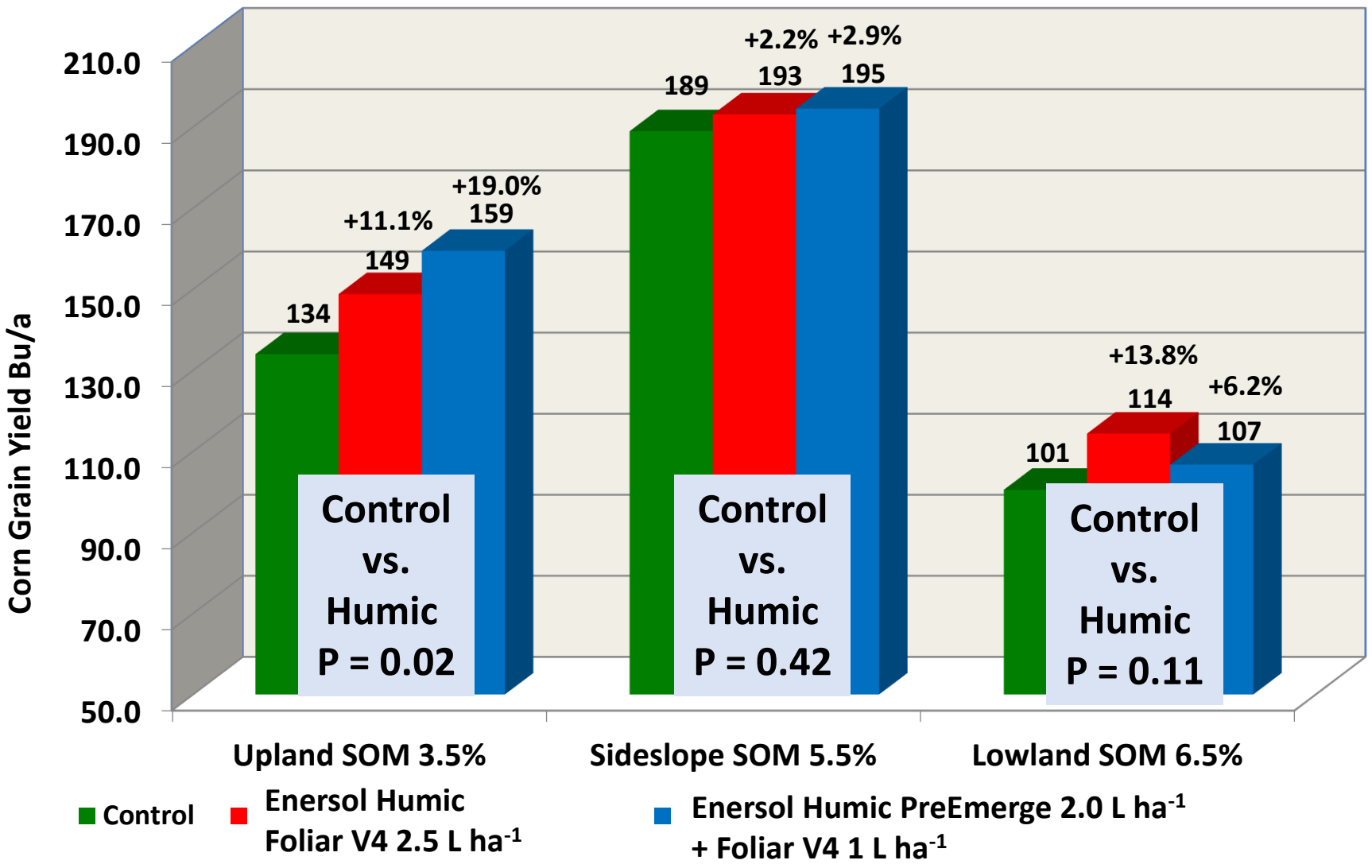
Application rates of 0.4-4 gallon/ acre. Cost as low as $10/ acre.
Some can be mixed into other agrochemical applications

# Iowa research: Strongest humic product responses occur with environmental stress

| Landscape position | Upland | Side-slope | Lowland |
|---|---|---|---|
| Soil organic matter (%) | 3.5 | 5.5 | 6.5 |
| Soil type | Clarion | Nicollet | Webster |

# Corn Grain Yield (Combine Monitor) by Soil Type
# 2012 Finch Field, Ames, IA, 4 Reps

**Severe Drought Year**



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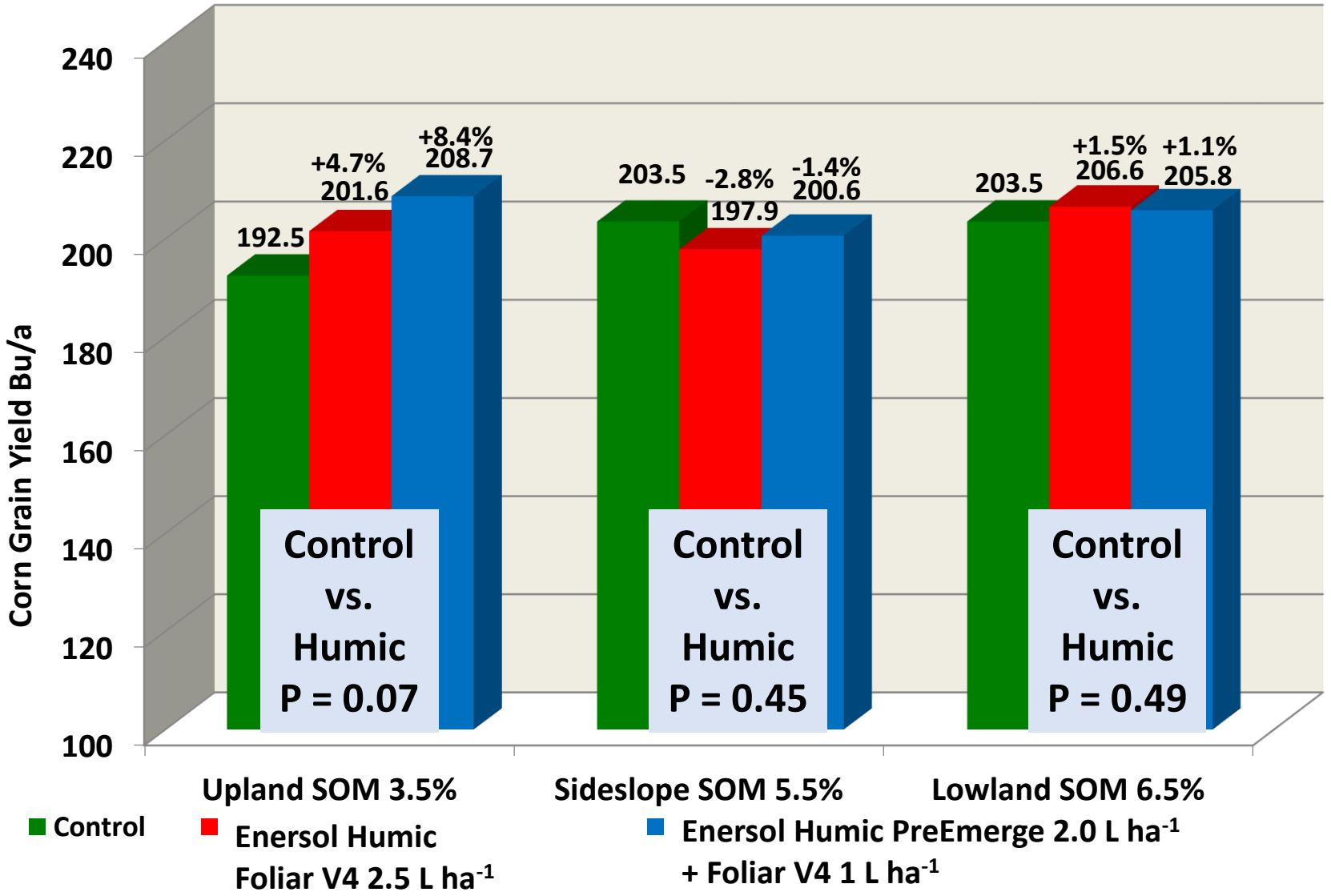
**Ideal Growing Conditions**

