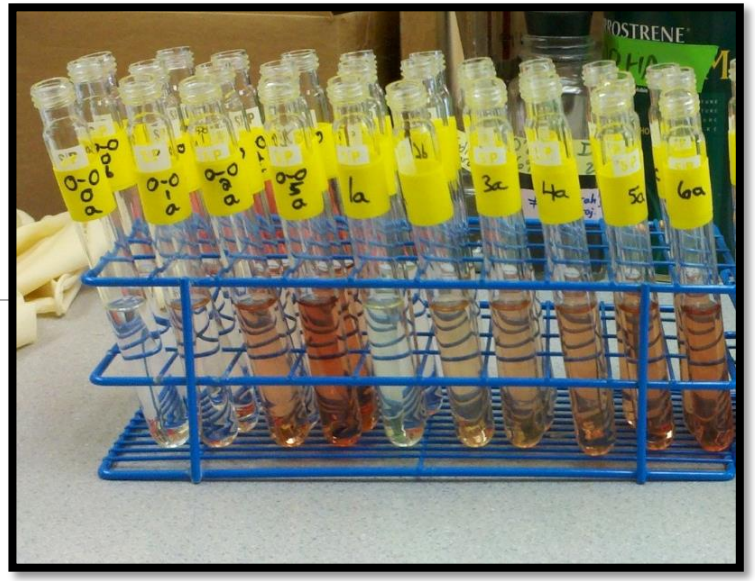
Exciting World of Chelation



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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.

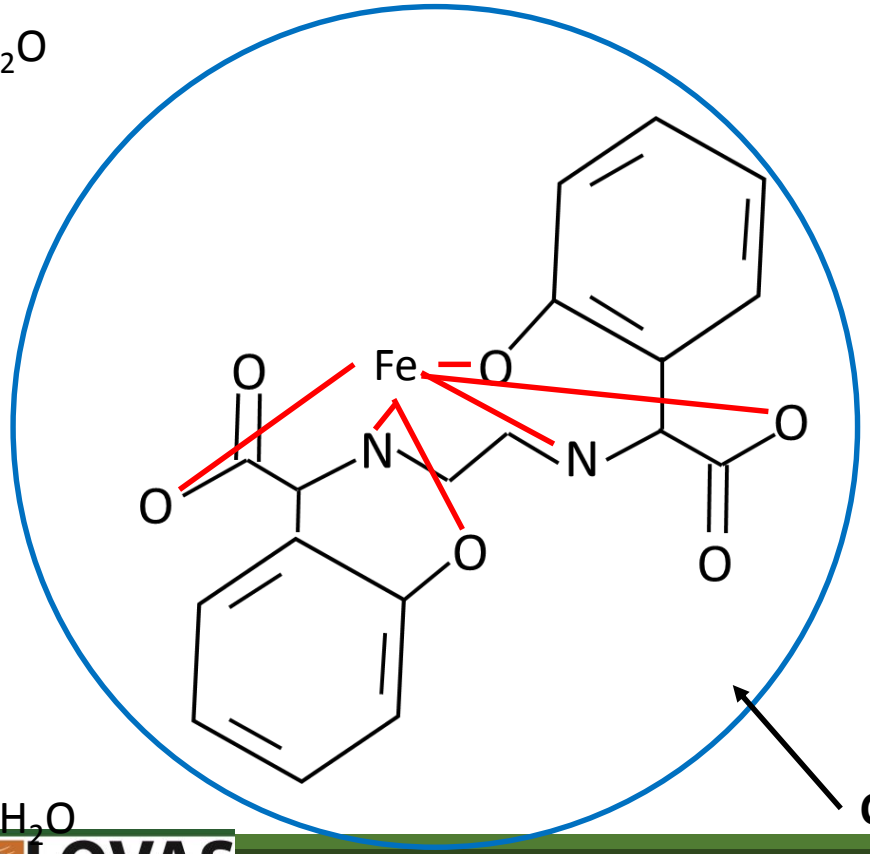
How chelates play a role in the Fe uptake mechanism of plants.

