# Dynamics of plant nutrients and the symptom of their deficiency and excess.

## Part 2: Micro elements
## Fe, Mn, Zn, Cu

Kiyoshi Tsutsuki
http://timetraveler.html.xdomain.jp

# Iron deficiency

- Susceptible to occur in neutral and alkaline soils such as calcareous soils or soils applied with excess amount of lime.
- Causes yellowing due to iron deficiency.
- Leaves become yellow-white, first net or stripe like, then spread to whole plant.
- Yellowing occur first in new leaves as iron is hardly translocated.

# Iron deficiency in corn

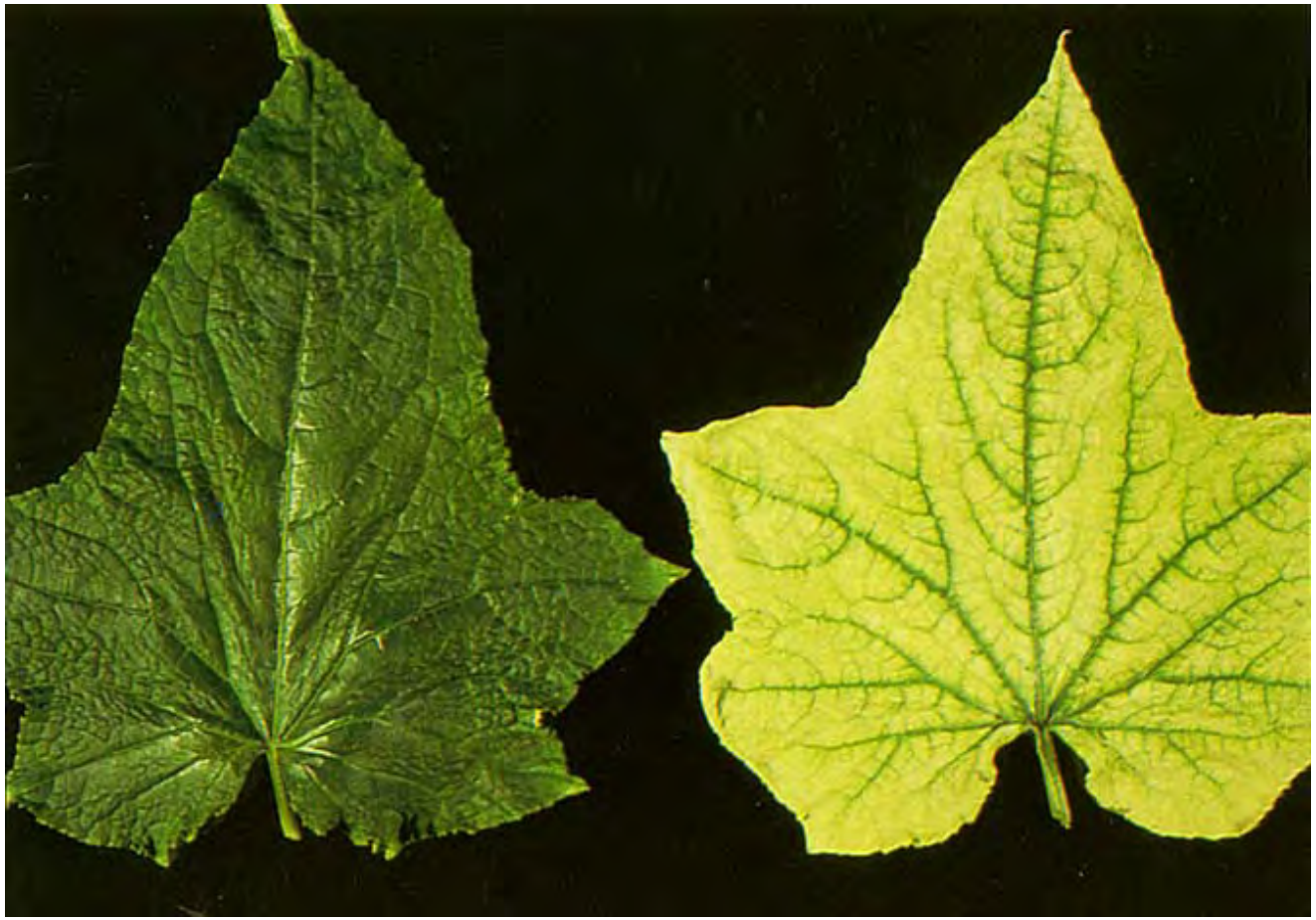
# Iron deficiency in tomato

Yellowing occurs in the leaf stalk, then it will be severe at the growing point of new leaves (6 weeks after depleting Fe, at the stage of 6$^{th}$ leaf ).

