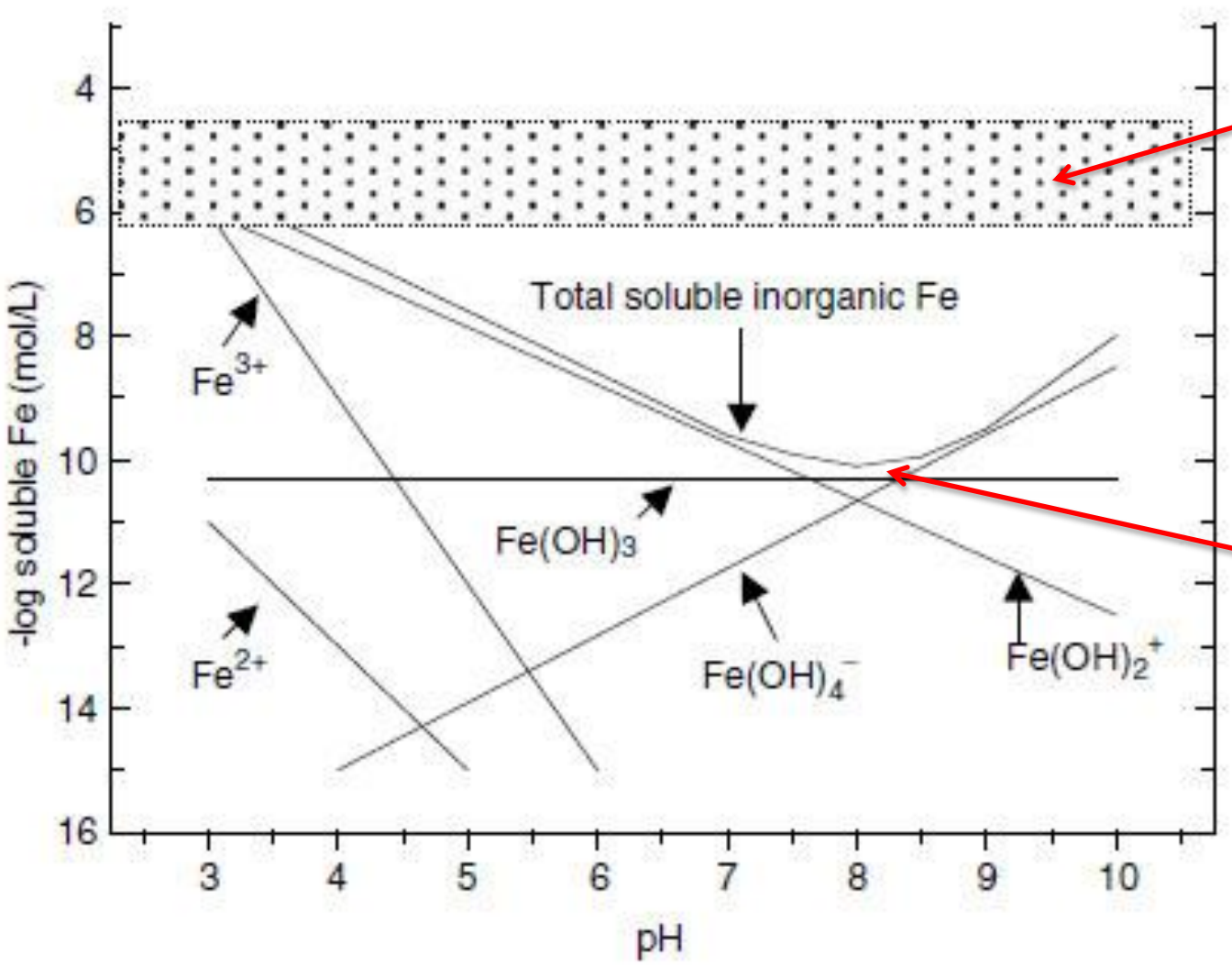
# Iron deficiency chlorosis in soybeans.....causes and control measures

R. Jay Goos

Professor Emeritus, NDSU

- Iron in soils
  - Primary minerals, “black sand”
  - Secondary minerals, mostly $Fe^{3+}$ oxides
  - $Fe^{2+}$ only with >prolonged< waterlogging

- Solubility of $Fe^{3+}$ oxides in soil VERY LOW
- Bottoms out at a pH of about 8




What plants need

What minerals provide

Marshner, Lindsay

- The common factor in all cases of IDC
- Calcium carbonate ("lime") in the topsoil

- Where do we find lime in the topsoil?
- Glacial till-derived soils
  - Eroded knobs
  - The "low flat" affected by a high water table in the spring

- Glacial till terrain, $CaCO_3$ in topsoil, eroded knob and "low flat"

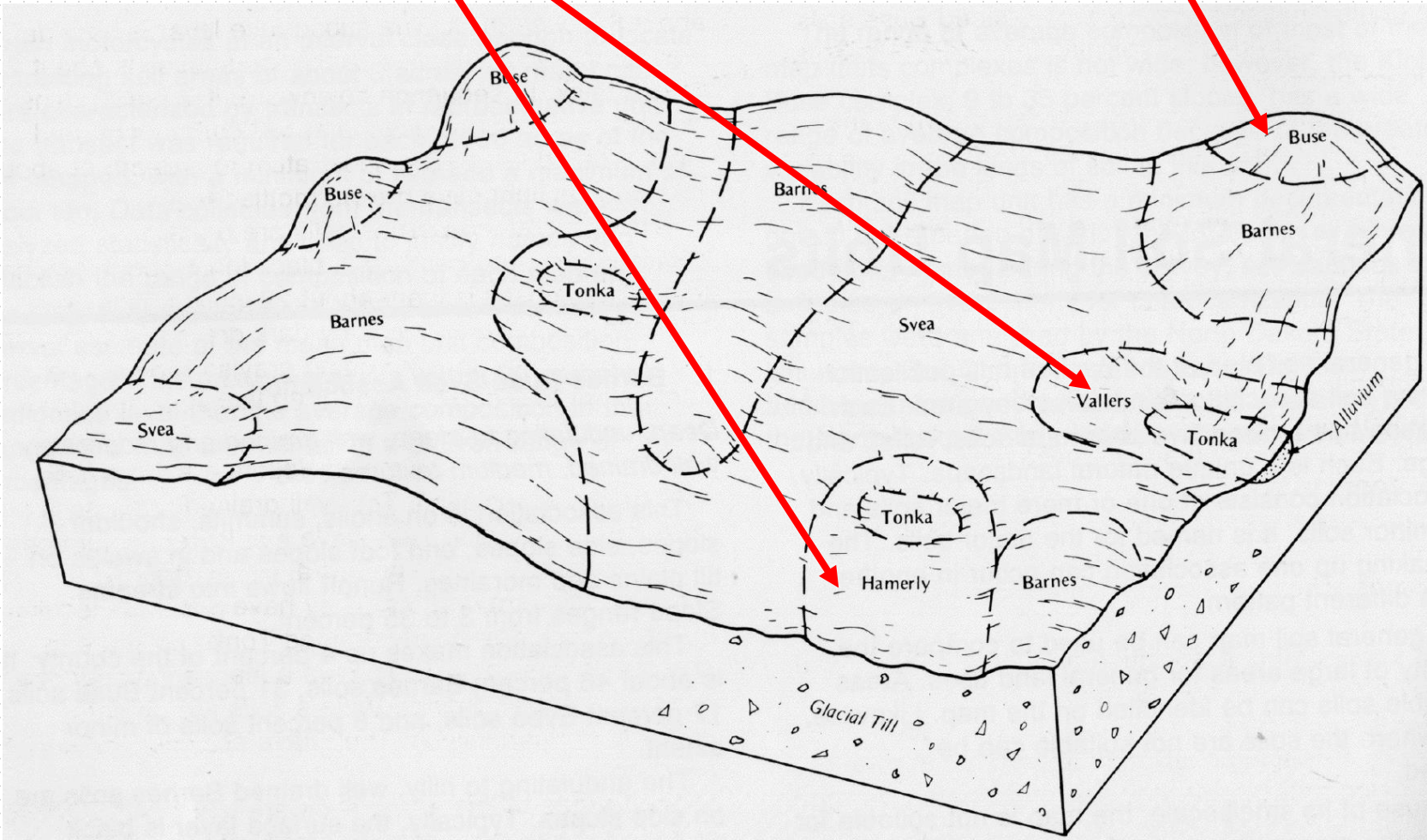
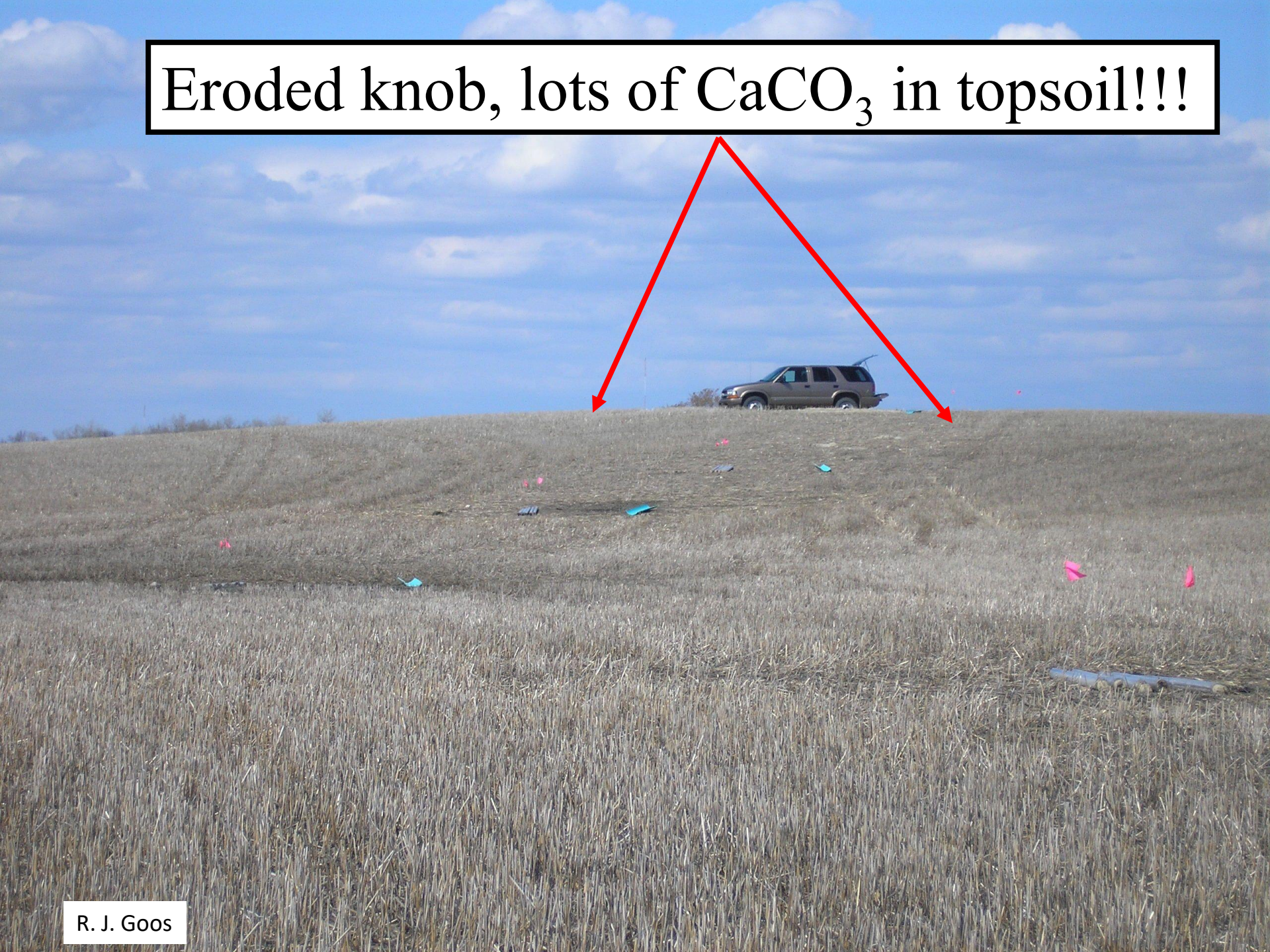



Figure 2.—Typical pattern of soils and parent material in the Barnes-Svea-Buse association.