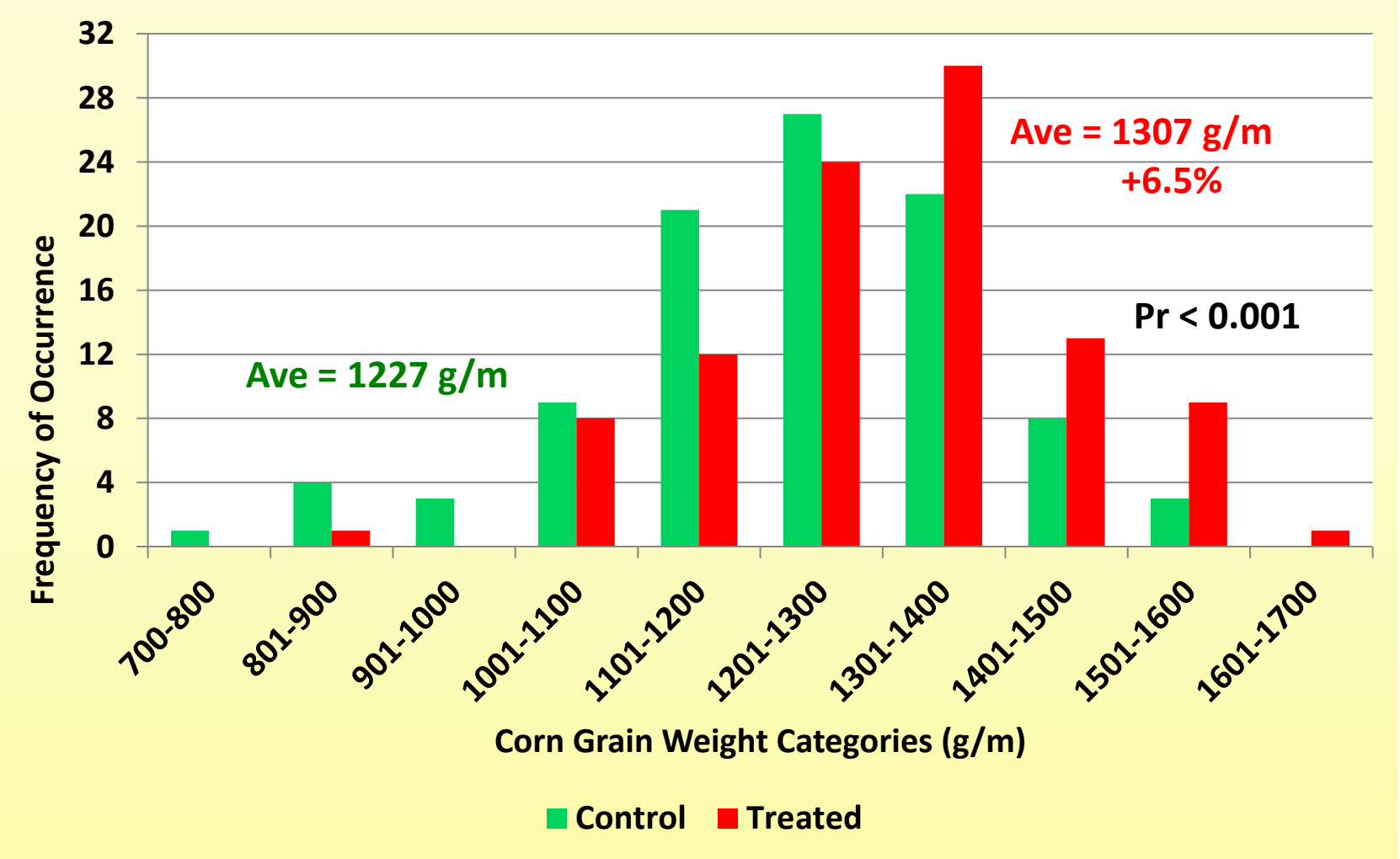


# Corn and soybean yield responses to a humic product: nearly ideal precipitation patterns (2014-2015) vs. drought stress (2013, 2016-2017).Boyd 11 farm. Ames, IA

| Year | Crop | Treatment | Timing | Grain Yield (bu/a) | % of Control | P > F[a] Compared to Control |
|---|---|---|---|---|---|---|
| 2013 | Soybean | Control | N/A | 45.1 | ----- | ----- |
| | | Humic 34 oz/a | V4 | 48.5 | +7.5 | 0.03 |
| | | Humic 41 oz/a | Pre-Emergence | 47.9 | +6.2 | 0.05 |
| 2014 | Corn | Control | N/A | 182.2 | ----- | ----- |
| | | Humic 34 oz/a | V4 | 179.4 | -1.5 | 0.79 |
| | | Humic 27+14 oz/a | Pre-Emergence + V4 | 186.3 | +2.2 | 0.69 |
| 2015 | Soybean | Control | N/A | 55.2 | ----- | ----- |
| | | Humic 64 oz/a | V4 | 56.9 | +3.2 | 0.49 |
| | | Humic 128 oz/a | Pre-Emergence | 57.3 | +3.9 | 0.42 |
| 2016 | Corn | Control | N/A | 226.6 | ----- | ----- |
| | | Humic 32 oz/a | V4 | 233.7 | +3.1 | 0.02 |
| | | Humic 64 oz/a | V4 | 236.1 | +4.2 | 0.003 |
| 2017 | Soybean | Control | N/A | 54.4 | ----- | ----- |
| | | Humic 64 oz/a | V4 | 60.3 | +10.8 | <0.001 |
| | | Humic 128 oz/a | Pre-Emergence | 61.5 | +13.2 | <0.001 |

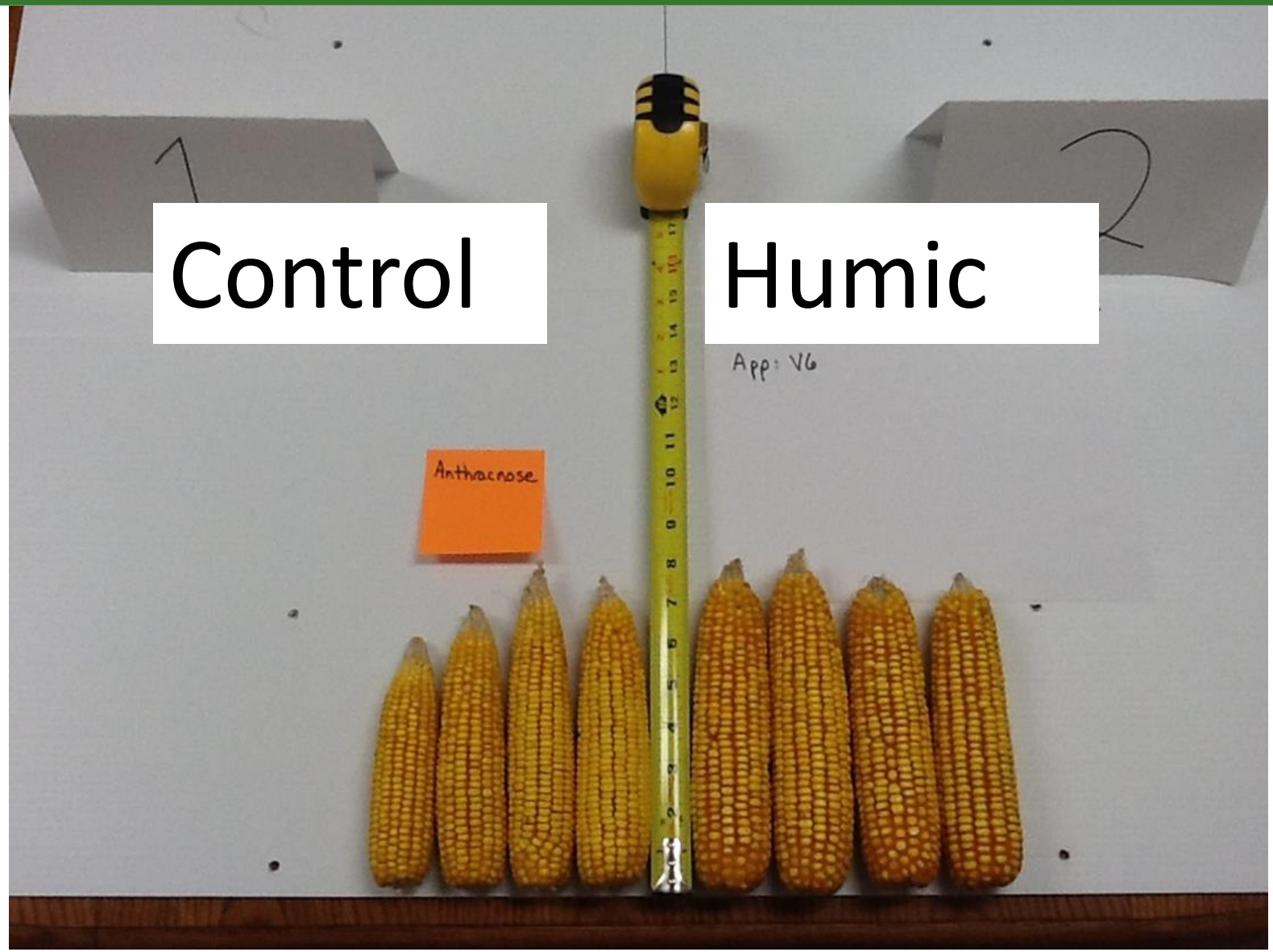
[a] **Probability of greater F values are the least significant difference T-tests from mixed models statistical analyses.**

