Exciting World of Chelation

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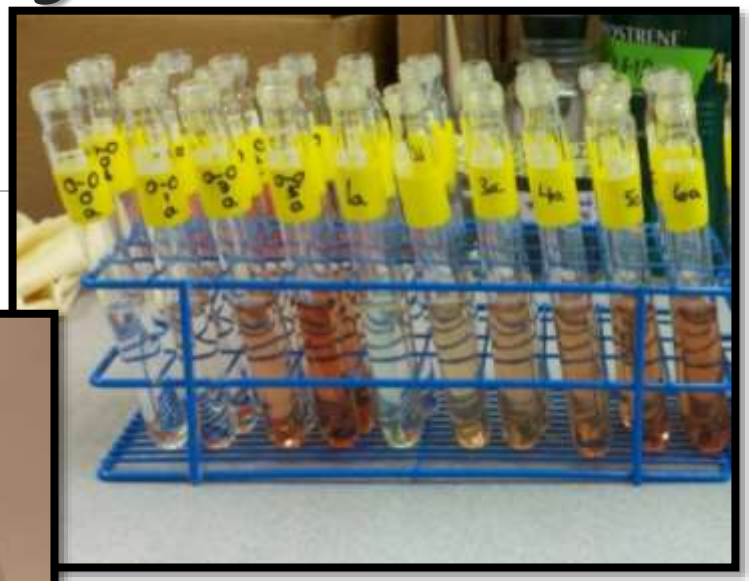

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What We Hope to Learn Today

What is a chelate?

What is a ligand?

Why do we use chelates in soil fertility?

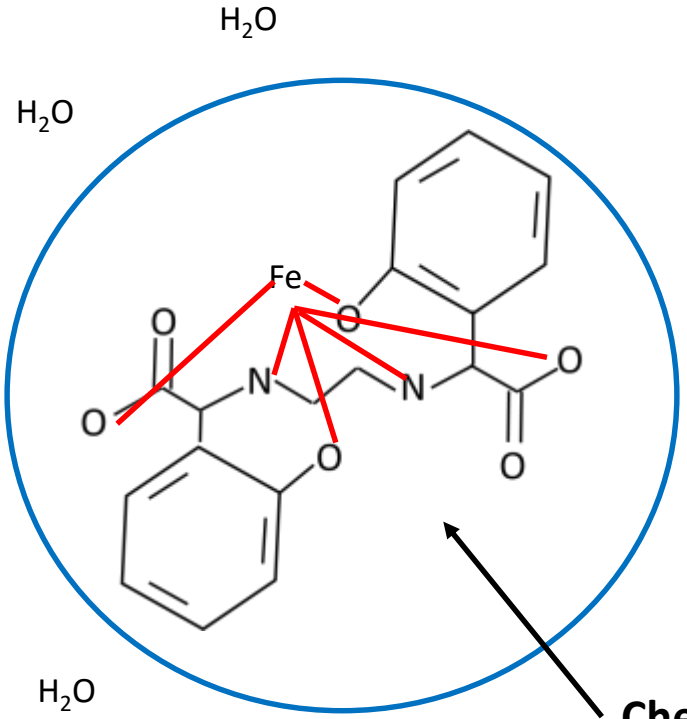
What is a stability constant and why is it important to chelate chemistry?

What causes iron deficiency chlorosis in soybeans.

How chelates play a role in the Fe uptake mechanism of plants.

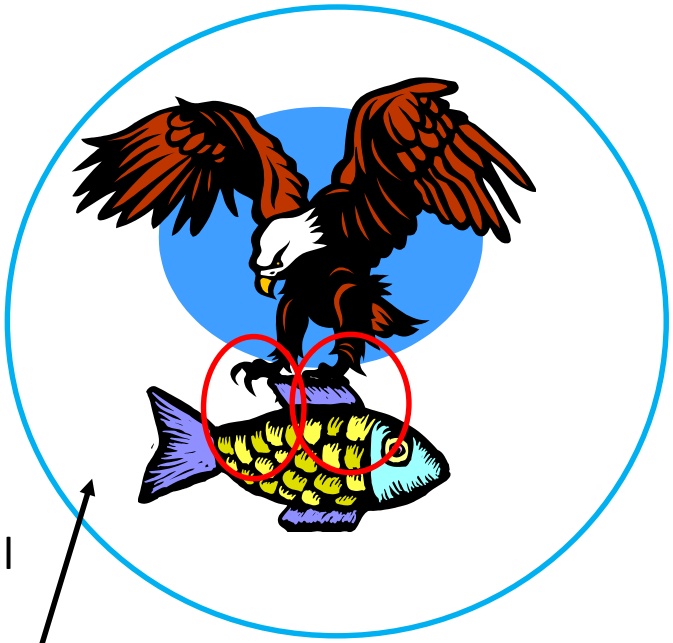
Chelate Means Claw

Ligand = organic molecule that complexes metal ion with more than one bond



Metal Ion = bonds to ligand with more than one bond

Chelate = an insoluble metal ion bonded by more than one bond to an organic molecule called a ligand – Prevents the metal ion from reacting with other materials