NRCS


Eroded knob, lots of $CaCO_3$ in topsoil!!!
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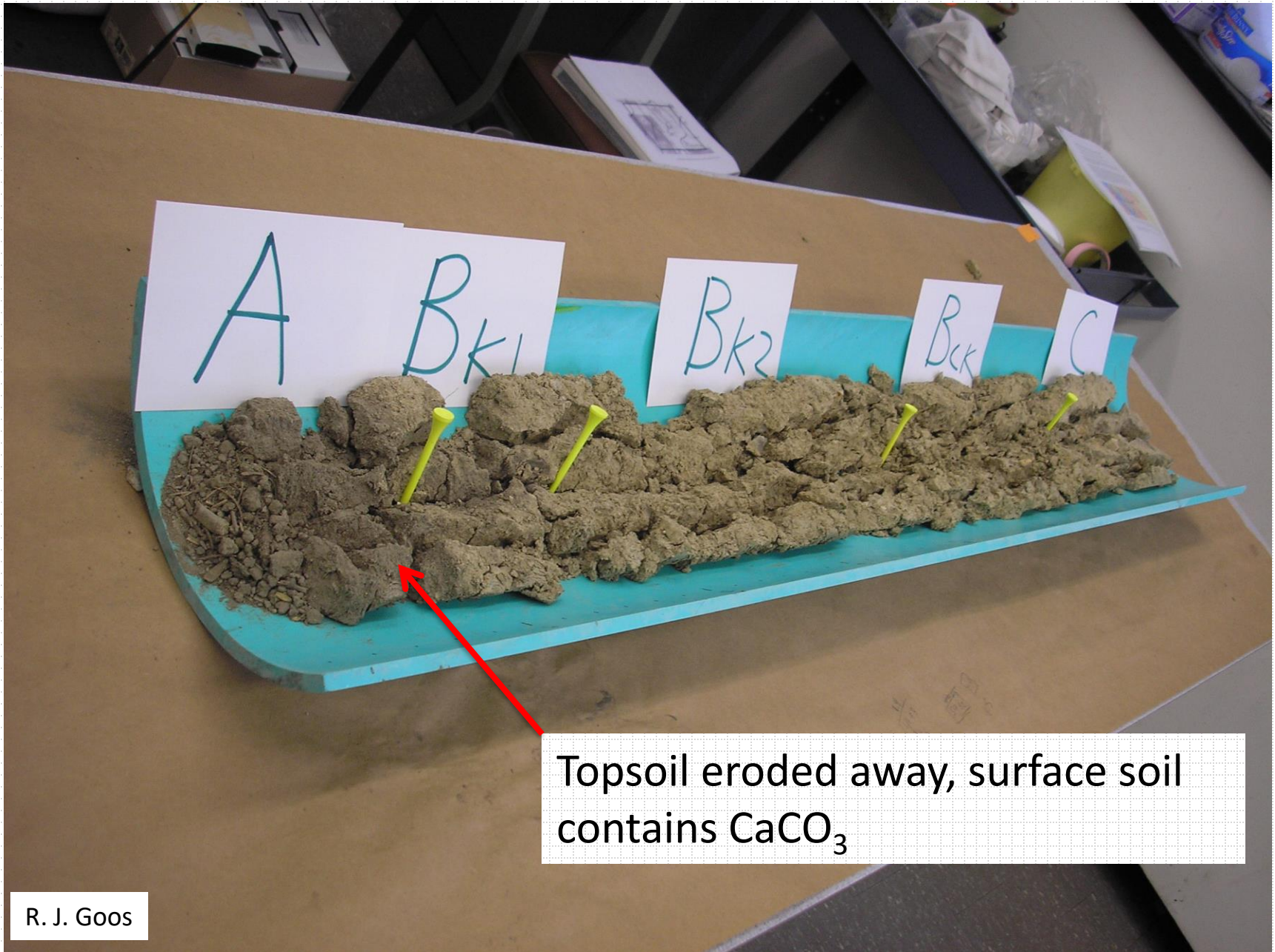
- Soil from eroded knob



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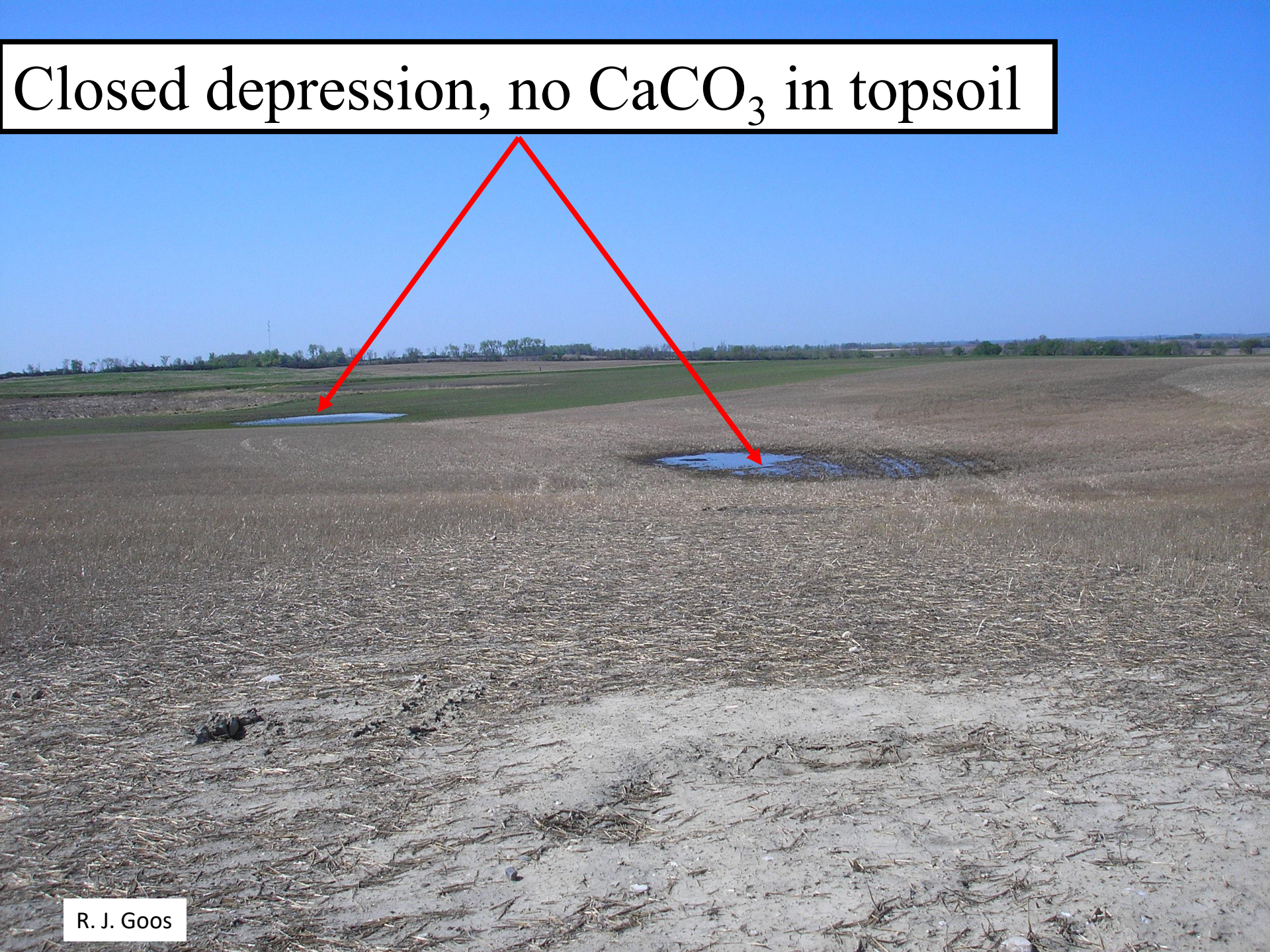
Closed depression, no $CaCO_3$ in topsoil
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Low flat, lots of $CaCO_3$ in topsoil!!!
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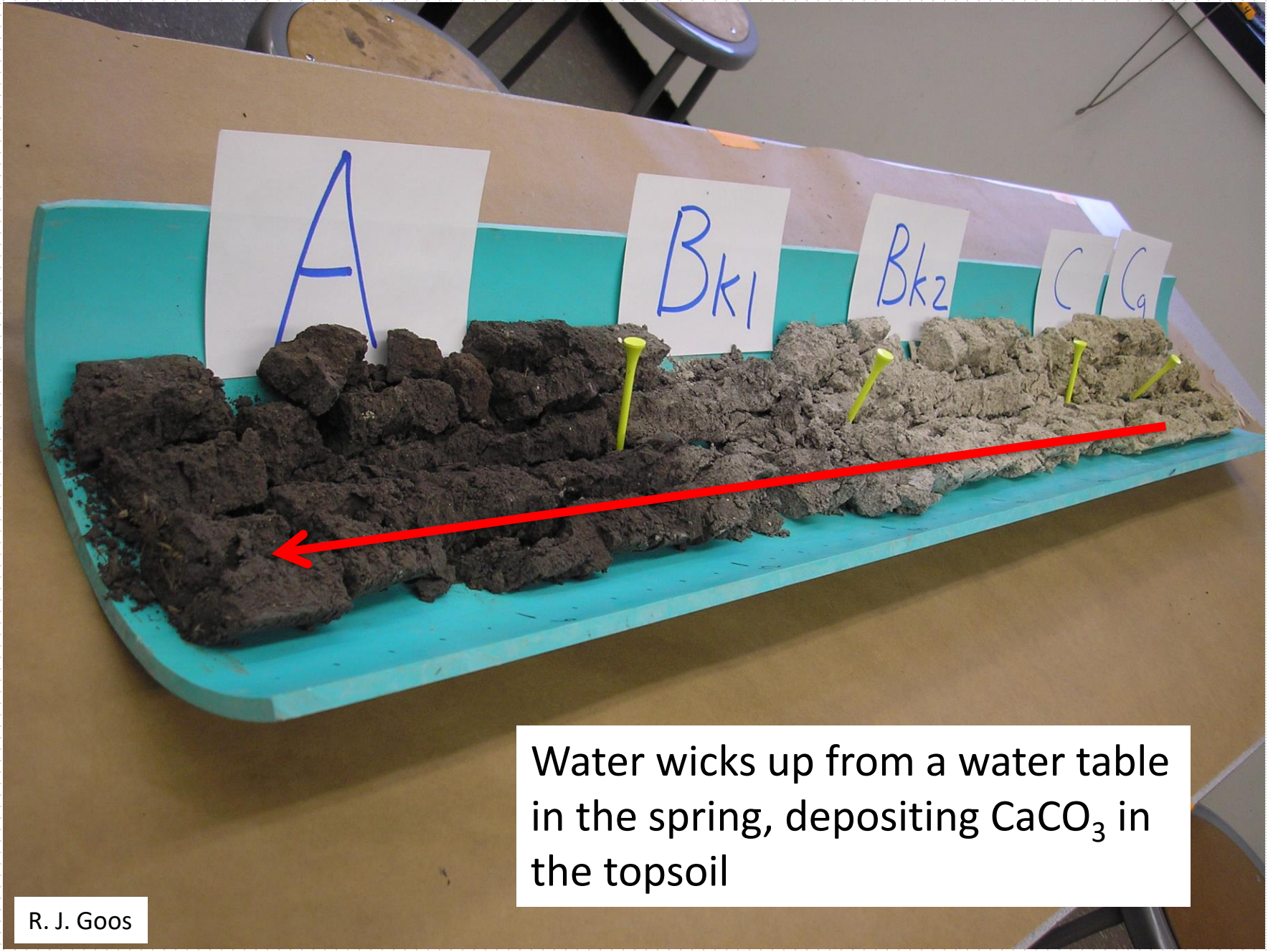
- Soil from low flat