Chelate Means Claw

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

H_2O

H_2O

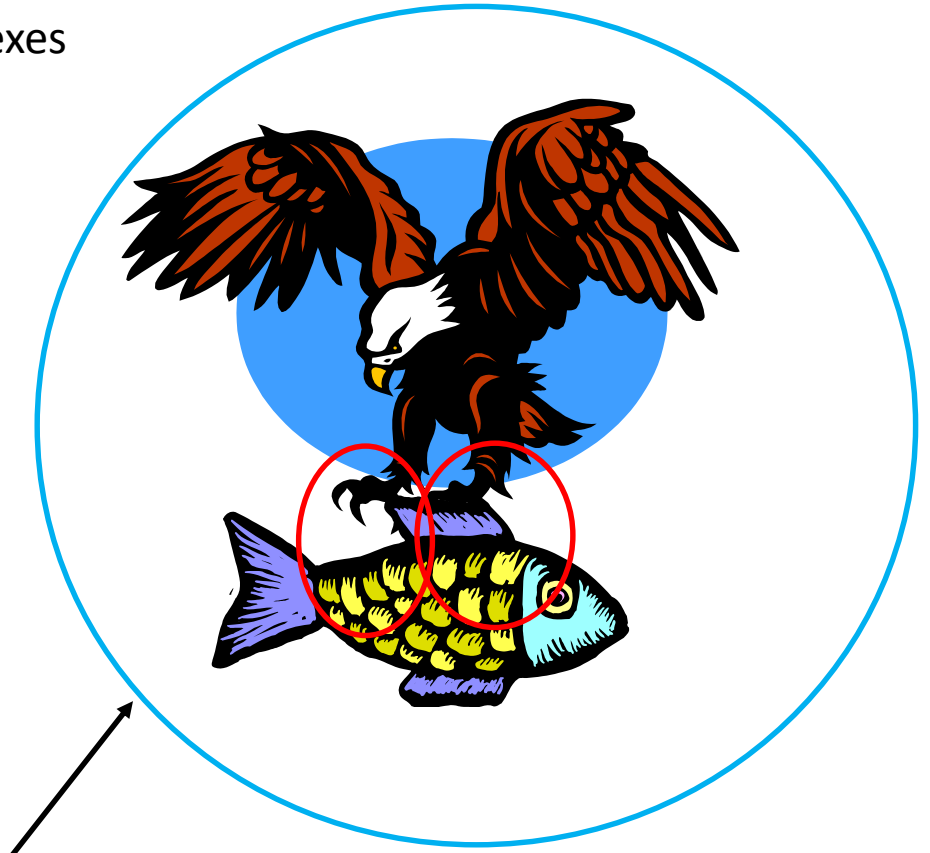


H_2O

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

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

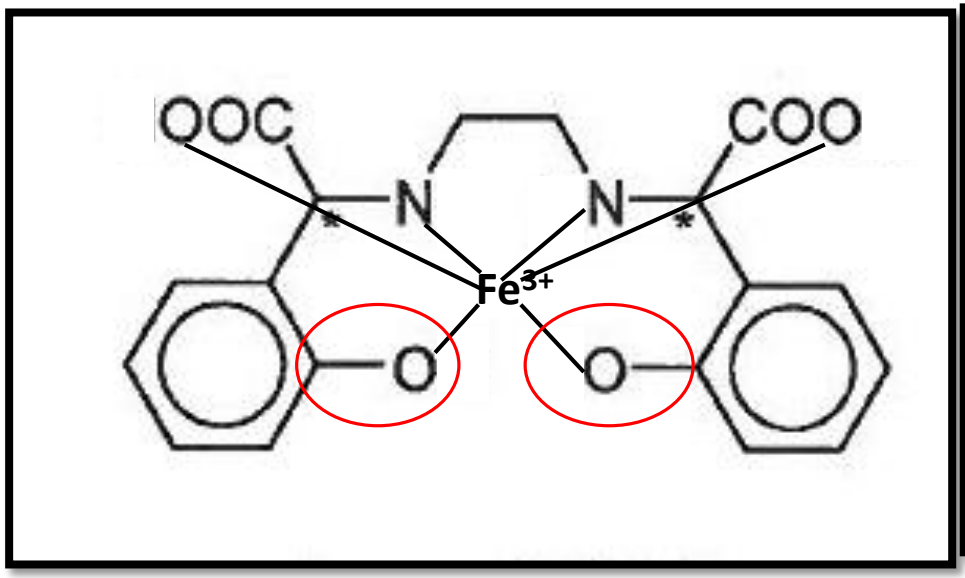
§ ethylene diamine di(hydroxyl phenyl acetic acid)