Chelate = Ligand + Metal Ion

Chelates Increase Solubility

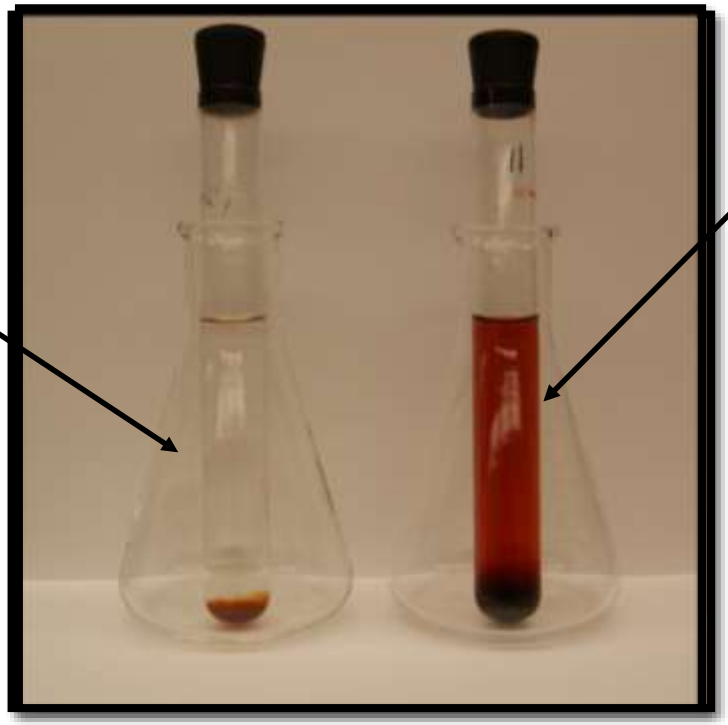
Increase the solubility of insoluble metal ions

What's solubility?

- How much of a substance can be dissolved into another substance

Chelates Increase Solubility

Iron nitrate shaken with water



Iron nitrate shaken with EDDHA ligand

Non-chelated Iron reacts with water and precipitates solid Fe(OH) species which plant roots can't take up

Stability Constant

The strength of the bond between the ligand and the metal ion which is described by a number called a "Log K"

1) The greater the stability constant, the more difficult it is to break apart the chelate

2) The greater the stability constant, the more the ligand prefers that metal ion

Table 3. Formation constants (Log K values) for some metal chelates (Lindsay, 1979).

	EDTA†	DTPA‡	EDDHA§
Reaction	---------- Log K ----------		
Fe(III) + L ↔Fe(III)L	26.50	29.19	35.40
Ca + L ↔CaL	11.61	12.02	8.20
Mg + L ↔MgL	9.83	10.61	9.00

† ethylenediaminetetraacetic acid

‡ diethylene triamine pentaacetic acid

§ ethylene diamine di(hydroxyl phenyl acetic acid)