Water wicks up from a water table in the spring, depositing $CaCO_3$ in the topsoil

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- Where do we find lime in the topsoil?
- Lacustrine-derived soils (Red River Valley)
  - Microrelief is very subtle, often less than 1-2' elevation difference in a field


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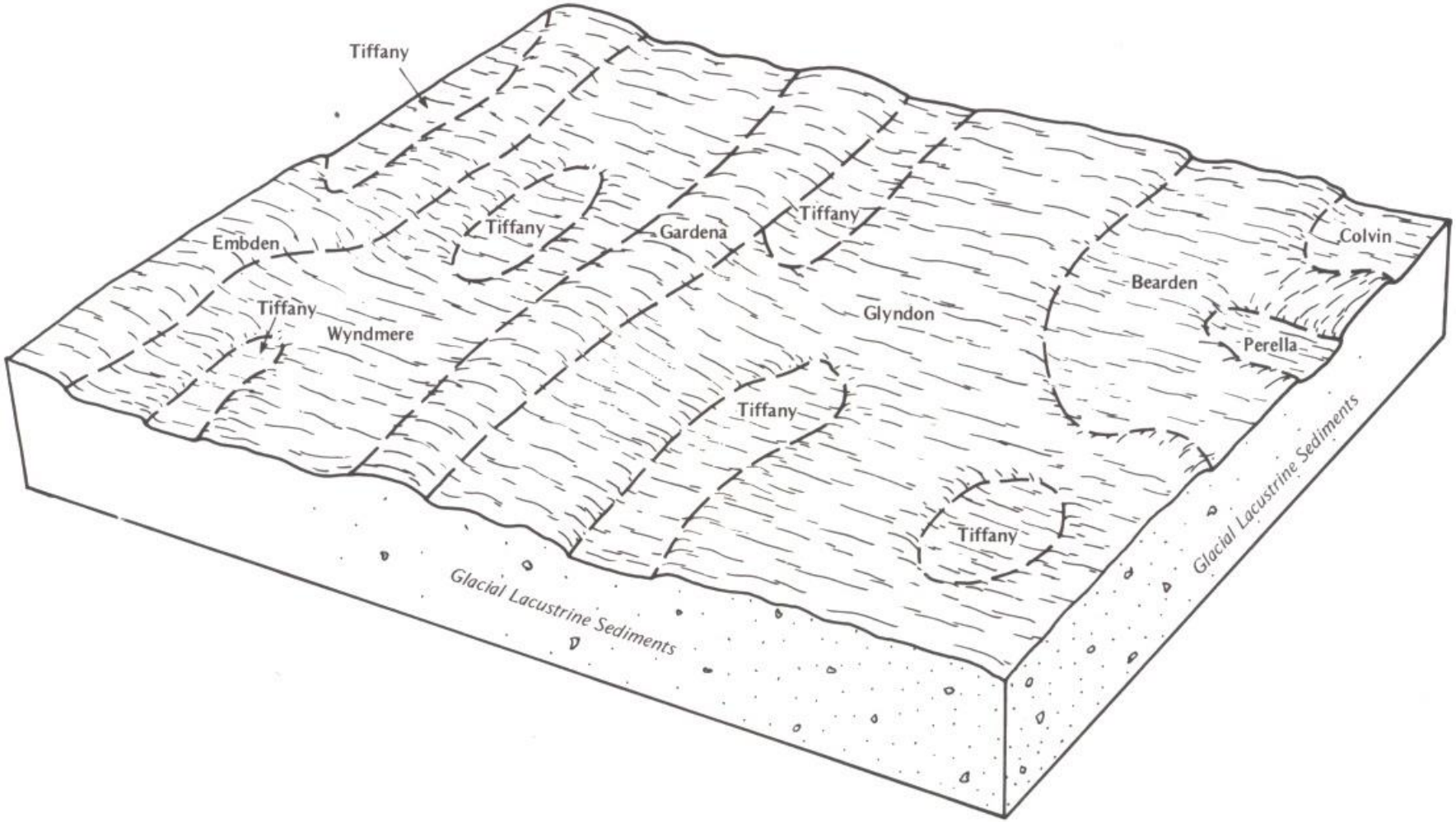
Elevation differences of ~1 foot can make a big difference

Where do we find lime in the topsoil in this field?

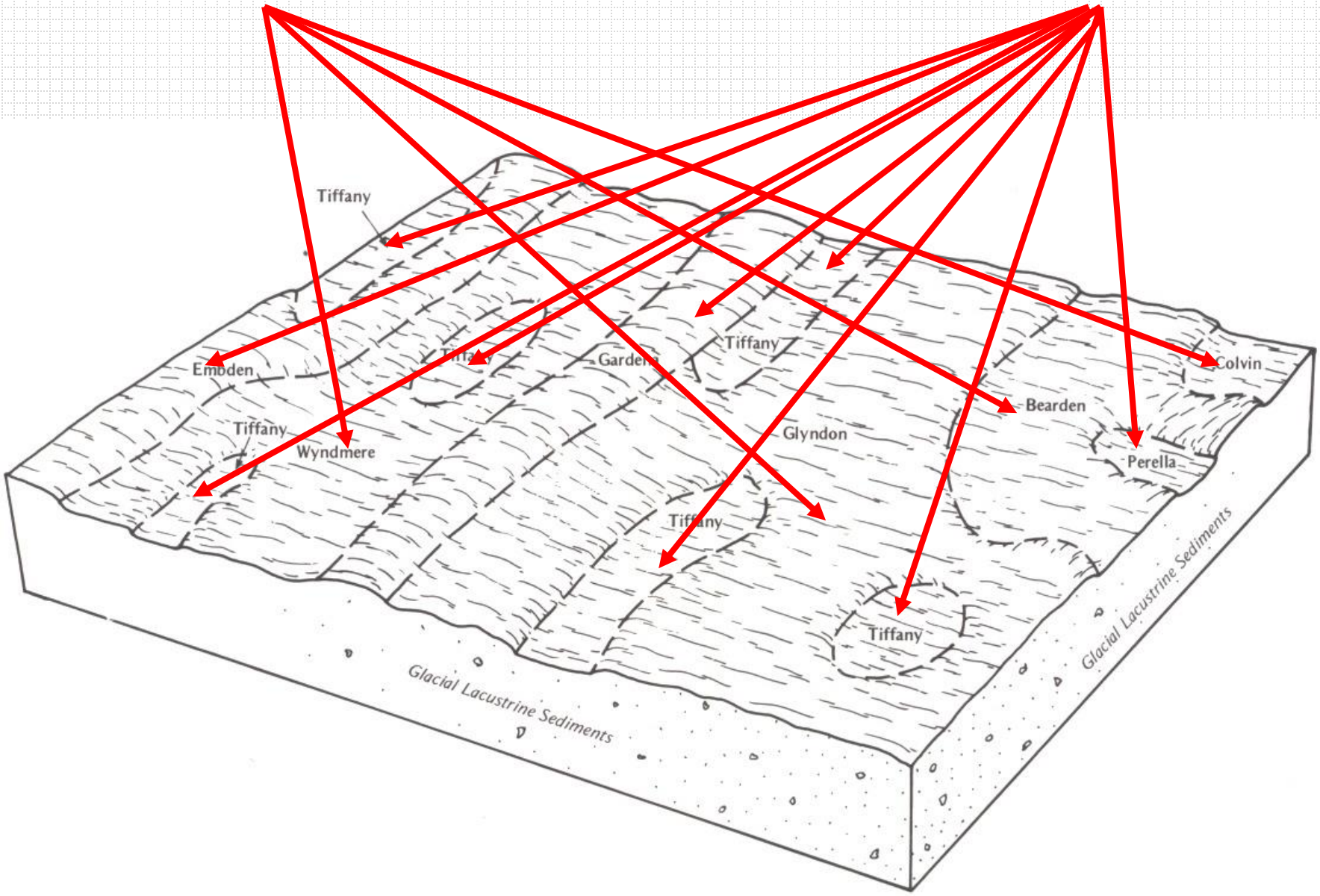



NRCS

- $CaCO_3$ in topsoil?

Yes

No

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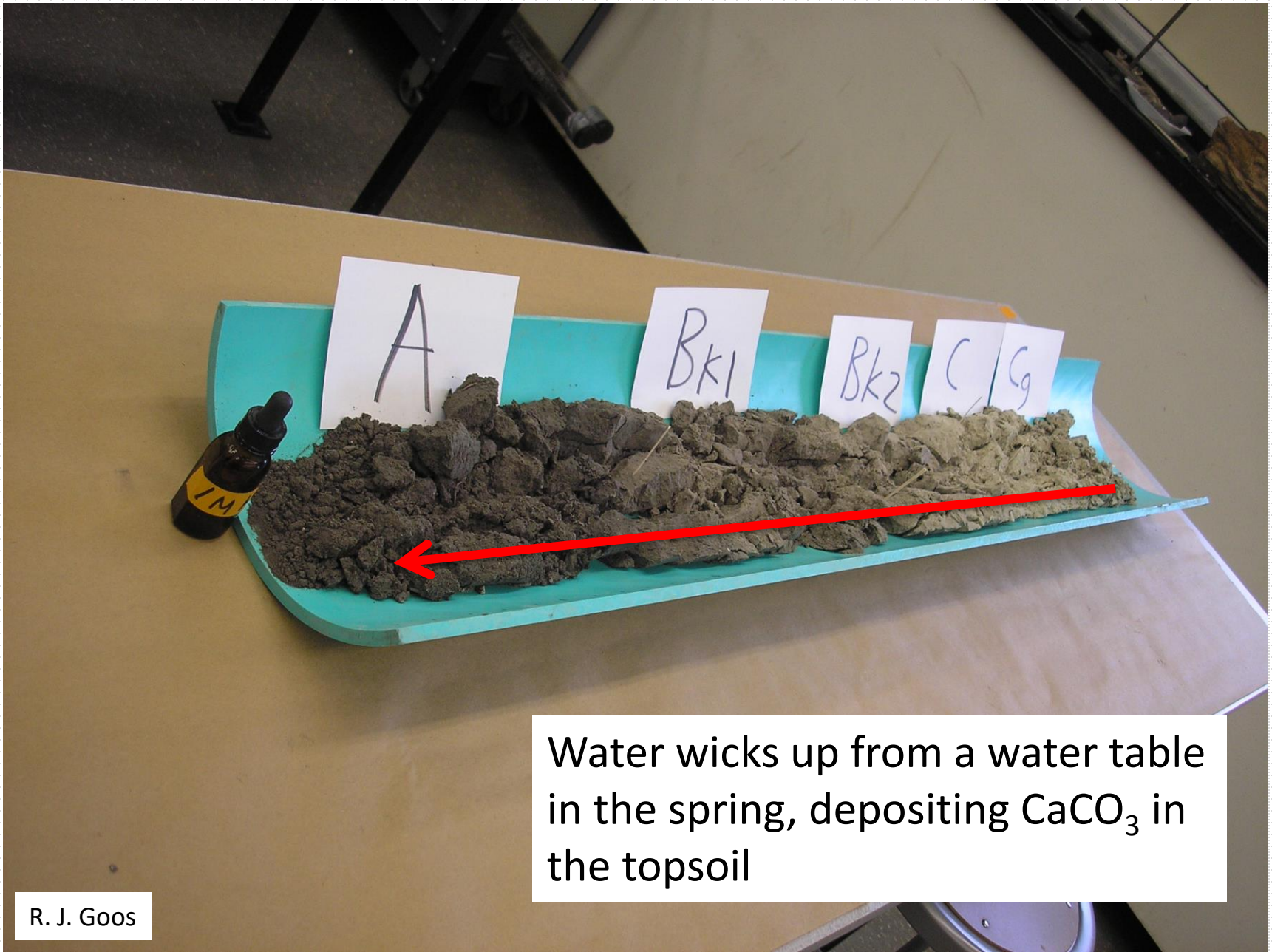
- Typical lacustrine soil giving chlorosis