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

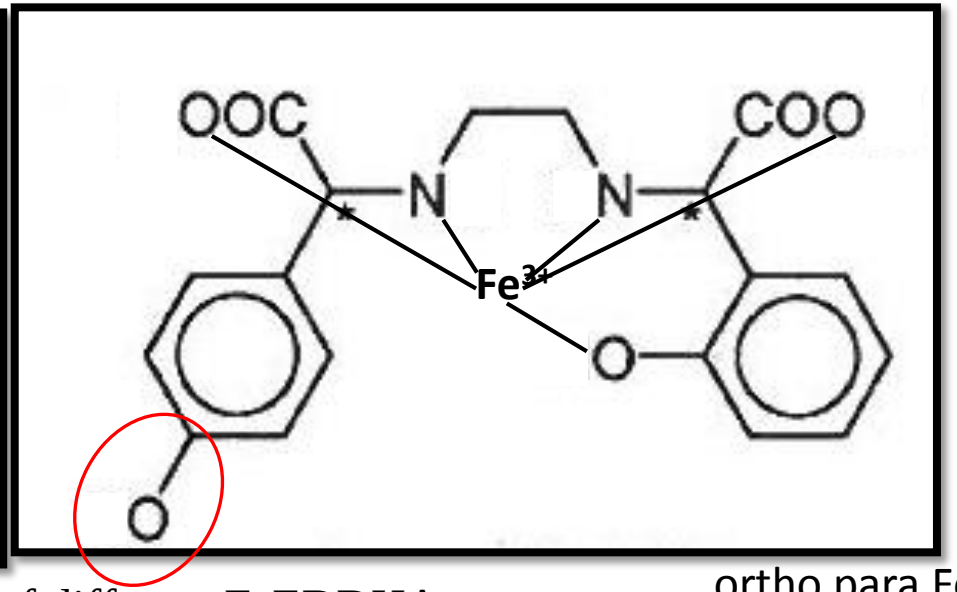
https://www.akzonobel.com/dissolvine/functions/the_right_chelate/