$$K_{Fe(III)EDDHA} = \frac{[Fe(III)EDDHA]}{[Fe(III)]\,[EDDHA]} = 10^{35.40}$$

https://www.akzonobel.com/dissolvine/functions/the_right_chelate/

Stability Constant

Picture Courtesy of Dr. R. Jay Goos, NDSU

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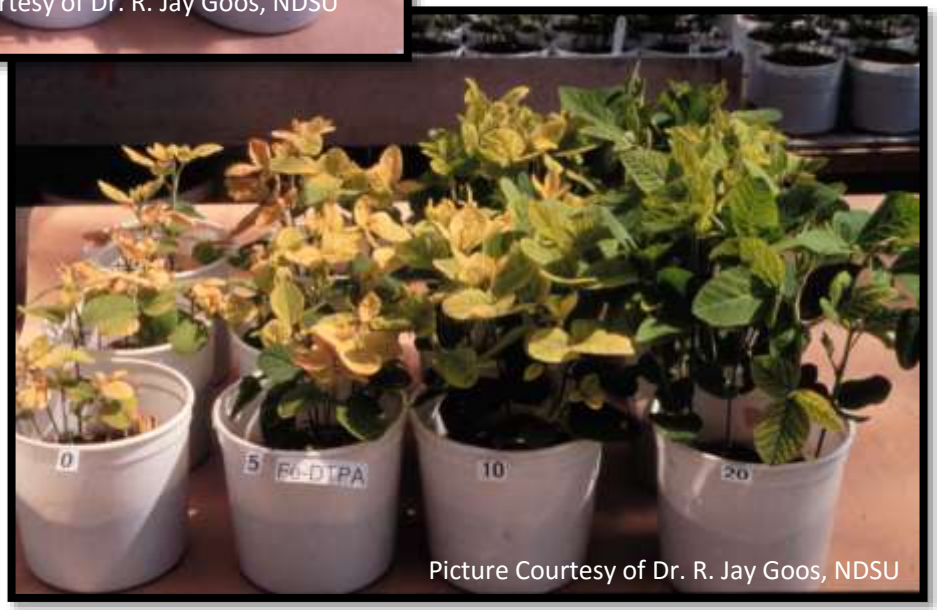
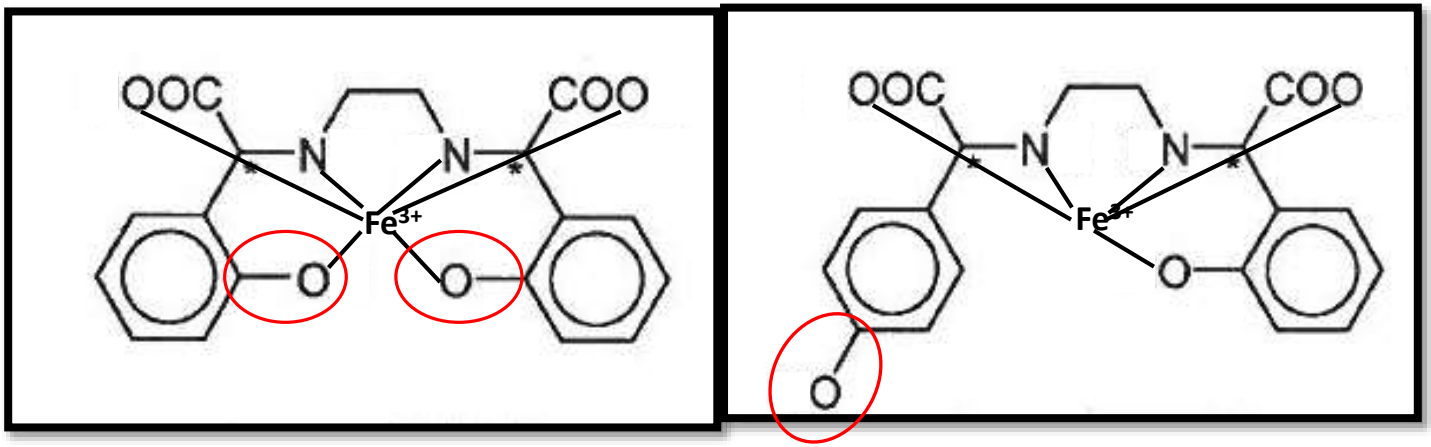