Water wicks up from a water table in the spring, depositing $CaCO_3$ in the topsoil

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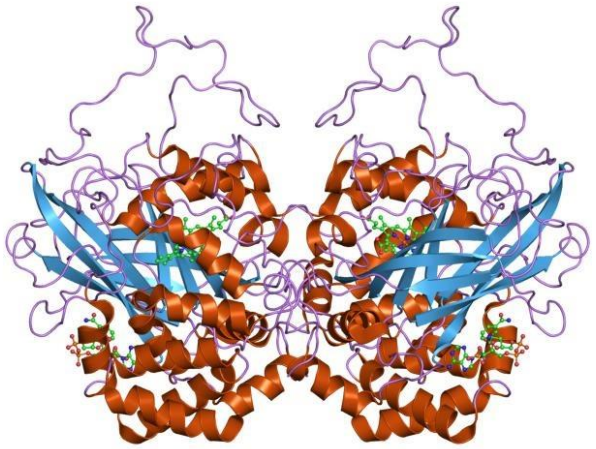
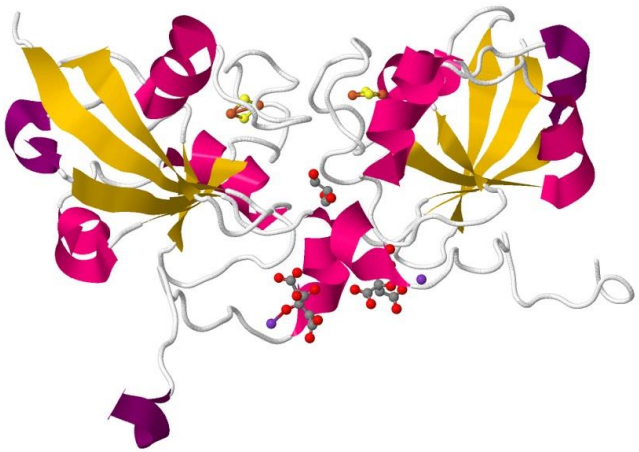
- Why is lime a problem?
- Buffers pH of soil around 8
  - The low point of Fe solubility
- Produces $HCO_3^-$ in the soil solution
  - Interferes with iron uptake and metabolism
- Other related factors
  - Wetness (produces more $HCO_3^-$)
  - Salinity
- Elevated nitrate in the soil

- Roles of Fe in plant nutrition
- Fe-heme proteins and enzymes, Fe-S proteins



Catalase (heme)



Ferredoxin (Fe-S)

Wikipedia.org

- Iron needed for many enzyme and energy-transfer reactions
- A true micronutrent, maybe 1 lb/A needed
- Can be inactivated inside the plant
- Very immobile in the plant
- Almost universal deficiency symptom: interveinal chlorosis

Colorado State Univ.

Colorado State Univ.

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- Fe deficiency affects the youngest tissues first
- If growing point of the plant is injured, yield is near zero
- Recovery is difficult, once chlorosis sets in

- What is the yield loss from IDC?
- We use 1-5 scale developed by Iowa State


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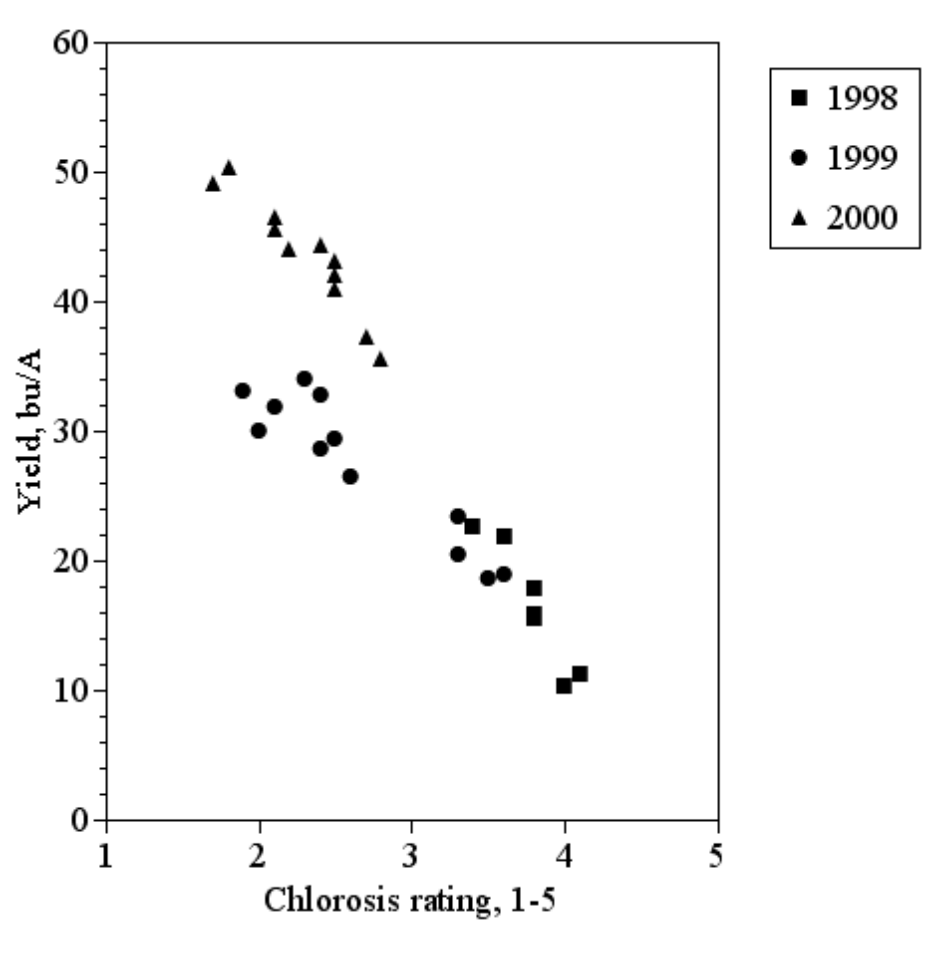


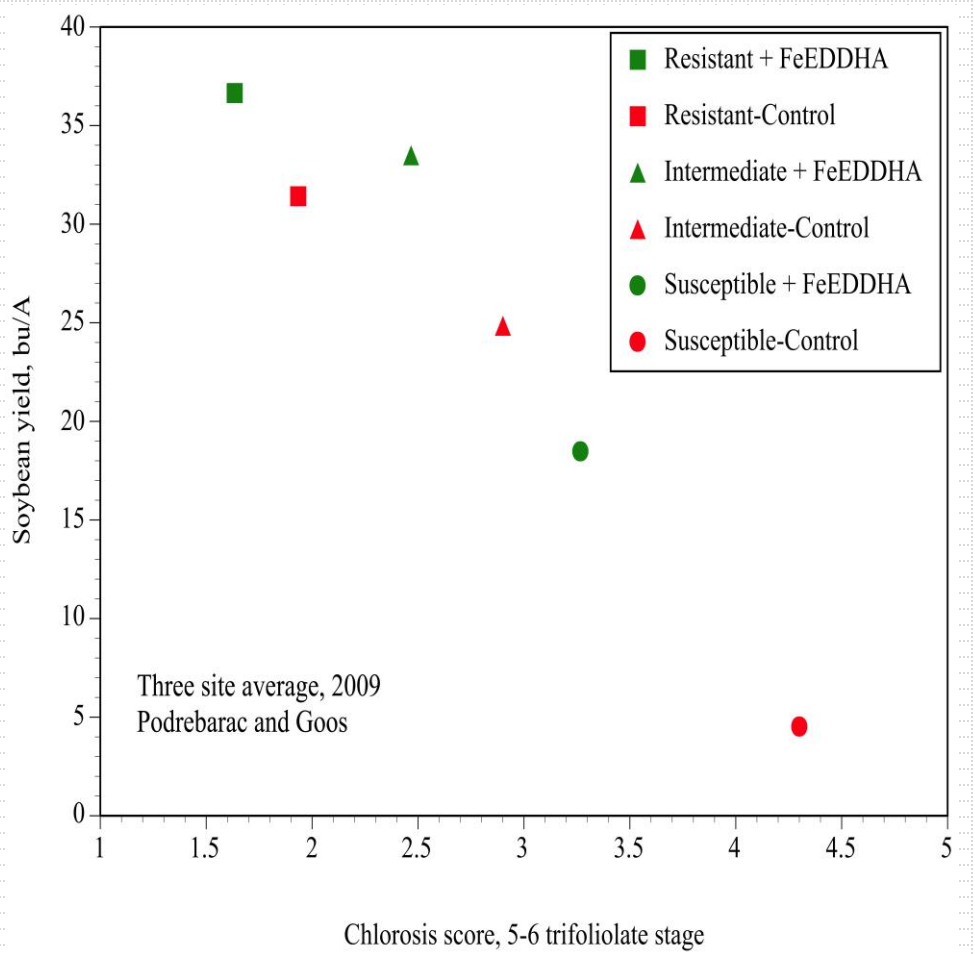


At 5-6 trifoliolate stage, each additional unit of chlorosis decreases yield about 10 bu/A

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- Control measures for IDC
- #1...variety selection
- #2...variety selection
- #3...variety selection
- Other control measures “stack” on top of a resistant variety, but can’t replace a resistant variety

- What does a more resistant variety do?
  - More active Fe uptake
  - Better internal Fe transport
  - 7 genetic associations, each giving a little bit