Stability Constant

Ligand Isomer Effect on Stability Constant



ortho,ortho FeEDDHA



ortho,para FeEDDHA

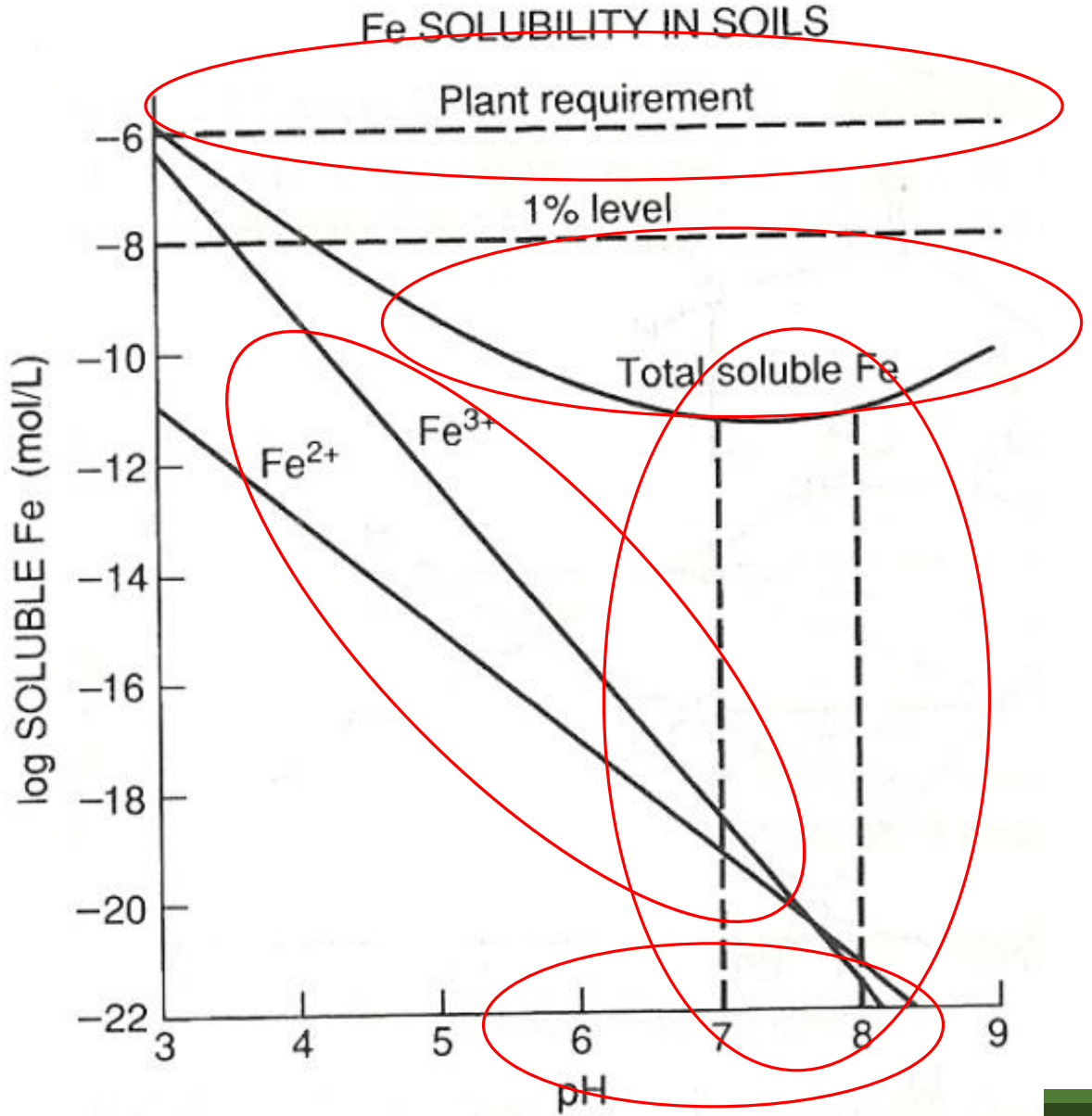
Table 4. Stability constants of different FeEDDHA regioisomers. (Yunta et al., 2003a, 2003b).