Picture Courtesy of Dr. R. Jay Goos, NDSU

Ligand Isomer Effect on Stability Constant



ortho,ortho FeEDDHA

ortho,para FeEDDHA

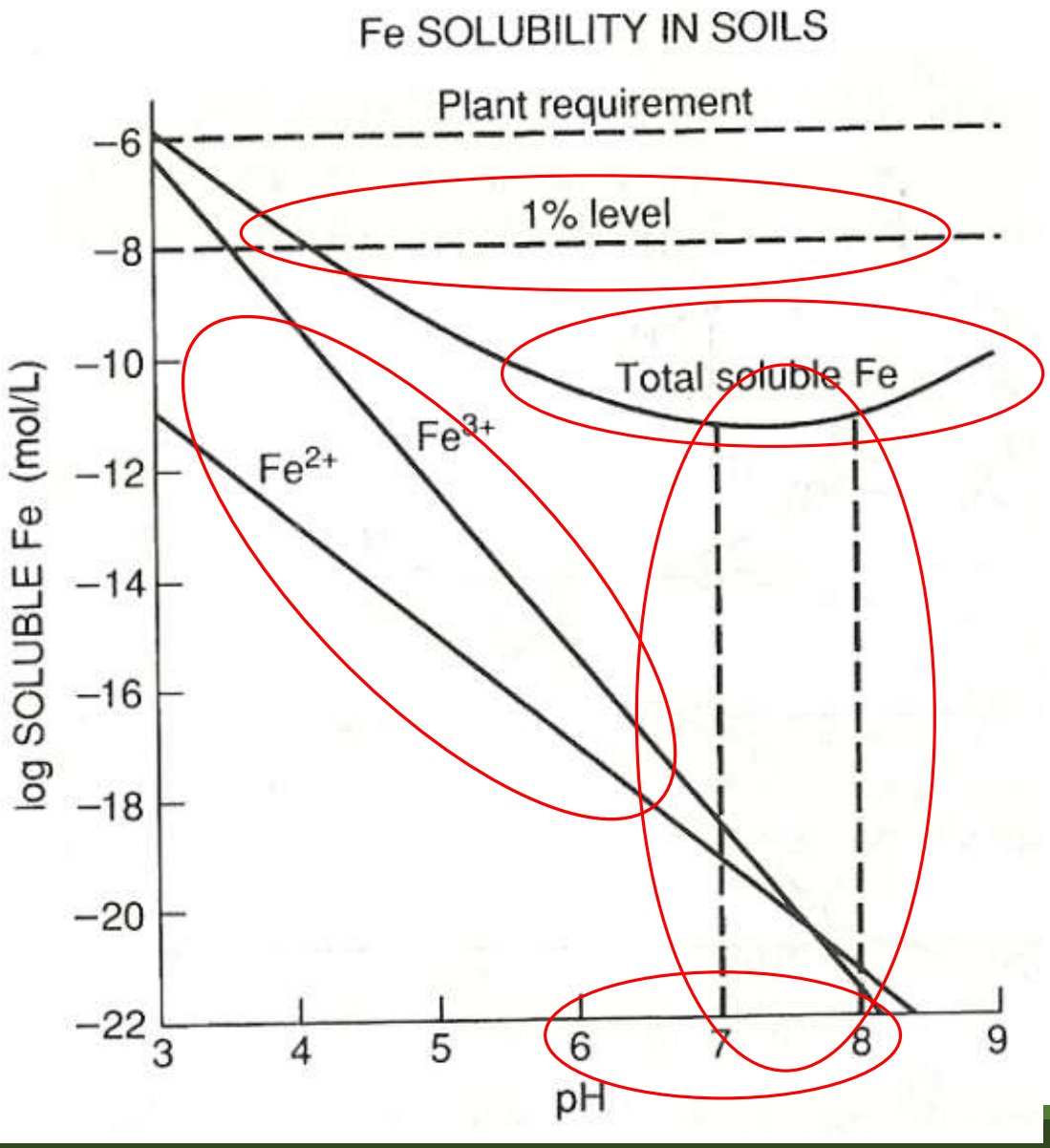
Table 4. Stability constants of different FeEDDHA regioisomers. (Yunta et al., 2003a, 2003b).

Regioisomer	Log K
racemic o,o-FeEDDHA	35.86
meso o,o-FeEDDHA	34.15
o,p-FeEDDHA	28.72