# Corn Grain Yield: On-Farm Hand-Sampled Grain Weights. 95 Pairings of Control vs. Humic Treated, 2009-2011

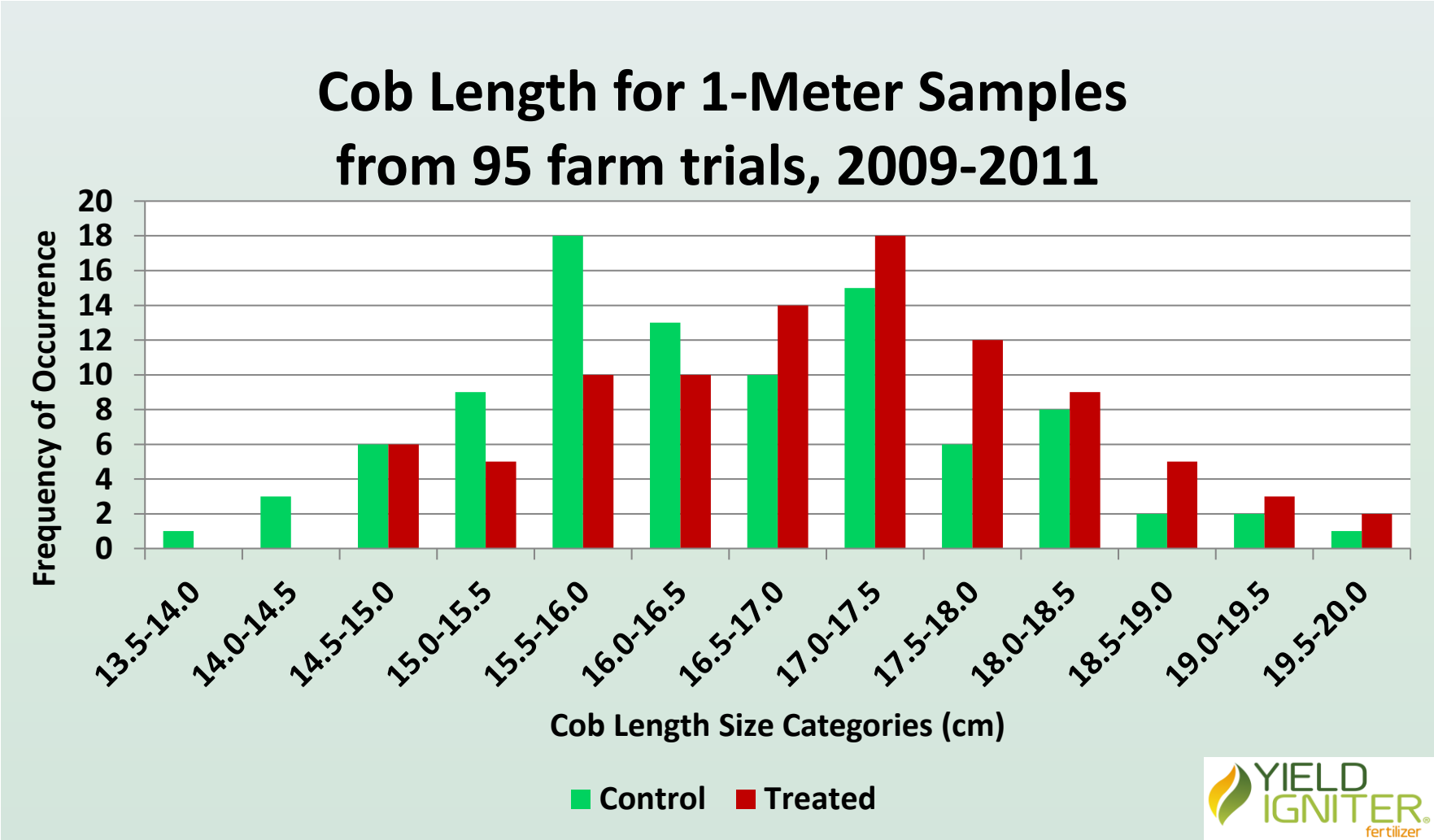



**Over 3 Years, 70-80% incidence of numeric grain yield increase**

# Corn Cob Length
# The yield component causing grain yield responses

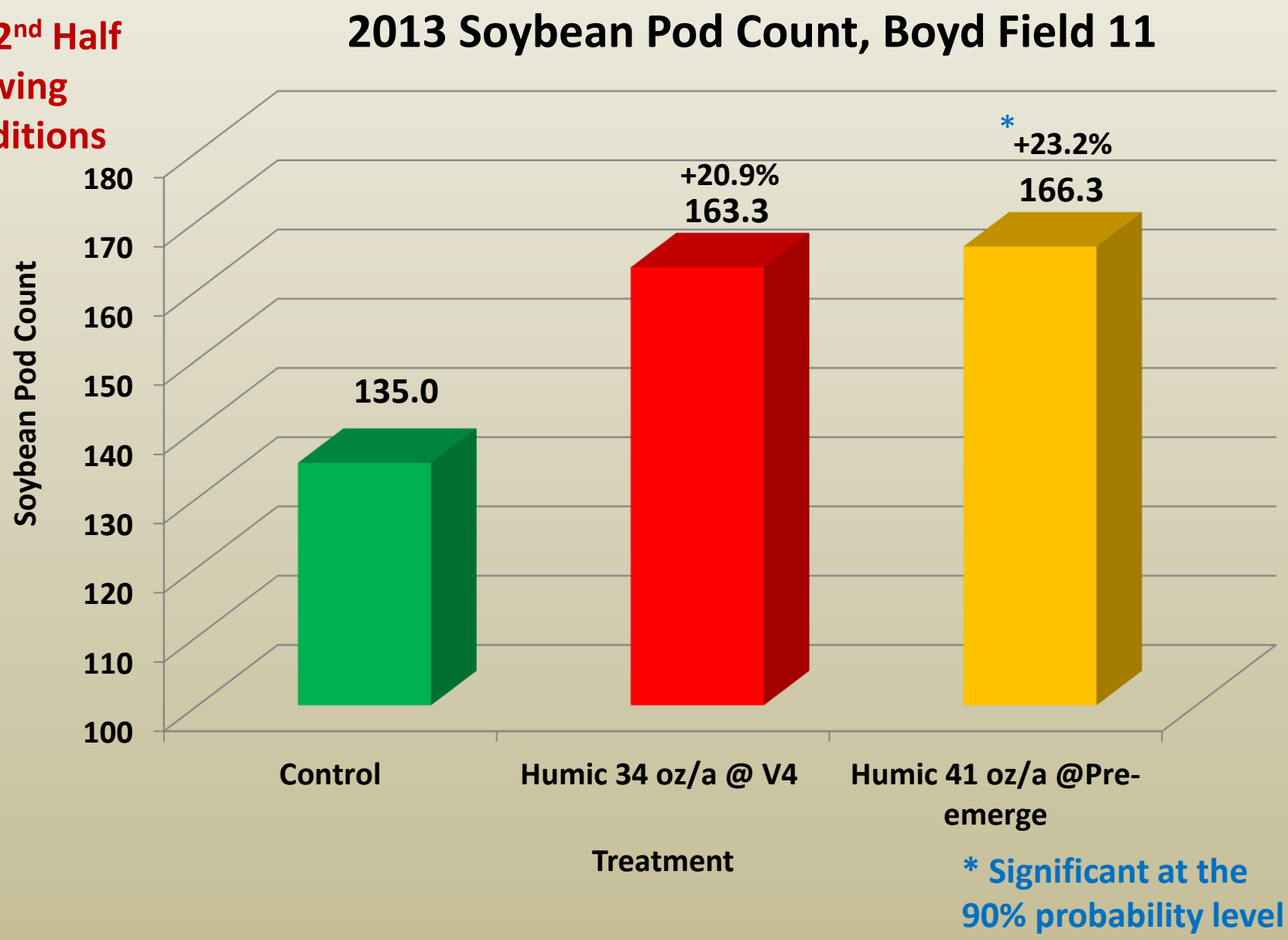


# Corn Cob Length.



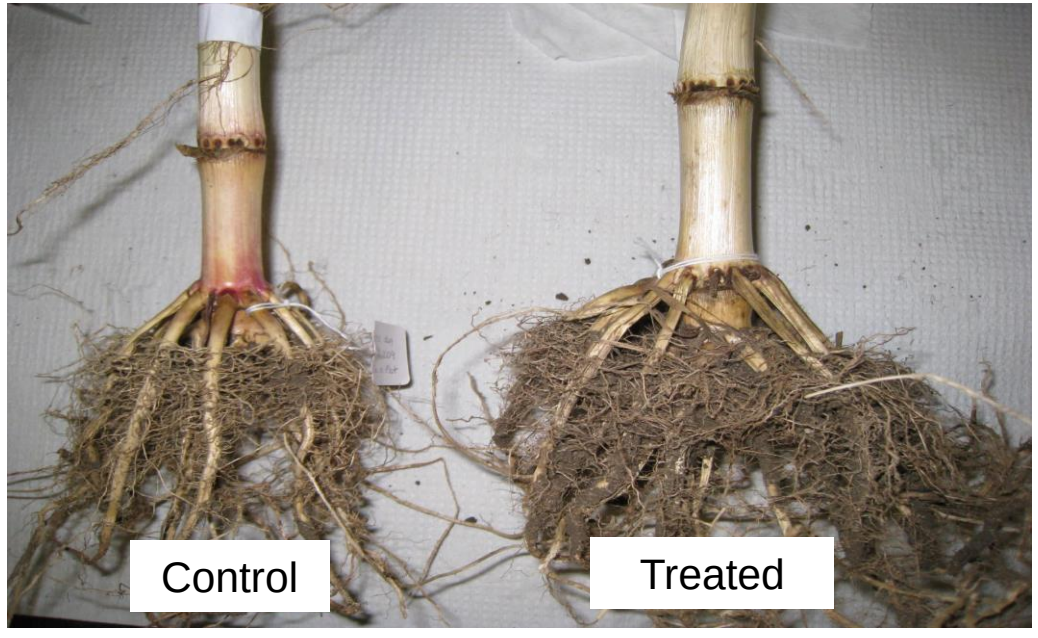

**The distribution shift is a form of <u>Stress Alleviation</u>**

Wet 1st Half
Dry 2nd Half
Growing
Conditions



# Drought stress, 2012 Finch field, Ames, IA

# Corn Root Measures (2013-2015)



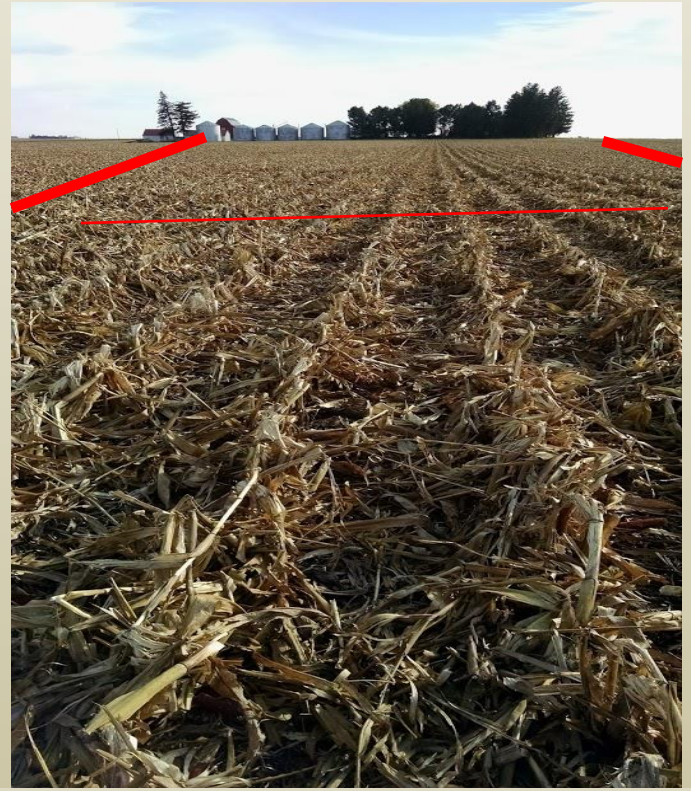