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

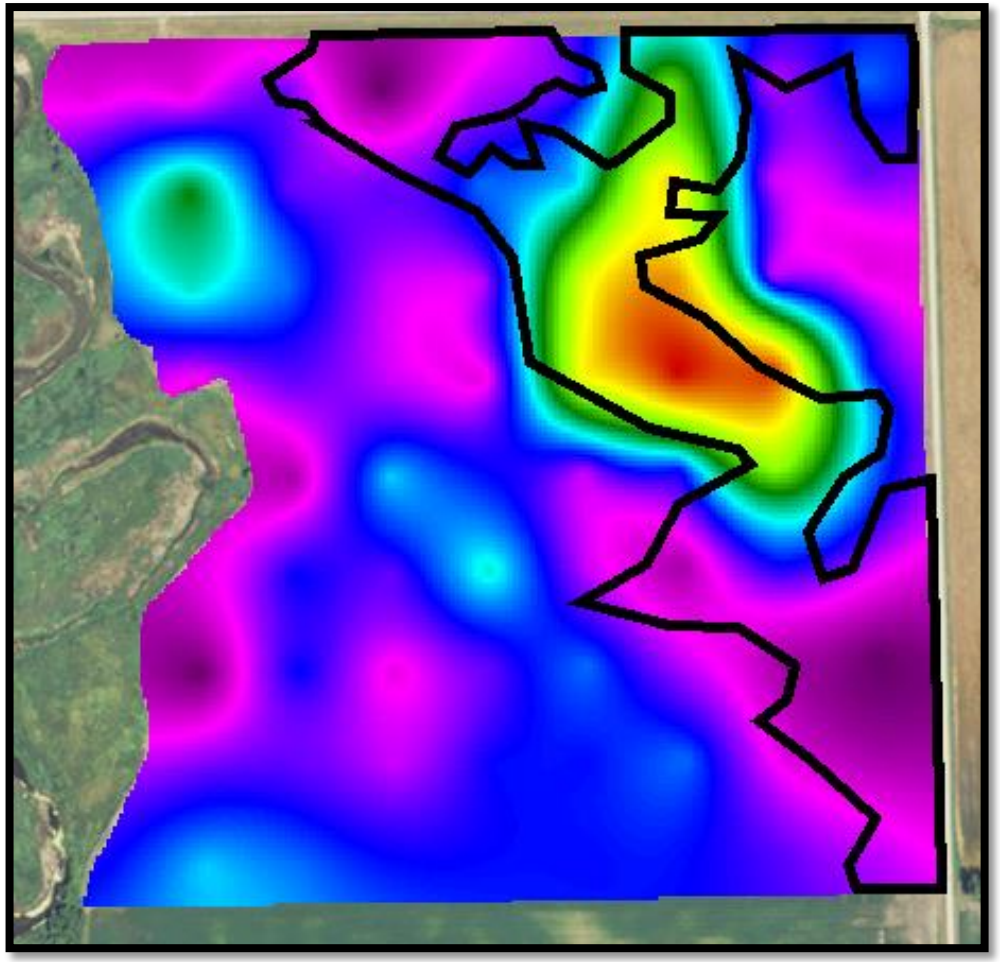
Effect of Different Ligand Isomers on Stability Constant