PLOS ONE

PUBLISH ABOUT BROWSE

OPEN ACCESS PEER-REVIEWED

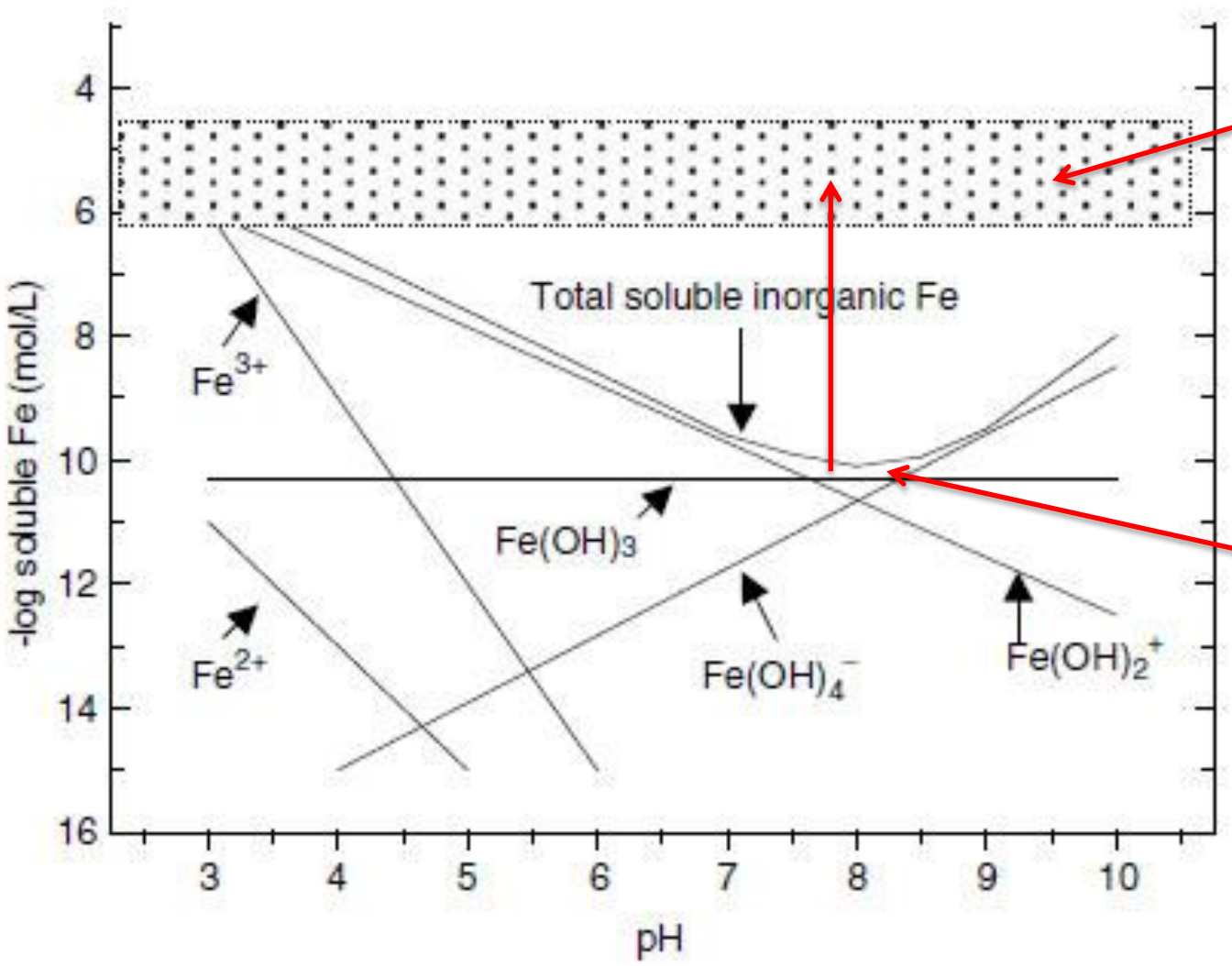
RESEARCH ARTICLE

# Genome-Wide Association Studies Identifies Seven Major Regions Responsible for Iron Deficiency Chlorosis in Soybean (*Glycine max*)

Sujan Mamidi, Rian K. Lee, Jay R. Goos, Phillip E. McClean

Published: September 16, 2014 • https://doi.org/10.1371/journal.pone.0107469

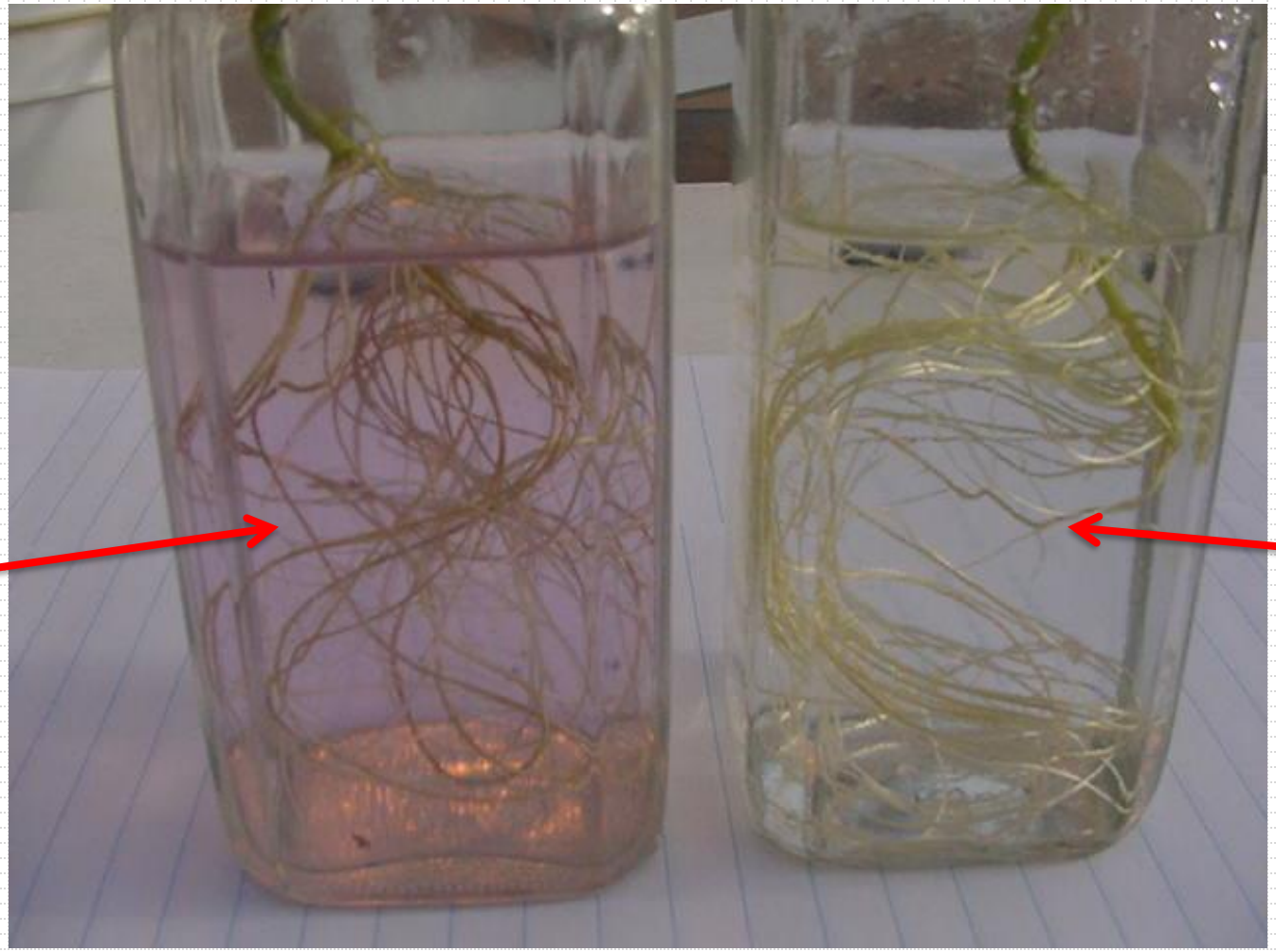
- Plants increase Fe availability at the root by reduction, acidification, and chelation




What plants need

What minerals provide

Marshner, Lindsay

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- Some varieties are good at obtaining Fe from the soil