Pictures adapted from Yunta et al., 2003

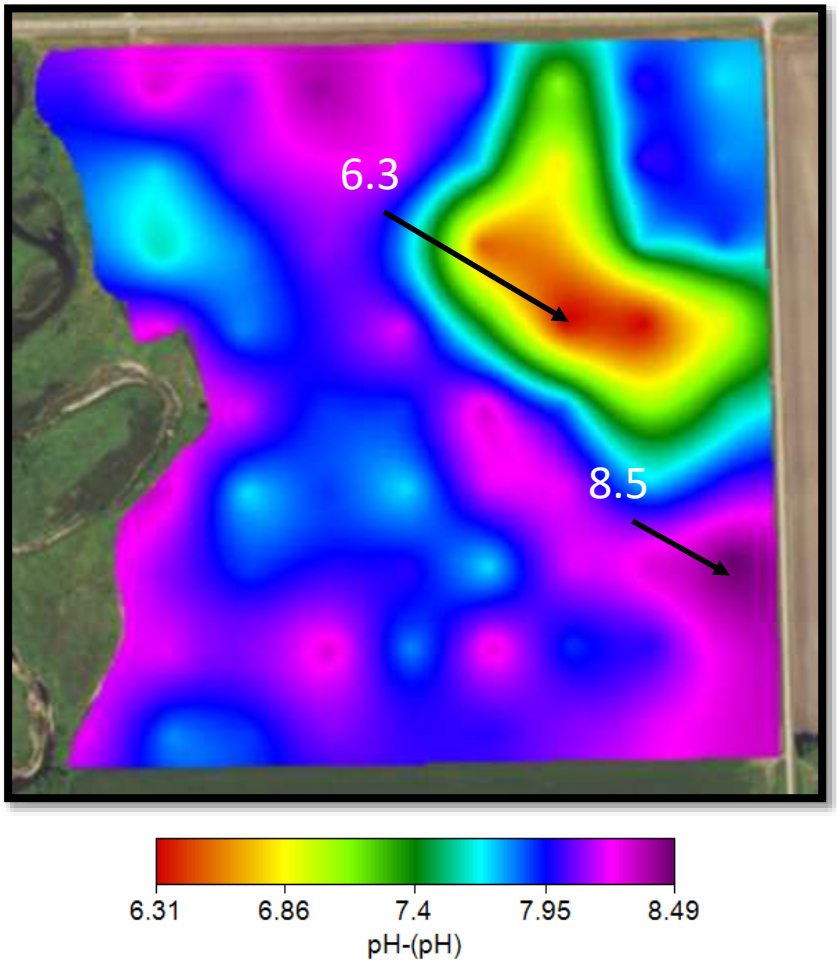
Effect of Different Ligand Isomers on Stability Constant