# Total corn root length (cm) for three plants in a 45 $dm^3$ soil volume at the R2 growth stage following AMCOL product at single or split application in two years.

| Year | Weather | | Upland soils | | | | Lowland soils | |
|---|---|---|---|---|---|---|---|---|
| 2013 | Wet, then drought | | Control | V4# | Pre + V4 | | Control | V4 |
| | | Total root length | 21,920 | 28,927 (+32%) | 32,831 (+50%) | | ND | ND |
| | | P level (LSD) | | 0.061 | 0.012 | | | |
| | | | | | | | | |
| 2014 | Near ideal | Total root length | 16,718 | 21,186 (+27%) | 18,105 (+8%) | | 19,083 | 23,225 (+22%) |
| | | P level (LSD) | | 0.16 | 0.67 | | | 0.13 |

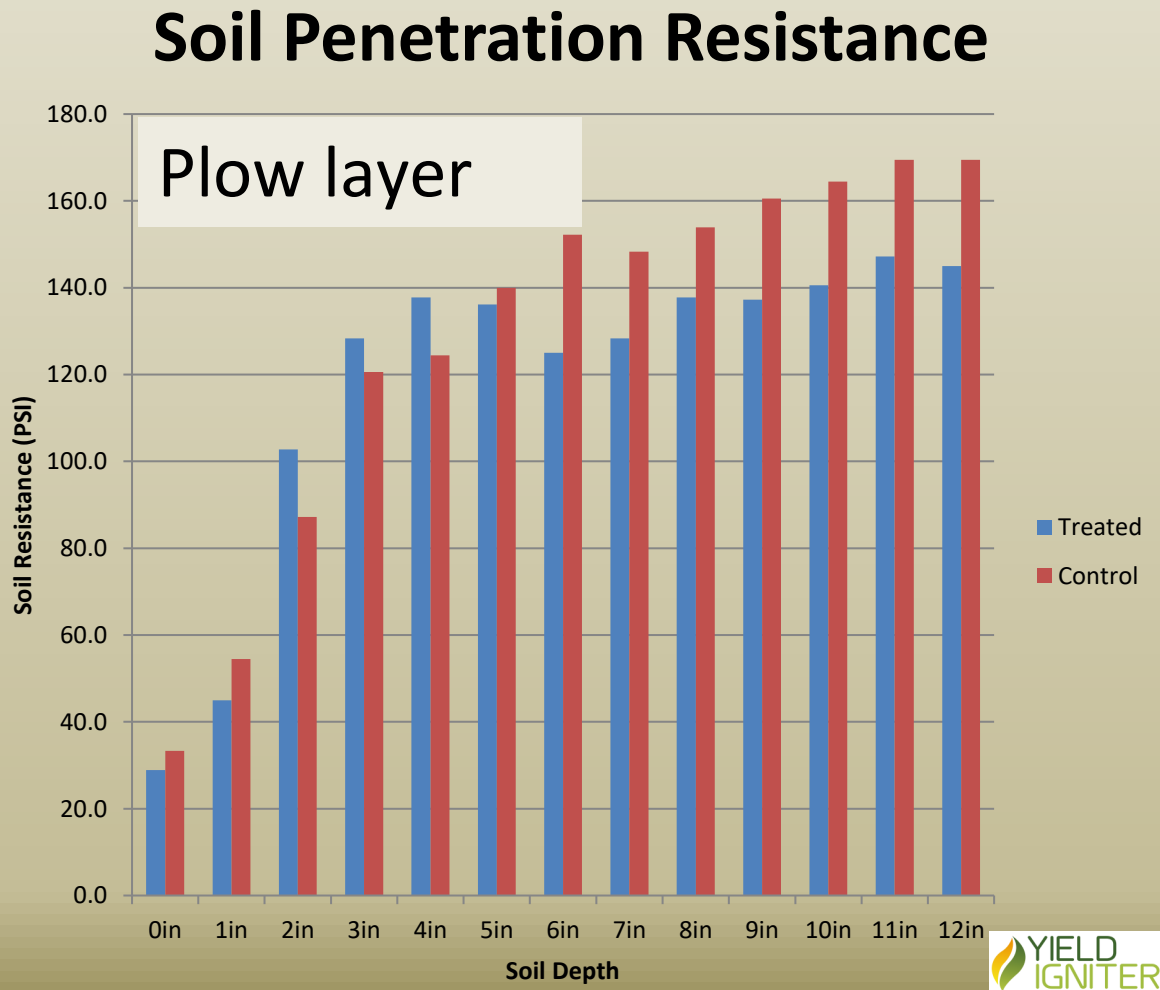
# Application rates: 2.5 L $ha^{-1}$ at V4, and 1+2 L $ha^{-1}$ for split application at pre-emergence and V4, respectively.