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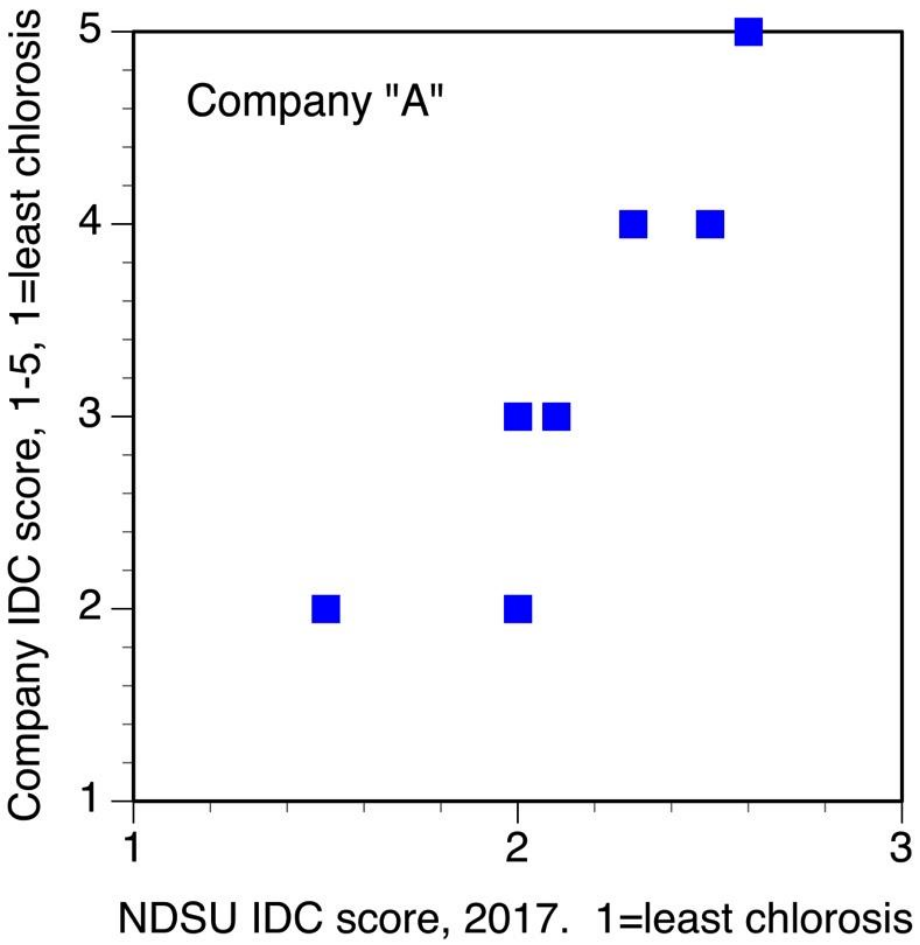
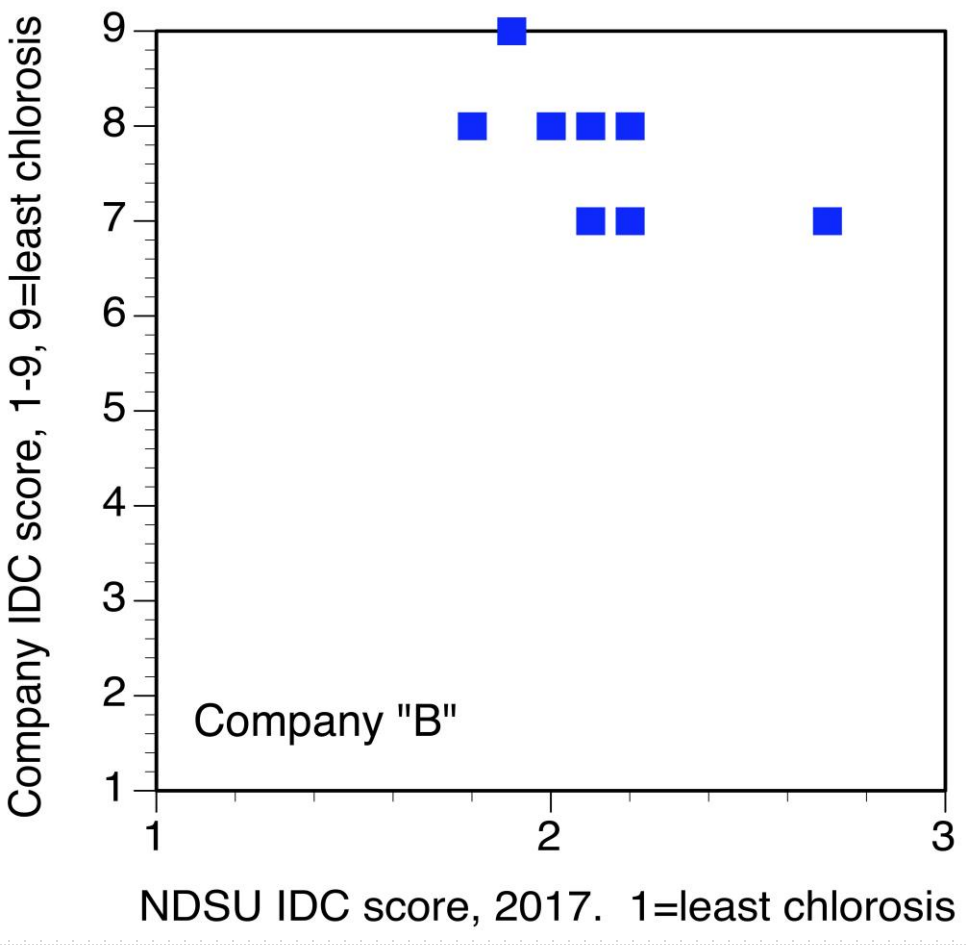
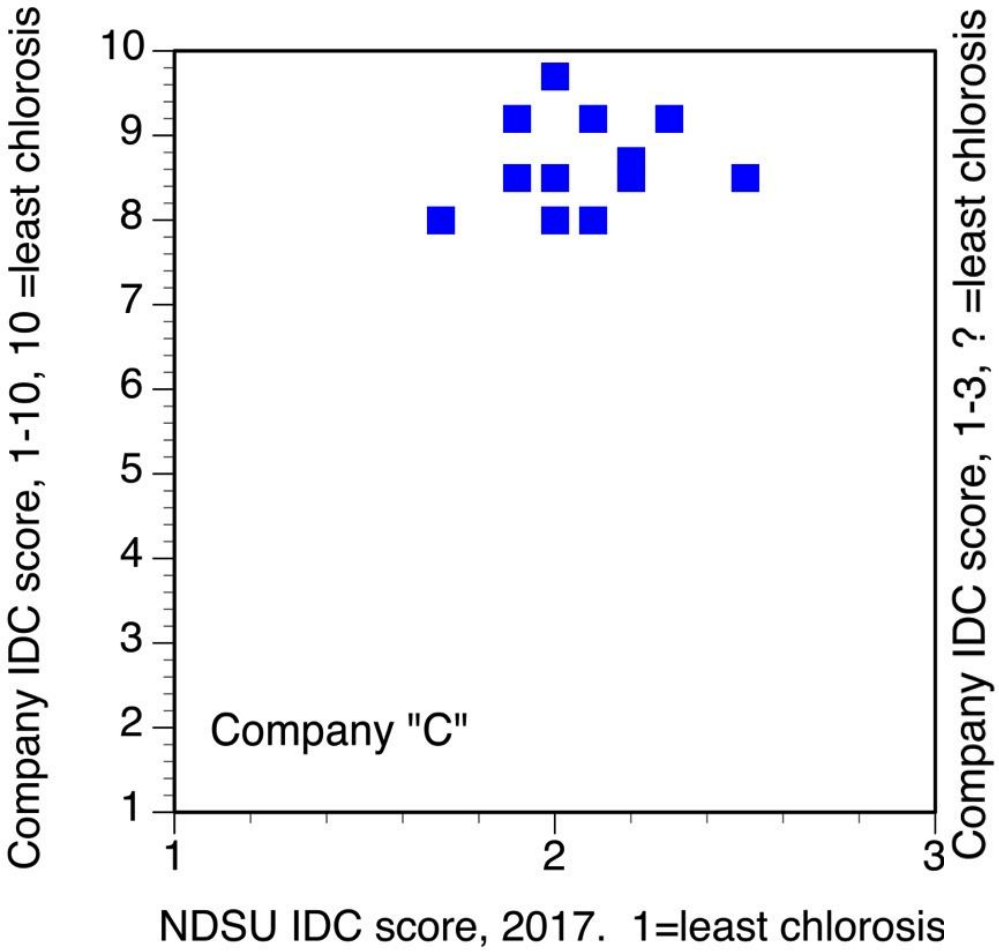
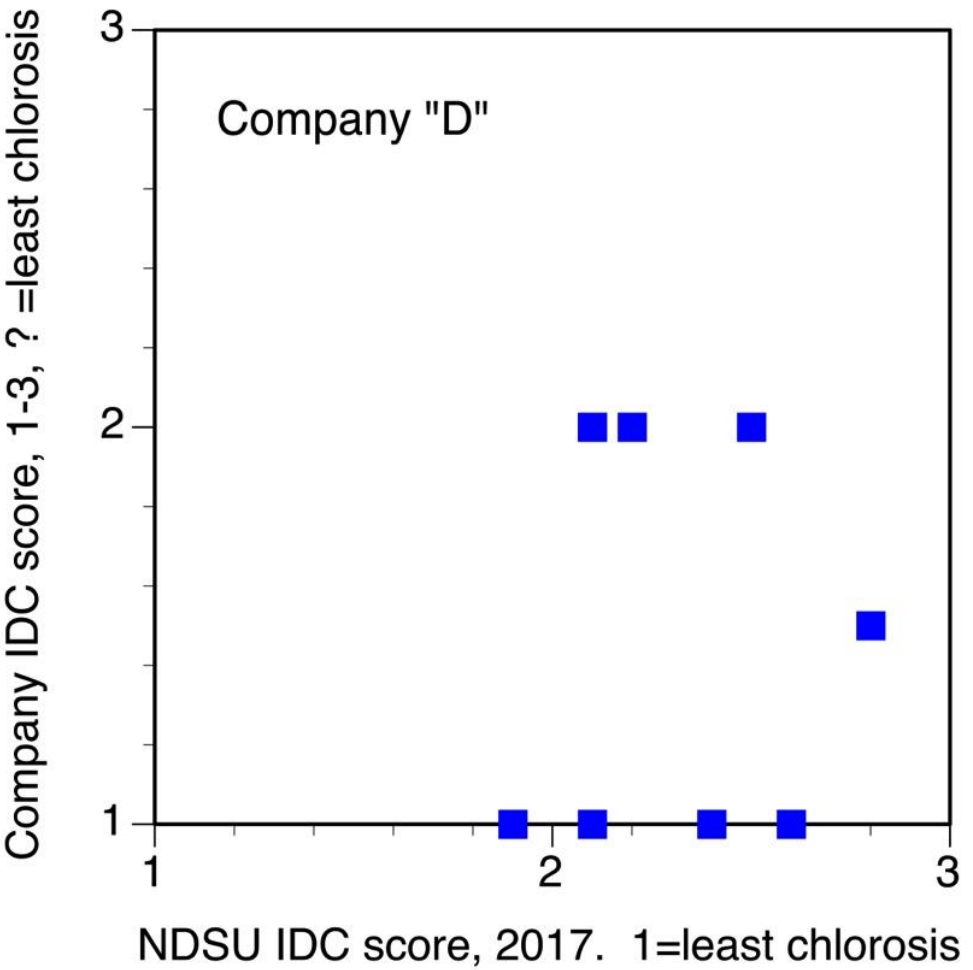
- So…it's easy, right??? Just plant an IDC-resistant variety!!!
- I wish it was that easy…
- "The problem of IDC is as bad as it ever was….because the varieties are as bad as they ever were." (a famous soil scientist)
- What I call "The Lake Wobegon Effect"
  - "All of the children are above average"


Company "A"
Company IDC score, 1-5, 1=least chlorosis
NDSU IDC score, 2017. 1=least chlorosis
1
2
3
4
5


Company "B"
Company IDC score, 1-9, 9=least chlorosis
NDSU IDC score, 2017. 1=least chlorosis
1
2
3
4
5
6
7
8
9

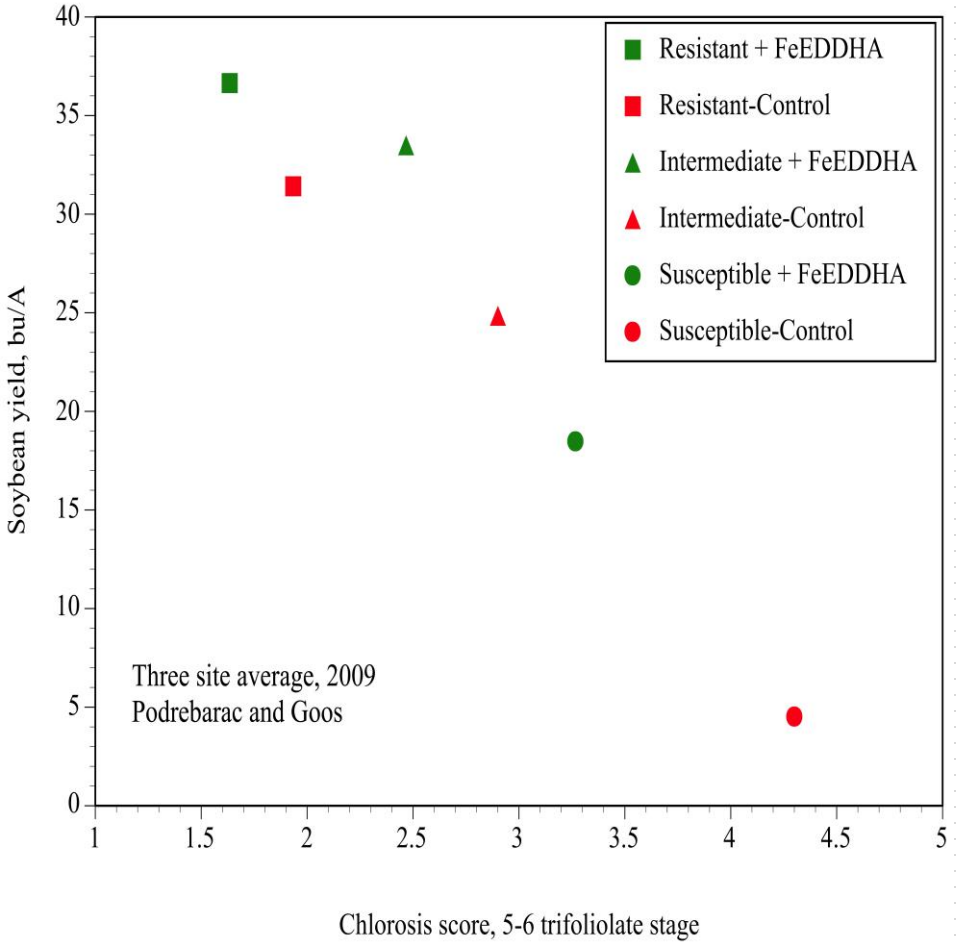



Many seed companies need to do a LOT better

- Other control measures in perspective
- Genetics….the 7 gene associations “stack,” they all give an additional increment of resistance
- Same with the other control measures, they “stack” on top of variety selection

- Other control measures
  - 2-3 lb/A of a high-quality FeEDDHA or FeHBED in-furrow at planting
  - WON'T MAKE A BAD VARIETY GOOD