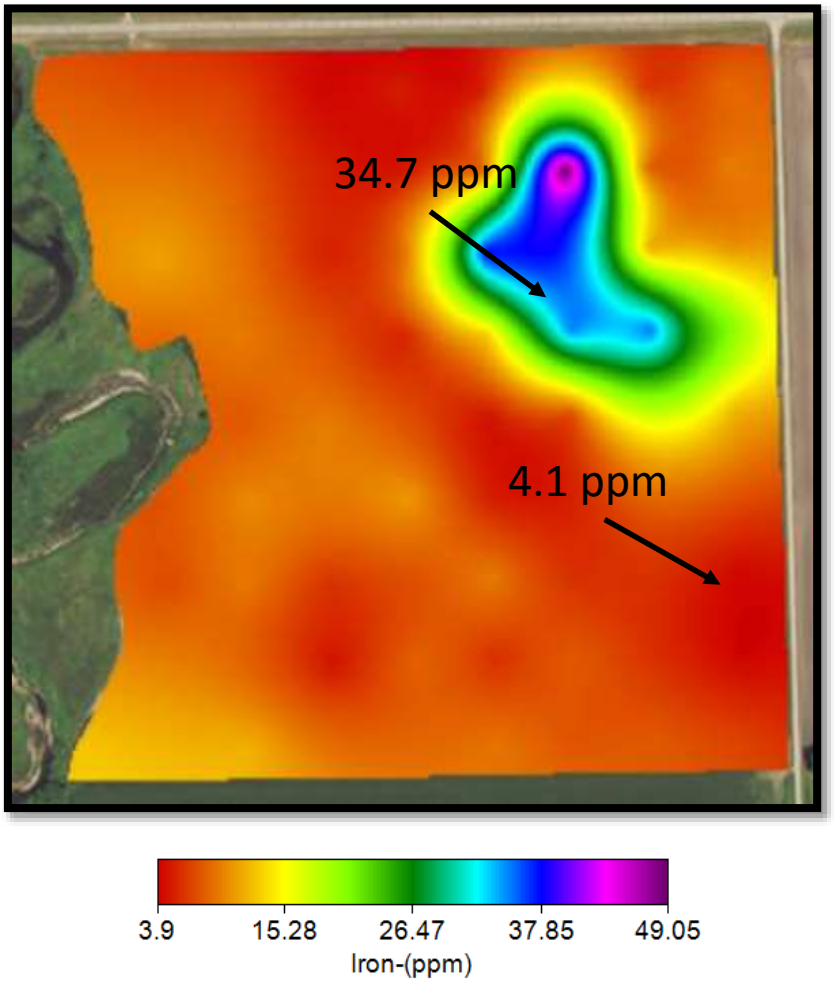
Iron Chemistry in Soil



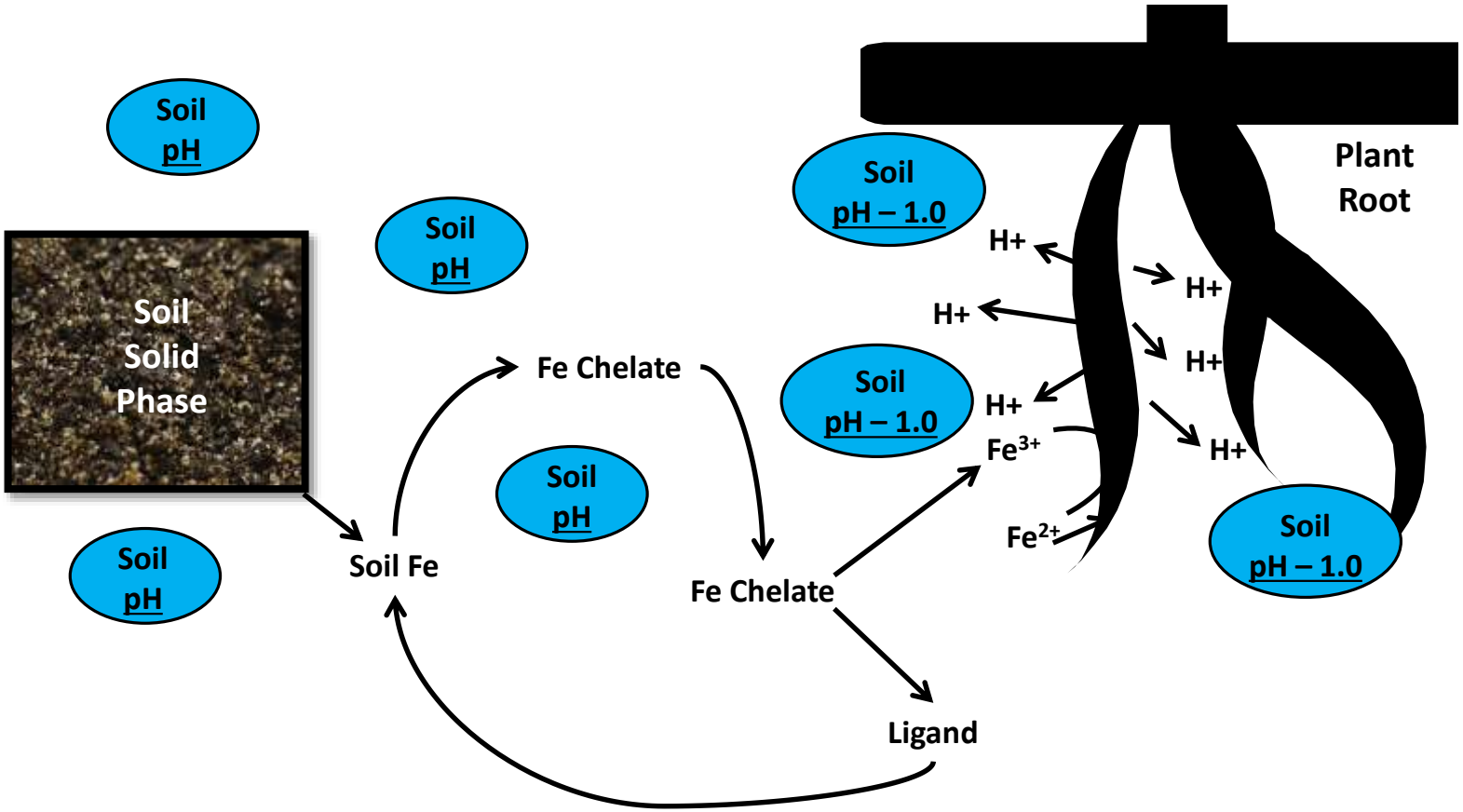
(Lindsay, 1974)