MINERALS TECHNOLOGIES

# Soil Benefits

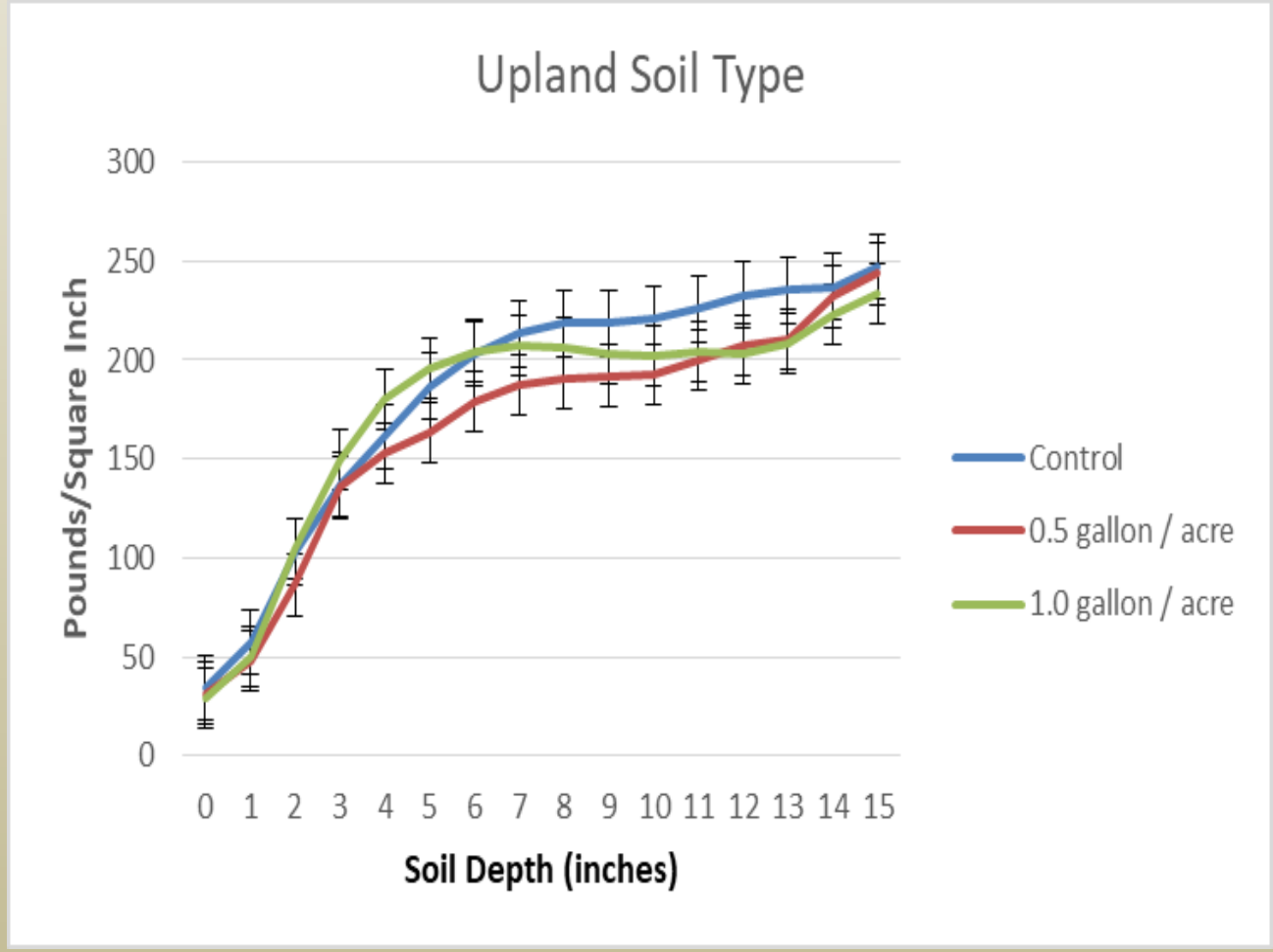


- **Strip outside Conrad, IA, received Ag Logic product 2009-2014.**
- **Soil penetration resistance measured October 2016**



# Five-year field trial of Minerals Technologies “Enersol” product

Iowa State University research farm, Boone, IA



# Corn Biochemistry

**Humic Product Treated**

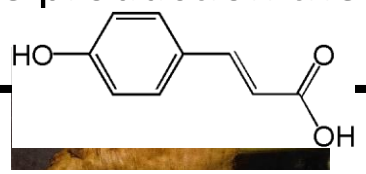
**Untreated 16 Border Rows**

# Corn plant biochemical responses to a humic product in two farmer's fields, by year.

| Year | Weather | Lignin-phenols (11) | | Non-glucose Carbohydrates (4) | |
|---|---|---|---|---|---|
| | | Stover | Roots | Stover | Roots |
| 2013 | Wet , then Drought | 0 | +9 to +28% P=0.09 and 0.24 | 0 | 0 |
| 2014 | Wet , then Ideal | -6% and -11% P=0.10 and 0.32 | 0 | 0 | +10 to +38% P=0.02 and 0.005 |

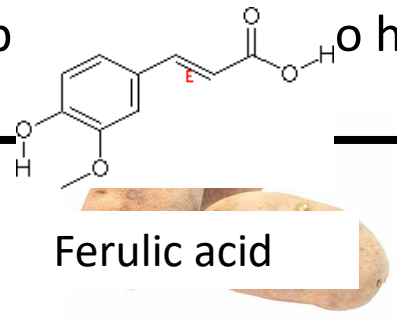
Syringaldehyde

arbohydrate production the default p ducts?



p-Coumaric acid

o humic



Ferulic acid

# 2022 Boyd 32 Field – N Rate X Humic Split-Plot Design
# 8 Row Plots with 30-inch Row Spacing

Now, let's look at nitrogen stress

**Treatments**

**Main Treatments (Nitrogen Fertilizer Rates):**

- **T1 = 0 kg N/ha (0 lb N/a)**
- **T2 = 70 kg N/ha (62 lb N/a)**
- **T3 = 140 kg N/ha (125 lb N/a)**
- **T4 = 210 kg N/ha (187 lb N/a)**
- **T5 = 280 kg N/ha (250 lb N/a)**

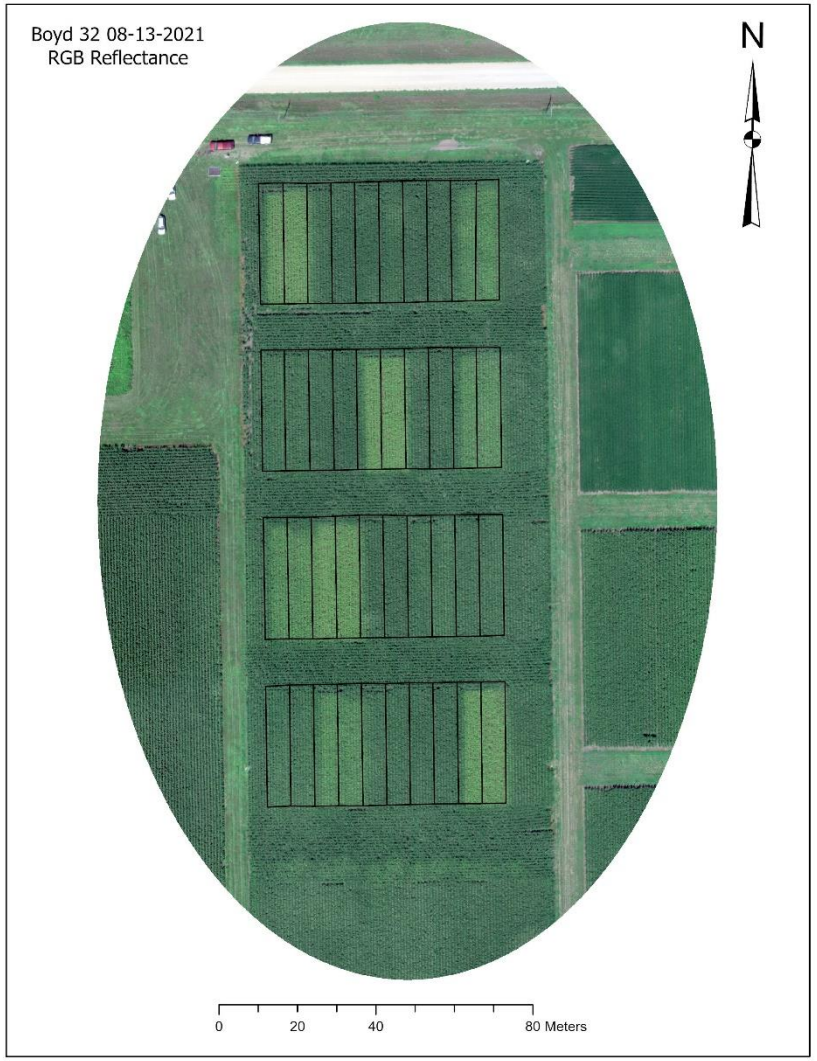
**Apply UAN sidedress in interrows centers at earliest possible after emergence**

**Split Treatments (Humic Product):**

- **H1 = Without (Control)**
- **H2 = With (Humic Treated)**
  **Enersol 32 oz/a broadcast foliar-applied at ~V4**

# 2022 Boyd 32 Field – N Rate X Humic Split-Plot Design

| | | | | | |
|---|---|---|---|---|---|
| Rep 1 | T1 H1 P1 | T1 H2 P2 | T4 H2 P3 | T4 H1 P4 | T3 H1 P5 |
| Rep 2 | T3 H1 P11 | T3 H2 P12 | T4 H1 P13 | T4 H2 P14 | T1 H1 P15 |
| Rep 3 | T2 H2 P21 | T2 H1 P22 | T1 H2 P23 | T1 H1 P24 | T5 H1 P25 |
| Rep 4 | T3 H2 P31 | T3 H1 P32 | T2 H2 P33 | T2 H1 P34 | T4 H1 P35 |