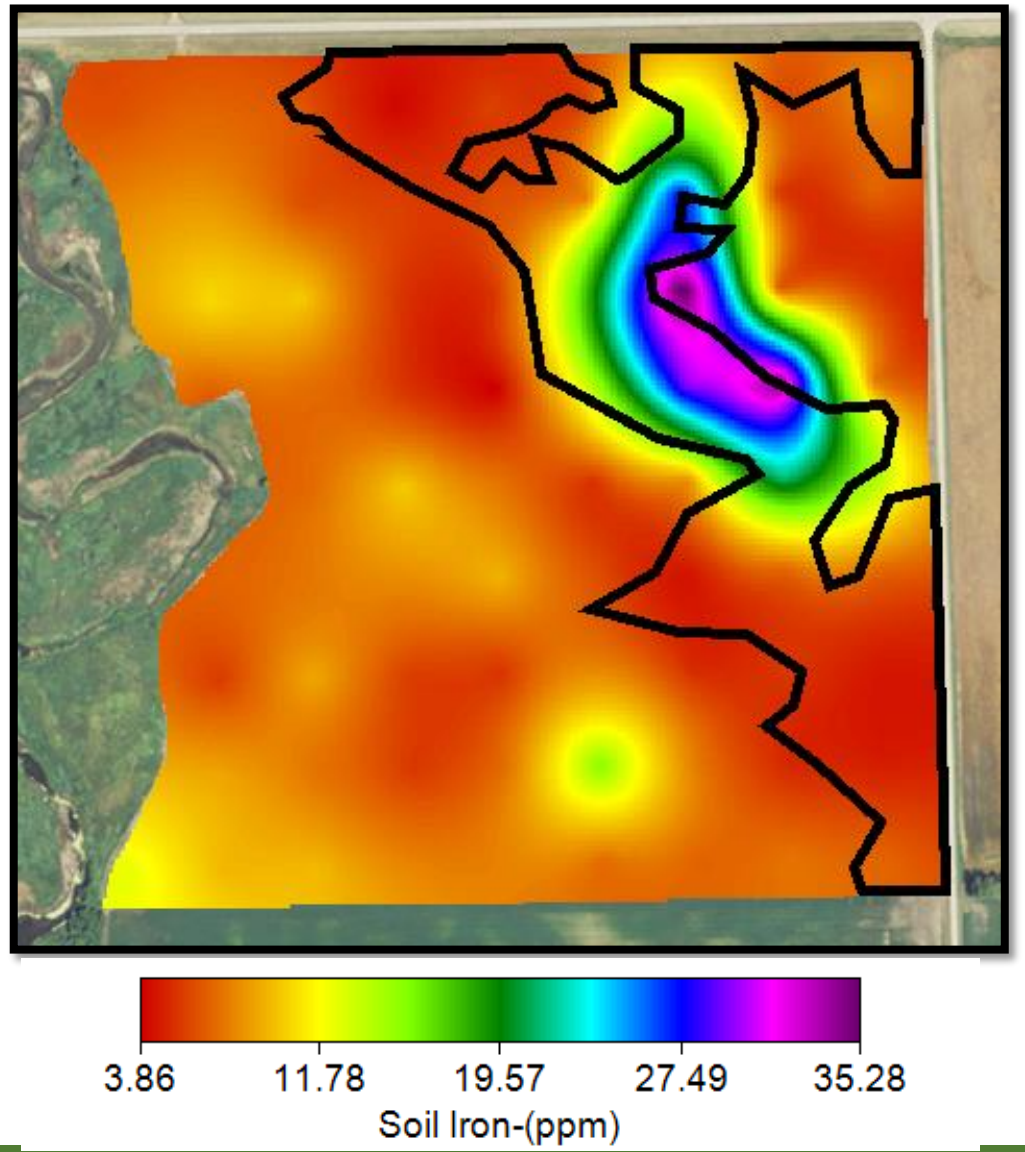
Iron Chemistry in Soil



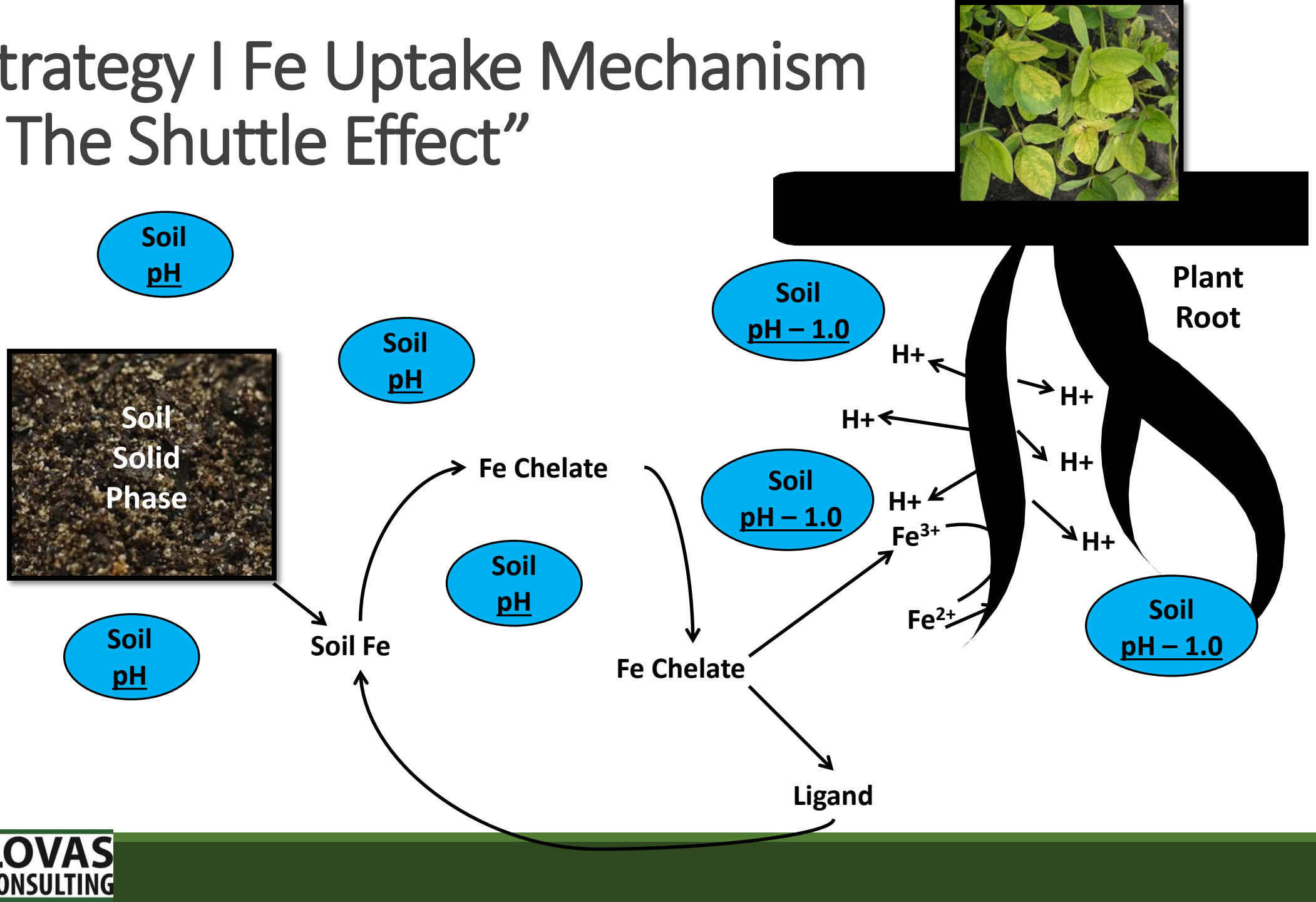
(Lindsay, 1974)

Iron Chemistry in Soils





Strategy I Fe Uptake Mechanism
" The Shuttle Effect"