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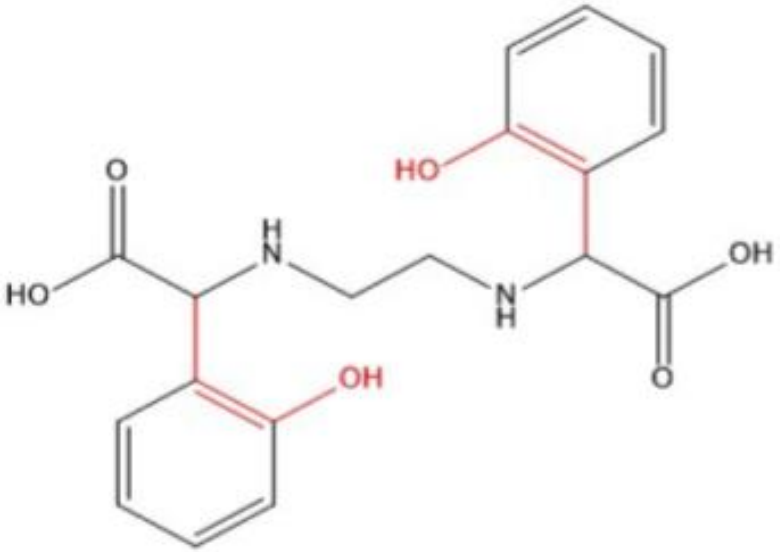
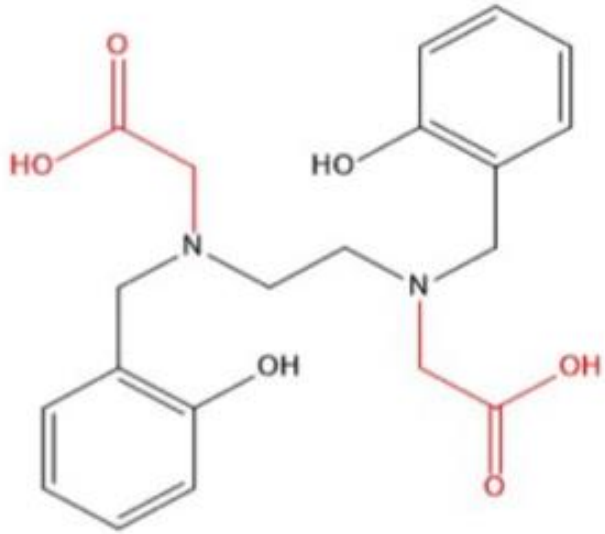
- Iron fertilizers in the marketplace
  - FeEDDHA, higher quality (75-80% ortho-ortho)
  - FeEDDHA, lower quality (50-60% ortho-ortho)
    - Need to use more
  - FeEDDHSA
    - Need to use more
- Newer to the marketplace, FeHBED

- FeHBED, hypothetically better than FeEDDHA
  - Stability constant, 10,000x greater
  - Can be made by a process with no ortho-para problems
  - How does it compare to FeEDDHA?