# Combine grain yield response to a humic product 2021 field trial, Ames, IA (bushels/ acre)

| N rate (lb acre$^{-1}$) | Control | Humic product | Difference | P level |
|---|---|---|---|---|
| 0 | 42.8 | 42.1 | -0.7 | 0.920 |
| 62 | 93.8 | 73.9 | -19.9 | 0.015 |
| 125 | 165.7 | 160.0 | -5.7 | 0.429 |
| 187 | 189.8 | 198.7 | +8.9 | 0.225 |
| 250 | 204.0 | 211.3 | +7.3 | 0.323 |

# Combine grain yield response to a humic product 2021 (and 2020) field trial, Ames, IA (bushel/ acre)

| N rate (lb acre$^{-1}$) | Control | Humic product | Difference | P level |
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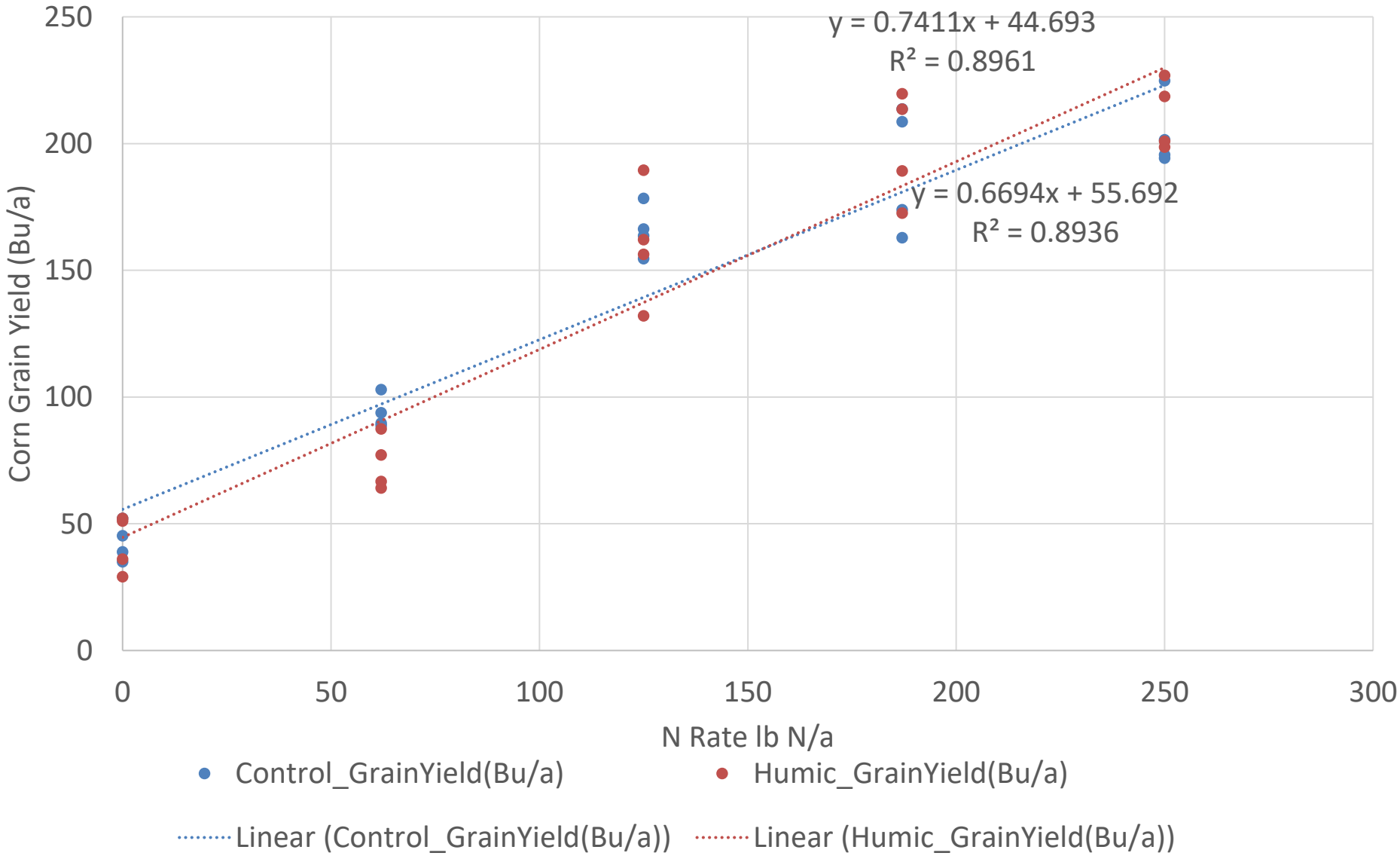
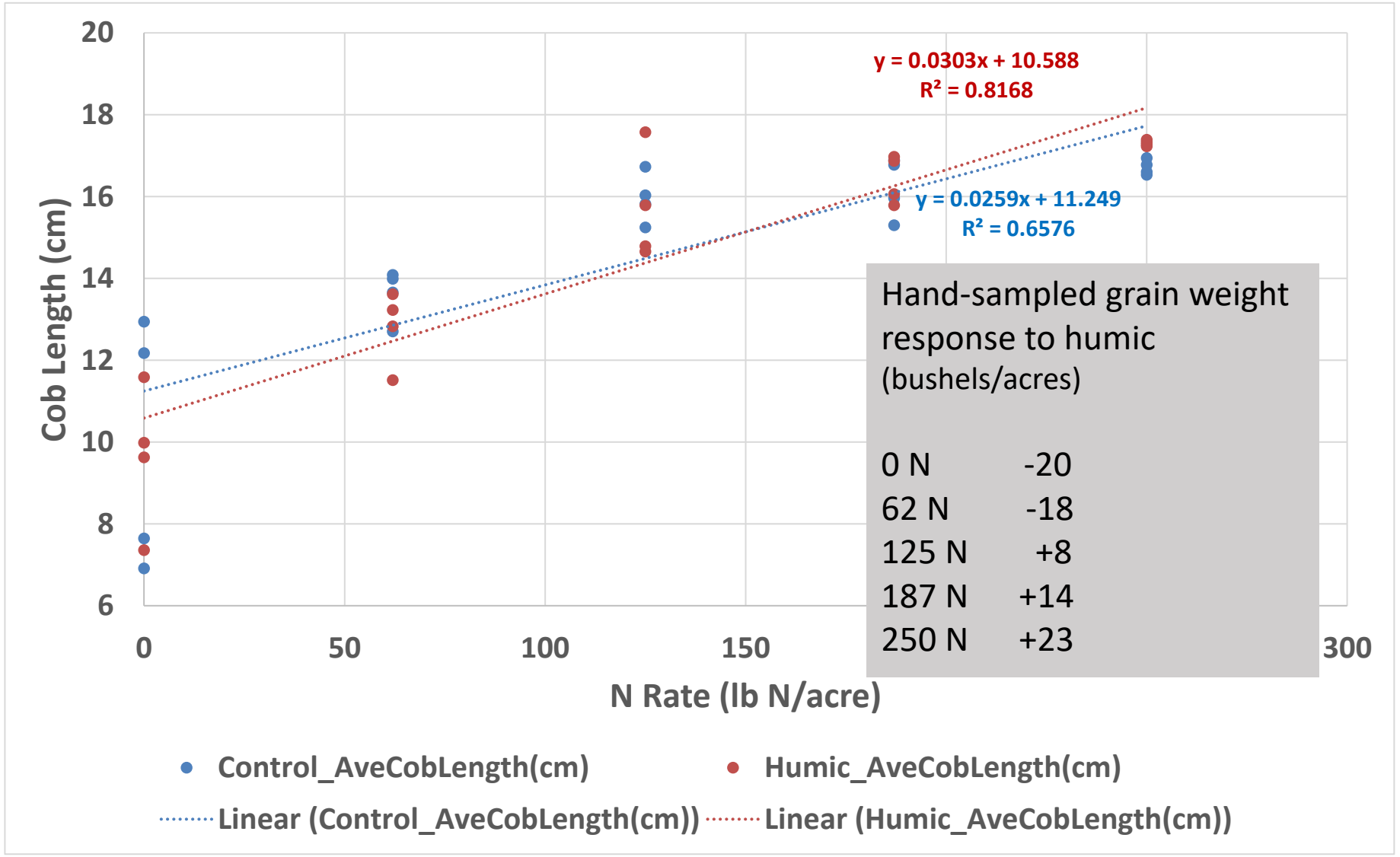
| 125 | 165.7 | 160.0 | -5.7 | 0.429 |
| 187 | 189.8 | 198.7 | +8.9 | Mainplot trmt: P=0.098 for 187 N and 250 N. |
| 250 | 204.0 | 211.3 | +7.3 | |
| | | | | |
| | | 2020 | | |
| 0 | 34.6 | 34.4 | -0.2 | 0.968 |
| 62 | 75.2 | 64.2 | -11.0 | 0.125 |
| 125 | 138.6 | 149.2 | +10.6 | 0.138 |
| 187 | 170.3 | 178.6 | +8.3 | 0.238 |
| 250 | 169.0 | 165.9 | -3.1 | 0.649 |