Iron Chemistry in Soils

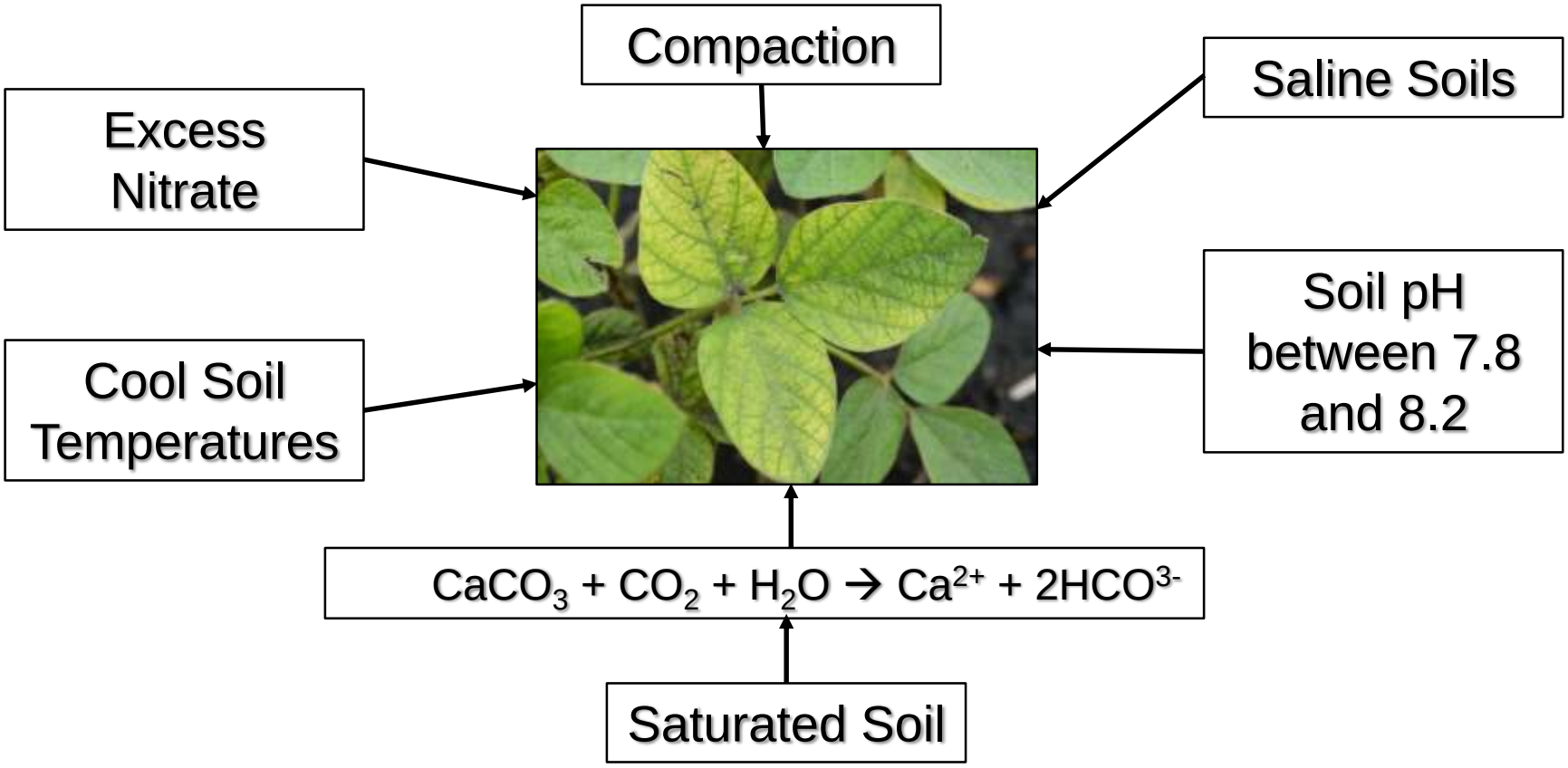




Strategy I Fe Uptake Mechanism
" The Shuttle Effect"