Factors that Contribute to IDC in Soybean

Compaction

Excess Nitrate

Saline Soils

Cool Soil Temperatures

Soil pH between 7.8 and 8.2

$CaCO_3 + CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO^{3-}$

Saturated Soil

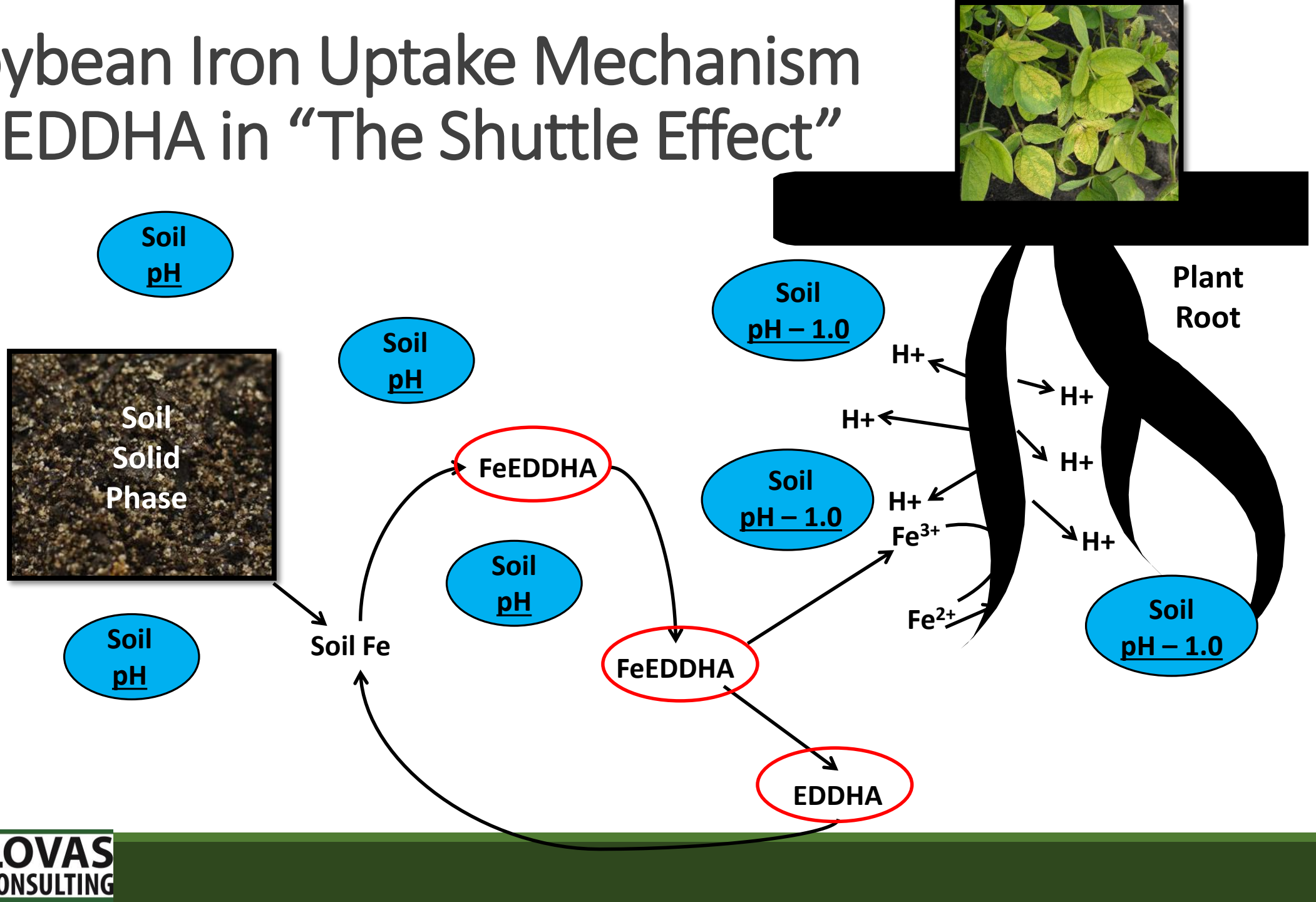
Diagnosis of Potential IDC Soils

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%

Soybean Iron Uptake Mechanism FeEDDHA in "The Shuttle Effect"



Are There Any Questions?

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Review…

1) A chelate is made up of __a ligand__ and a ____metal ion_____ .

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

3) The greater the __stability____ _constant___, 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) _D_ _T_ _P_ _A_ is the chelating agent that is used for the soil test which determines how much Zn, Cu, Fe, and Mn are available for plant uptake.

6) the _ortho____ __ortho___- FeEDDHA isomer is the most effective isomer for managing IDC in soybean.

7) As soil pH increases, the solubility of Fe in soils __decreases_____.

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

9) There are 3 steps to the iron uptake mechanism of a soybean plant.
1)_____Chelation_____ 2)_____Acidification_____ 3)____Reduction_____

10)___CaCO3_____ inhibits the iron uptake mechanism of a soybean plant.