# 2021 Combine grain yield
# Humic vs Control across five N fertilizer rates



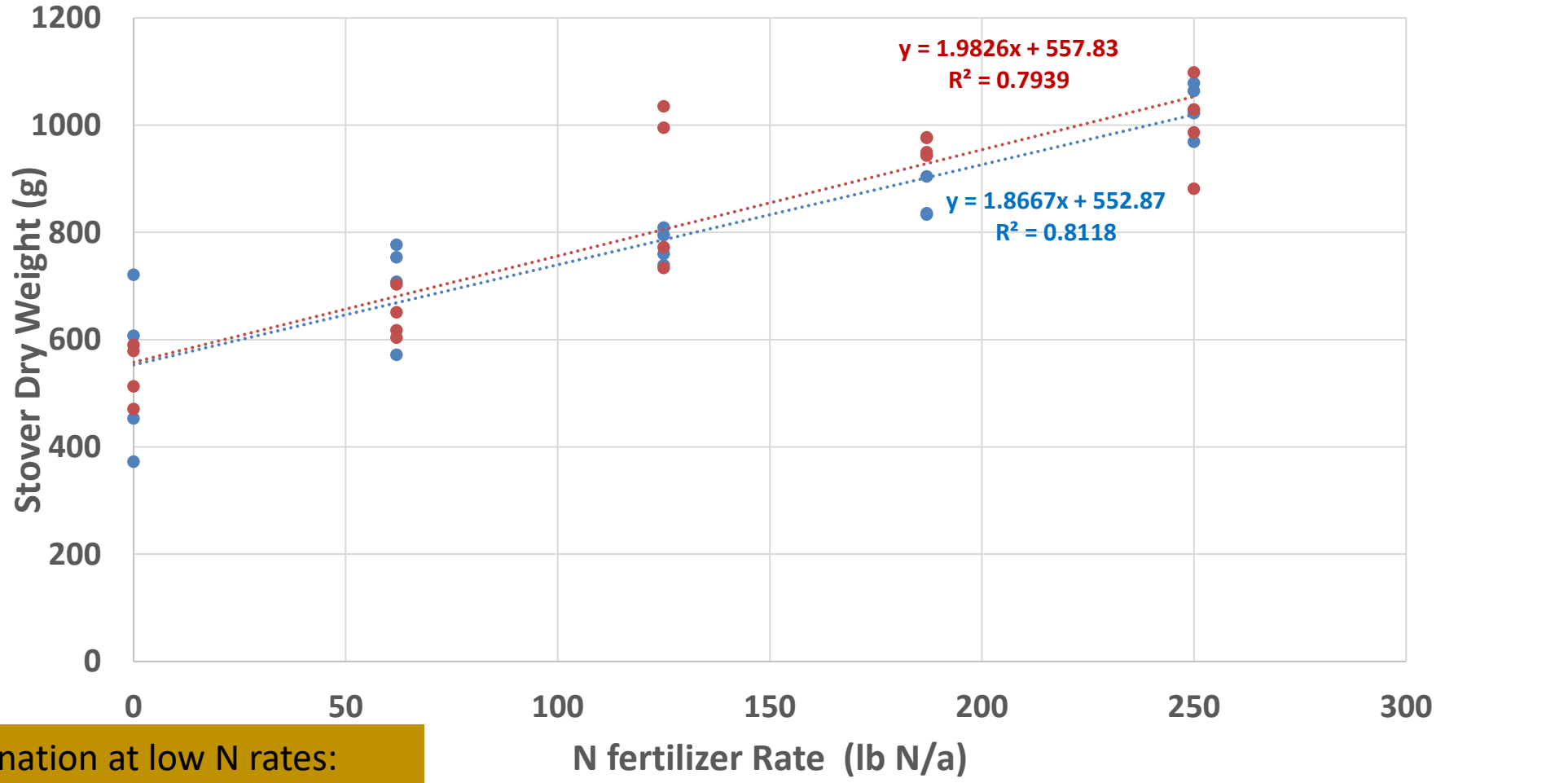
# 2021 Cob length for hand-samples (7 plants/plot)
# Humic vs Control across five N rates




Hand-sampled grain weight response to humic
(bushels/acres)

| | |
|---|---|
| 0 N | -20 |
| 62 N | -18 |
| 125 N | +8 |
| 187 N | +14 |
| 250 N | +23 |

# 2021 Stover weight for hand-samples (7 plants/plot)
# Humic vs Control across five N rates




Speculative explanation at low N rates:

The humic product stimulates the crop to grow excessively, more than the extent supported by the limited N supply.

- In this field study on fertile Iowan soils, the humic product did not increase nitrogen availability at the low N fertilizer rates.

- Yet it increased corn grain yield at the higher N fertilizer rates.

- Might there be mechanism(s) for humic product efficacy other than enhancing nutrient supply?

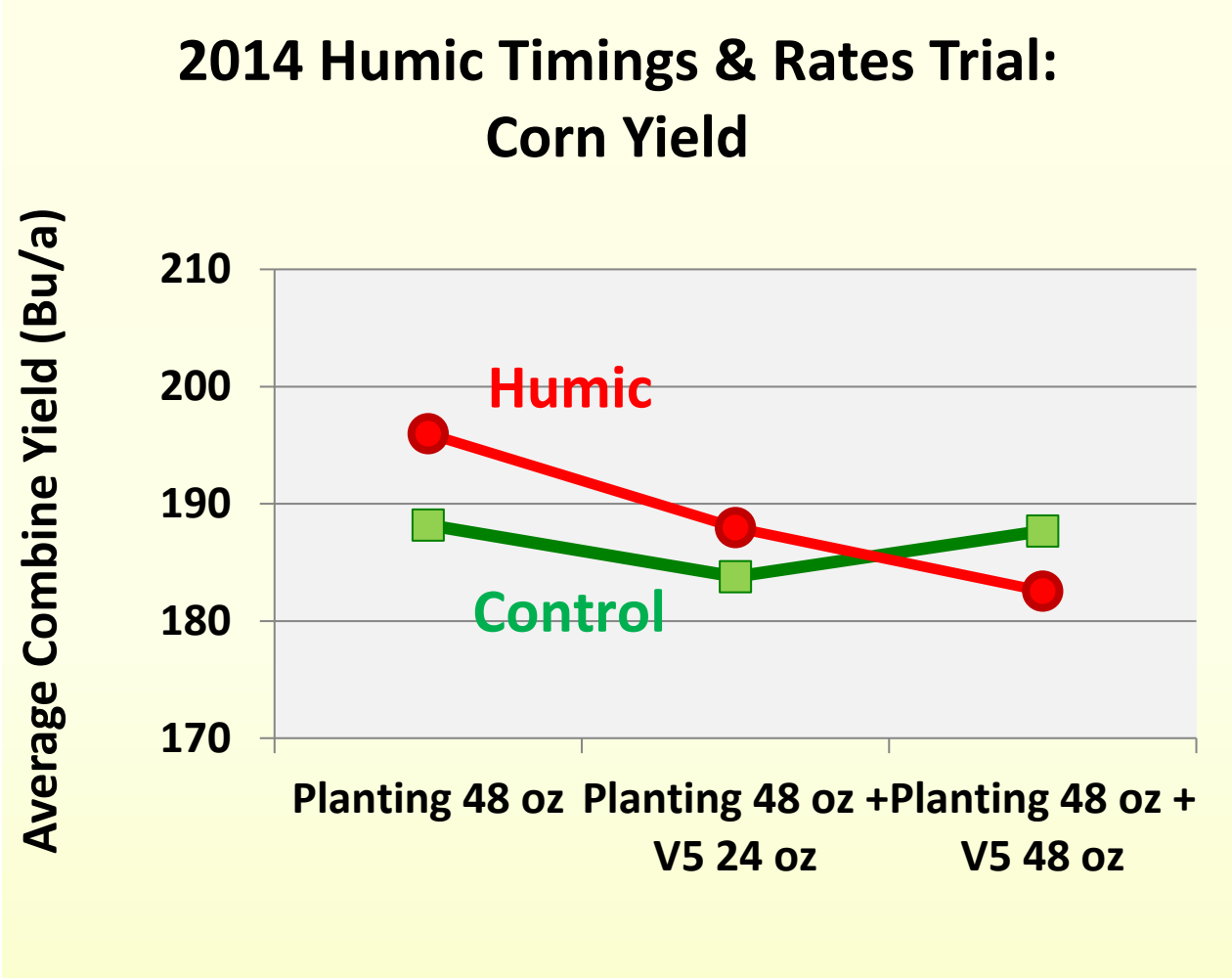
# Humics can be biostimulants, not fertilizer enhancers