Factors that Contribute to IDC in Soybean



Diagnosis of Potential IDC Soils

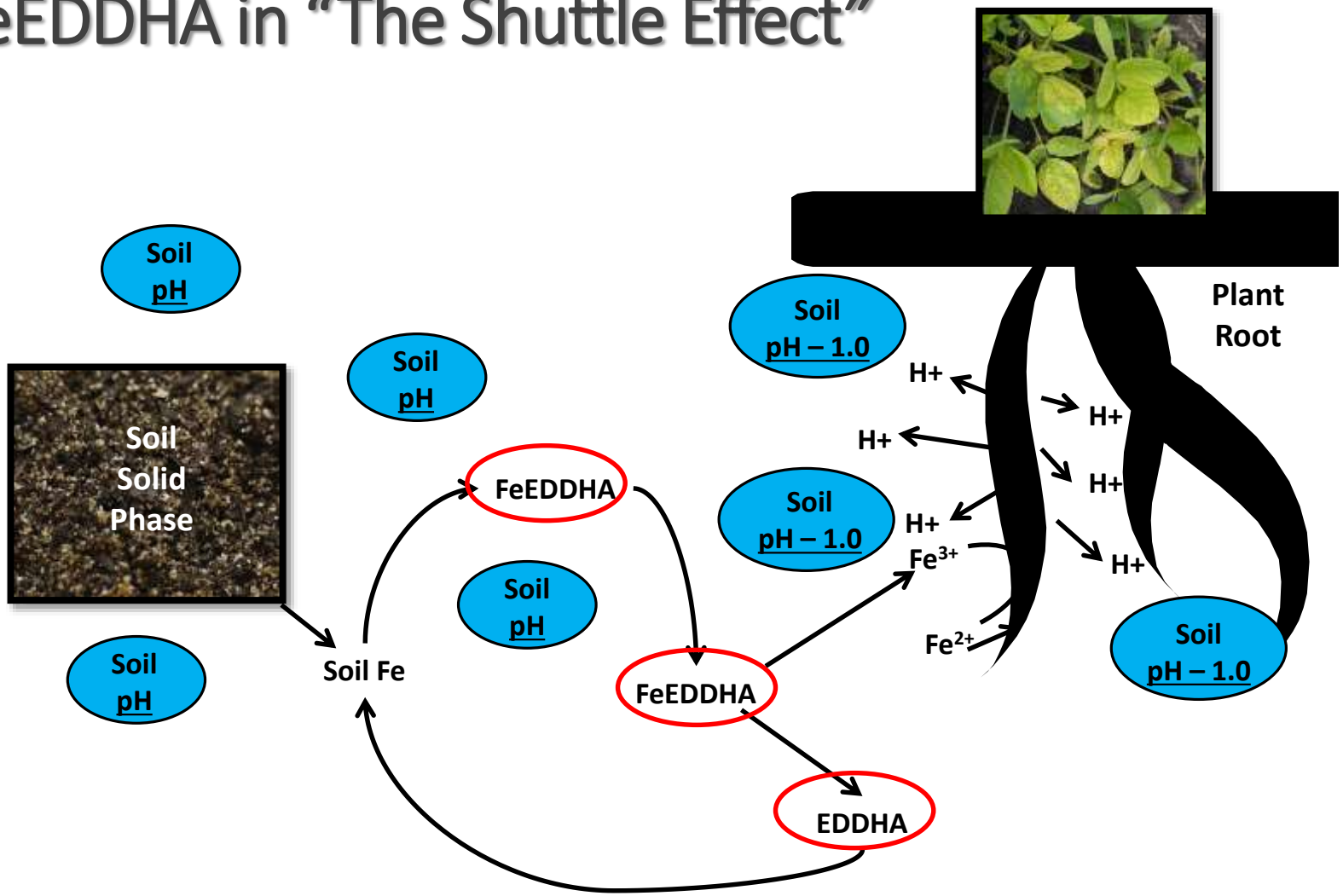
Risk of iron chlorosis in soybeans based on salinity and $CaCO_3$ content of soil

$CaCO_3$, %	Salinity, mmho/cm			
	< 0.25	0.26-0.5	0.51 - 1.0	> 1.0
0 - 2.5	Low	Low	**	High
2.6 - 5.0	Moderate	Moderate	High	V. High
> 5.1	Moderate	High	V. High	Extreme

** Low if $CaCO_3$ is less than 1%, moderate if $CaCO_3$ is 1-2.5%

Agvise Laboratories- Slightly modified by Dr. R Jay Goos

Soybean Iron Uptake Mechanism FeEDDHA in "The Shuttle Effect"



Are There Any Questions?

Review…

1) A chelate is made up of _____ and a _____ .

2) The purpose of using chelates in soil fertility is to _____ _____ .

3) The greater the _____ _____, the more the chelate wants to stay intact.

4) What is solubility? Chemical characteristic that describes how much of a substance can be dissolved in another substance.

5) The _____ _____- FeEDDHA isomer is the most effective isomer for managing IDC in soybean.

6) As soil pH increases, the solubility of Fe in soils _____.

7) (circle one)There (is/is not) enough iron soluble in any given “normal” agriculture soil to provide the basic requirement for plant nutrition.

8) There are 3 steps to the iron uptake mechanism of a soybean plant.
1)_____ 2)_____ 3)_____

9)_____ inhibits the iron uptake mechanism of a soybean plant.

10) Name three contributing factors to the development of IDC.