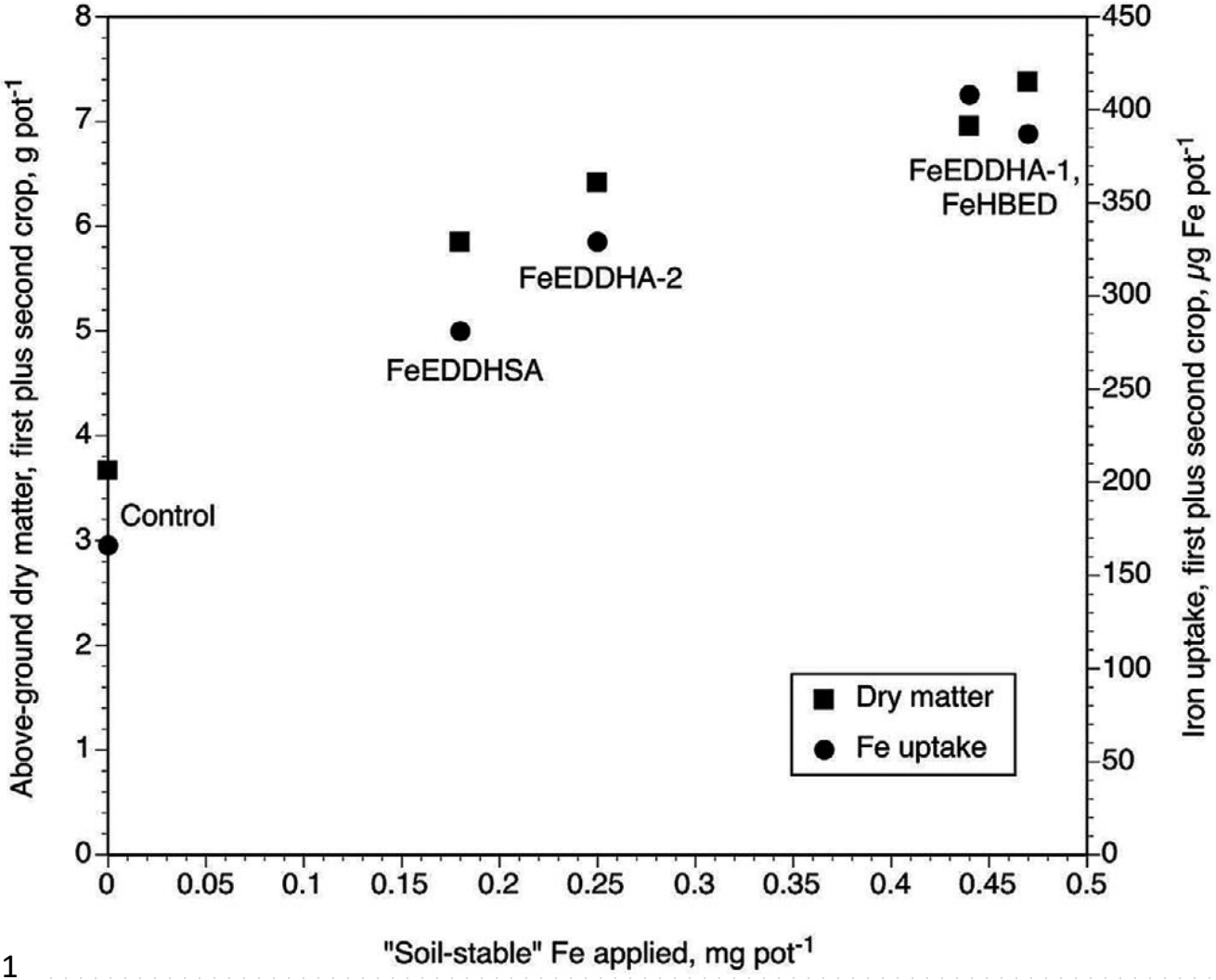



*ortho-ortho* EDDHA, 33.91



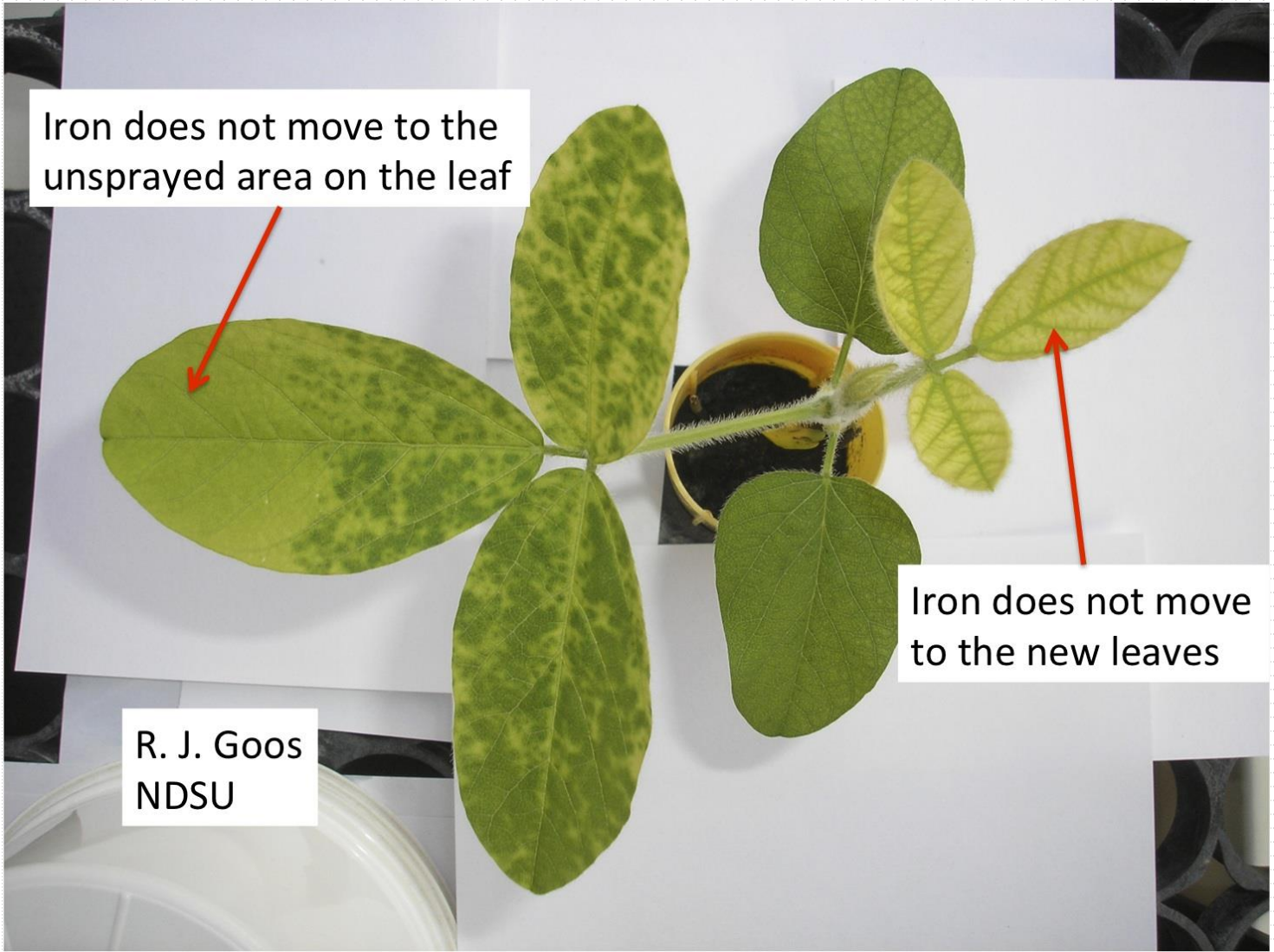

HBED, 39.68

- A high-quality FeHBED product performs the same as a high-quality FeEDDHA

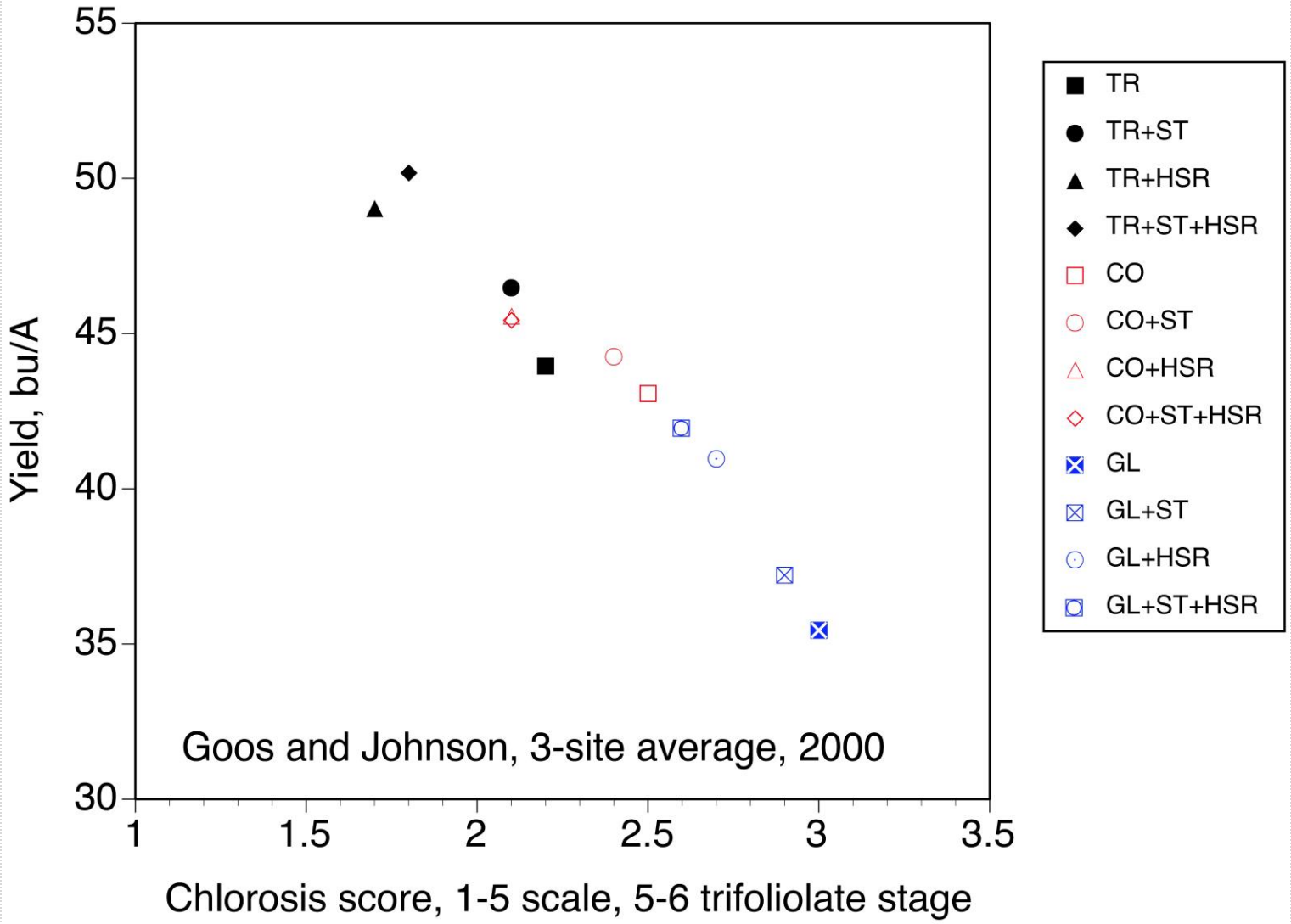



Goos, 2021

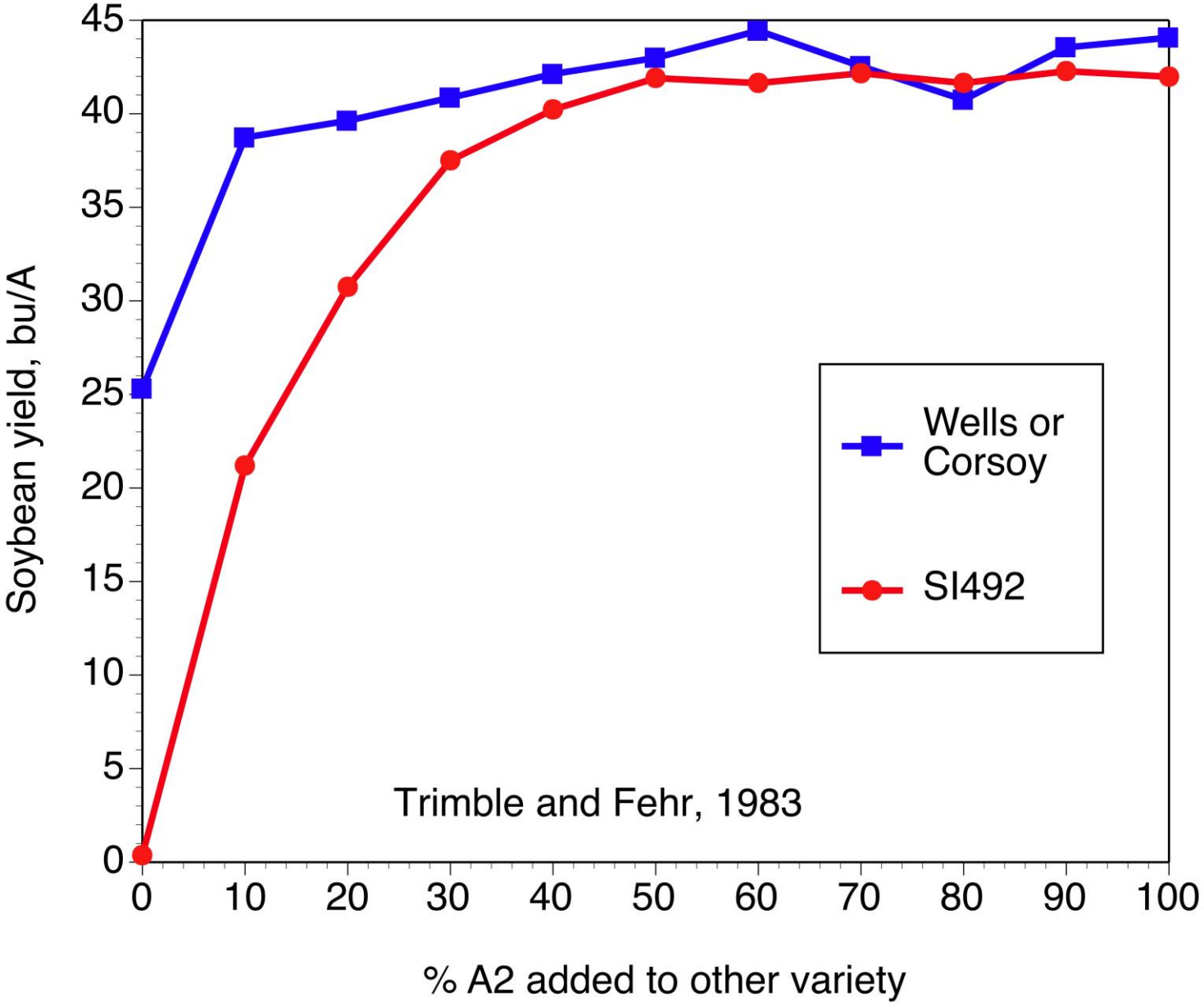
- Foliar sprays….just don’t translocate

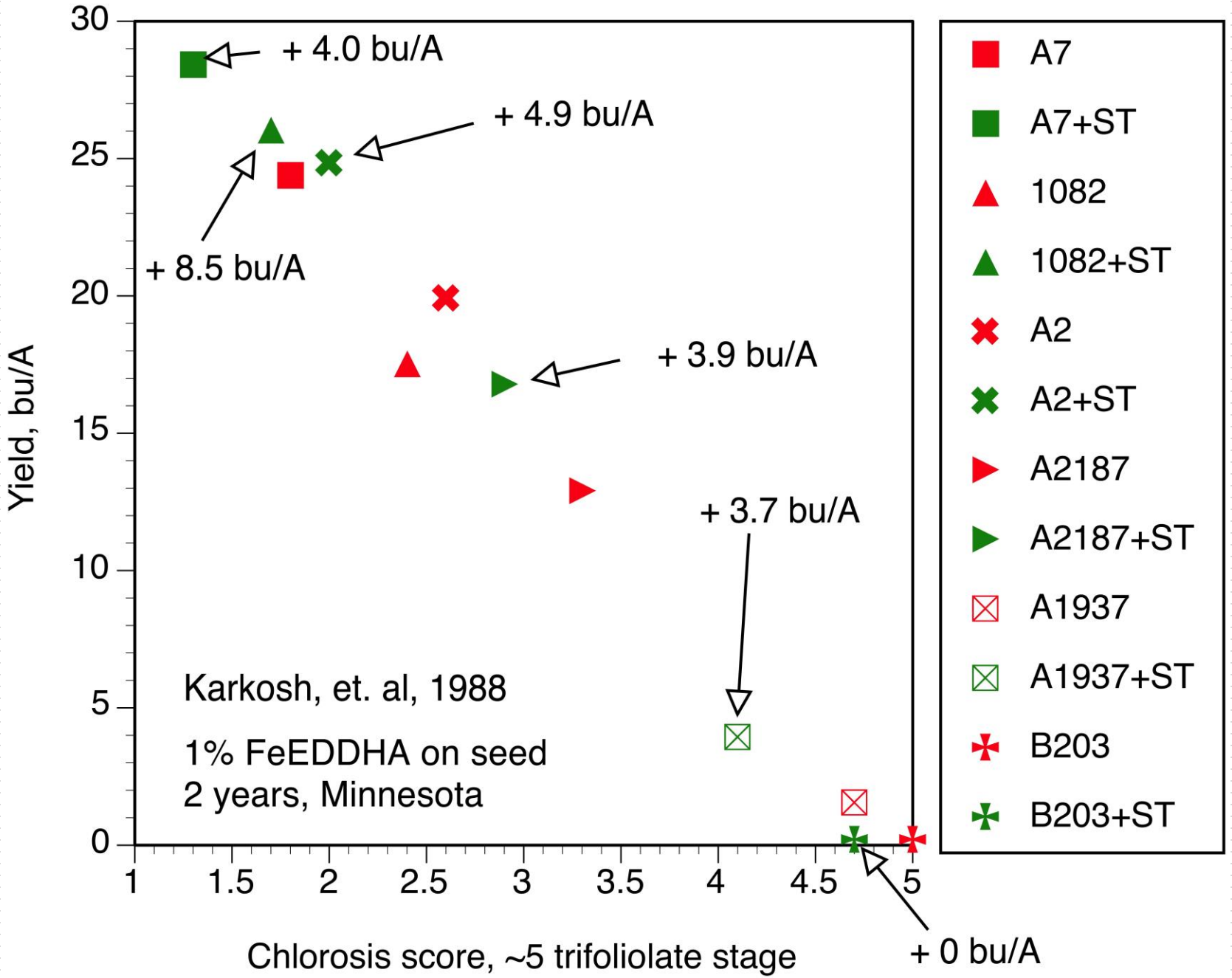


- Another example of how control measures "stack"



- Other control measures worth trying
  - For “spotty” chlorosis (chlorotic areas within a mostly non-IDC field)
    - Variable rate chelate
    - Variety blends
  - Seed treatment needs to be reevaluated now that we have better-quality chelates


Soybean yield, bu/A
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
% A2 added to other variety
Wells or Corsoy
SI492
Trimble and Fehr, 1983


30
25
20
15
10
5
0
Yield, bu/A
1
1.5
2
2.5
3
3.5
4
4.5
5
Chlorosis score, ~5 trifoliolate stage
+ 4.0 bu/A
+ 4.9 bu/A
+ 8.5 bu/A
+ 3.9 bu/A
+ 3.7 bu/A
+ 0 bu/A
Karkosh, et. al, 1988
1% FeEDDHA on seed
2 years, Minnesota
A7
A7+ST
1082
1082+ST
A2
A2+ST
A2187
A2187+ST
A1937
A1937+ST
B203
B203+ST

- But, we need to be asking new questions about IDC, based on the concept that control measures “stack”
- Medical analogies
  - Doctors often treat the cause >and< the effects of a problem

- To summarize….

- IDC occurs with $CaCO_3$ in the topsoil
  - Usually due to poor drainage
- Any degree of chlorosis present at the 5-6 trifoliolate stage means that yield was lost
- The “genes exist” for increased resistance to IDC, but it’s complicated
- Additional control measures can be “stacked” on top of a resistant variety for even better control

- Thanks for the invitation to speak