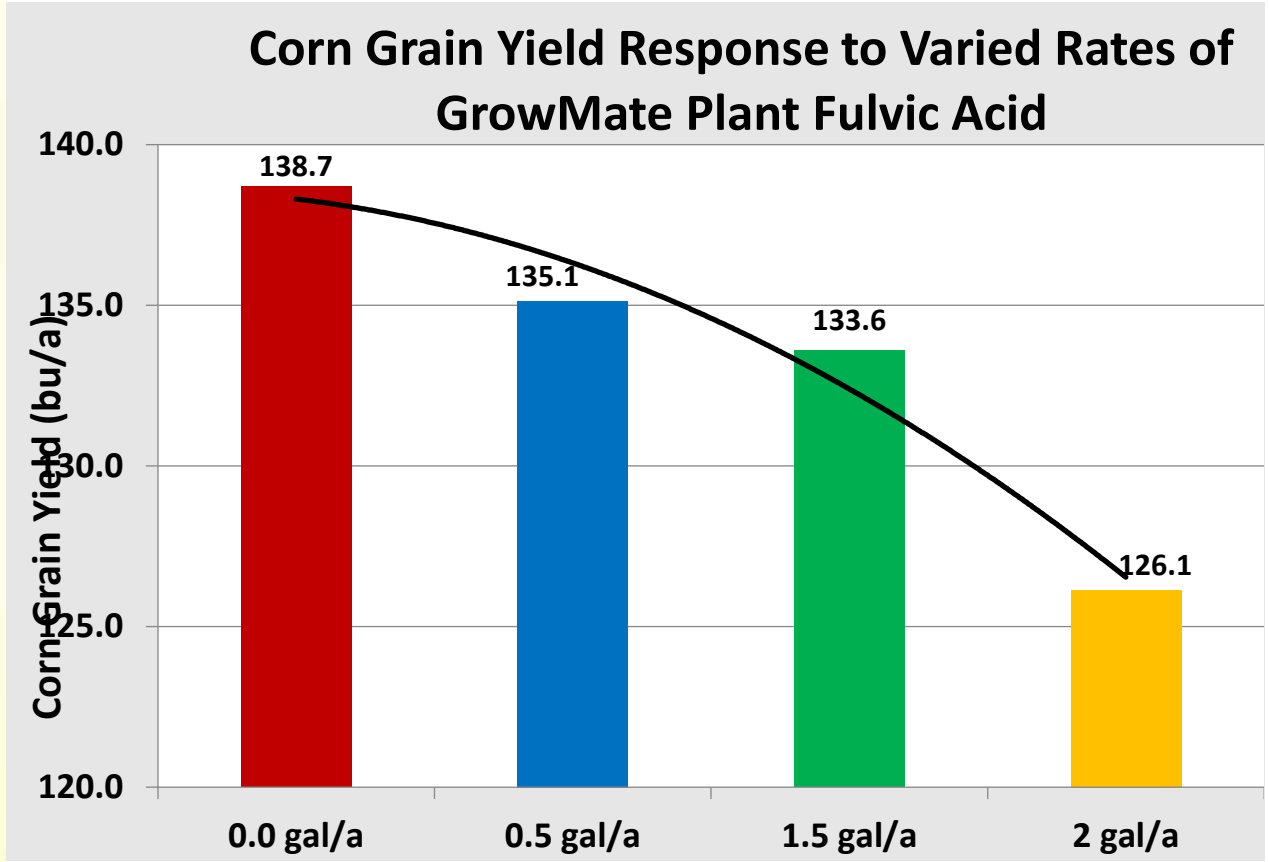
- Very low application rates—negligible nutrient input
- They make soil micronutrients more available? Must then prove micronutrients are limiting crop growth. Does not explain plant responses to foliar applications or responses in hydroponic systems.
- Excessive application rates lead to diminished crop benefits or even yield loss. USDA research, and also Rose et al. (2014) review.
- Limited evidence: Negative responses for corn in seasonally flooded soils

# How much carbon are we adding via humic products?

| Carbon source | Carbon input to soil (kg $ha^{-1}$) |
|---|---|
| Humic product (2 gallon/acre, 20% HA+FA) | 2 |
| Crop residues (5 tons $ha^{-1}$) | 2150 |
| Soil organic carbon (2% SOC, 6-inch plow layer, 1.2 g/ $cm^3$ bulk density) | 1,800,000 |

# Toxic effects at excessive rates



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# Very different corn grain yield response under excessively wet conditions, 2018.

| Factor | Trt Mean | Proc Mixed Pr>F | Proc Mixed LSD Pr>F | Proc Mixed Dunnett's Pr>F |
|---|---|---|---|---|
| Corn Combine Whole-Pass Grain Yield Bu/a @ 15.5% Market Moisture | | | | |
| Trt 1 (Control) | 182.4 | | | |
| Trt 2 (32 oz/a Enersol) | 183.0 | | | |
| Trt 3 (64 oz/a Enersol) | 169.8 | | | |
| Main Trt Effect | | 0.1753 | | |
| Trt 1 vs. Trt 2 | | | 0.9317 | 0.9942 |
| Trt 2 vs. Trt 3 | | | 0.1026 | . |
| Trt 1 vs. Trt 3 | | | **0.1161** | 0.1933 |
| | | | | |
| Corn Combine Whole-Pass Grain Yield Mg/ha @ 15.5% Market Moisture | | | | |
| Trt 1 (Control) | 11.45 | | | |
| Trt 2 (32 oz/a Enersol) | 11.49 | | | |
| Trt 3 (64 oz/a Enersol) | 10.66 | | | |

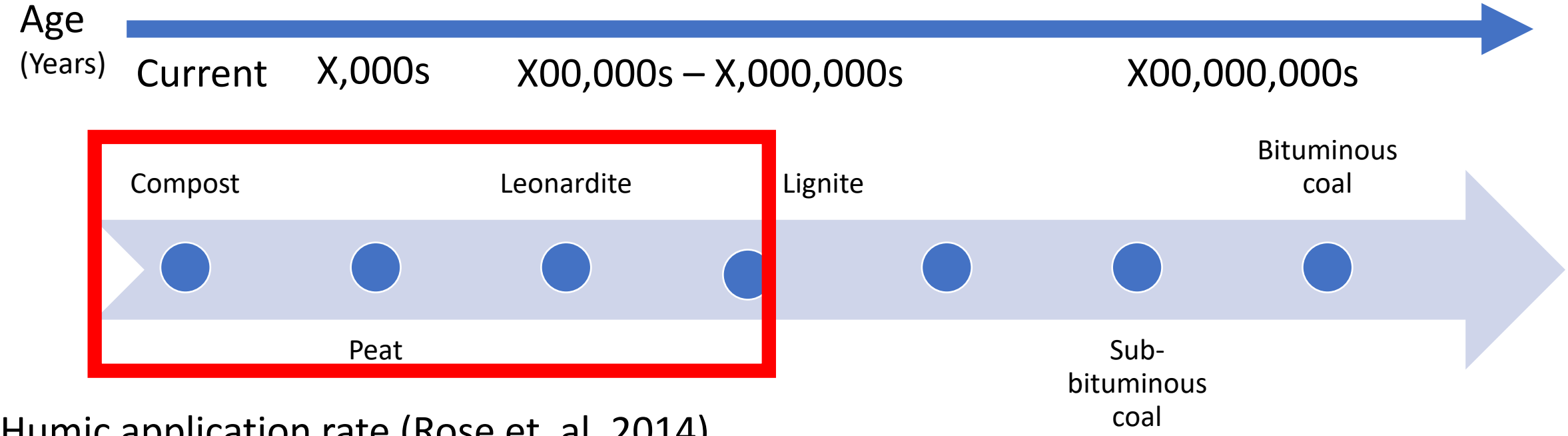
# Our thoughts (Per the Scientific Process)

- The active ingredient is NOT the whole humic acid molecule or the whole fulvic acid molecule. Literature review on soil humic substances: plant growth promotion not linked with one specific fraction or subfraction (Zandonadi et al., 2013).

- The active ingredient(s) is/are specific biochemical compounds that mimic life-promoting compounds. These active compounds are likely NOT true hormones.

- What might the nature and origin of these compounds be?

- A geologic view:




Humic application rate (Rose et. al, 2014)

1,000+ ppm

<200 ppm

Amino acids,
Carbohydrates

X

Lignin,
Phenols

Aromatic rings,
Fatty acids

X

# Conclusions

- Field efficacy of humic products in Iowa was demonstrated (1) especially during environmental stresses, and (2) by positive grain yield responses of corn at medium to high N fertilizer rates.

- At low N fertilizer rates, corn grain yield decreased with humic product use. This product did NOT make N more available to the crop.

- Multiple mechanisms might explain humic product field efficacy. Our data and previous results in Iowa are inconsistent with nutrient-based mechanisms. Instead, humic products might contain mimics of growth-promoting compounds, possibly of lignin origin.


THANK
YOU