# Iron deficiency in wheat field

# Iron deficiency

- Oak tree on a strongly alkaline soil (right).

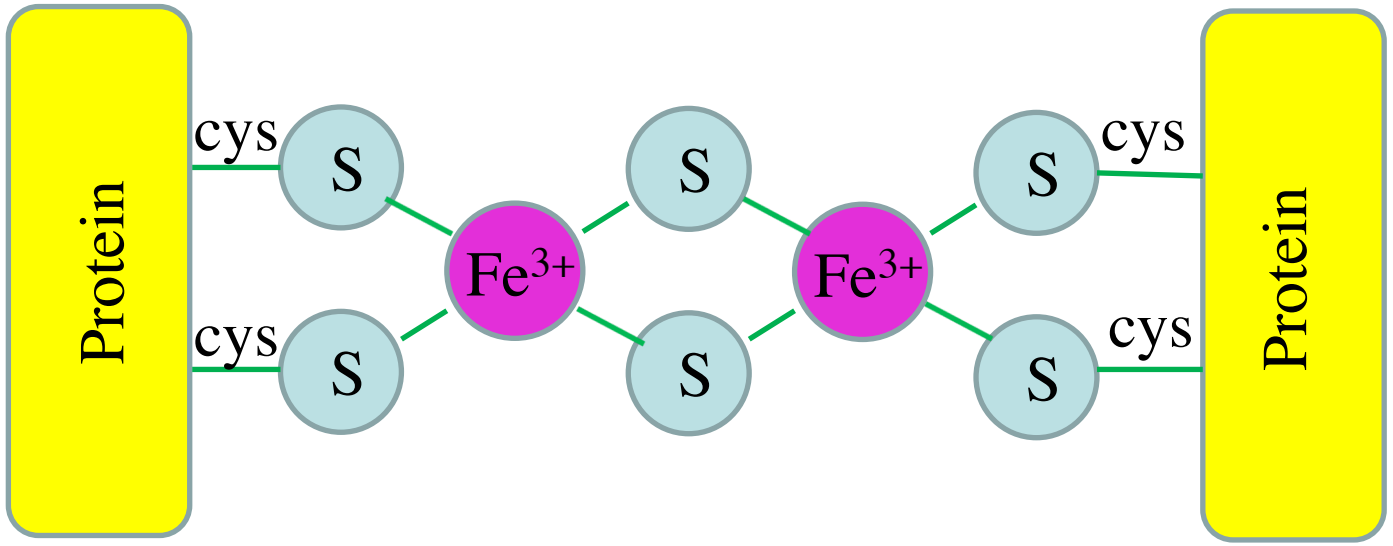


# Iron containing enzymes involved in photosynthesis and respiration.

- Glycine + succinyl CoA → δ amino-levulinic acid → → Proto-porphylin (PP)
- PP + Mg → Proto-chlorophyllide → Chrolophyll
- PP + Fe → Proto-heme → Heme
- Heme enzymes: Cytochrome, Catalase, Peroxidase

# Non-heme type iron protein

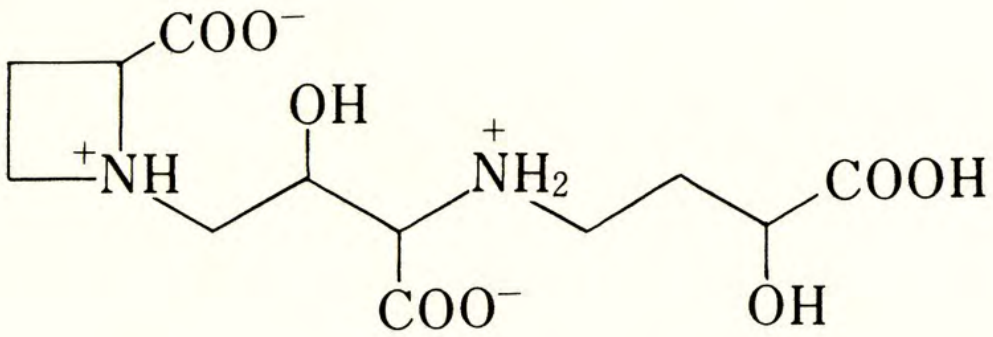
- Oxidized ferredoxin




- Engaged in photosynthesis, nitrogen fixation, carbonate fixation, oxidation and reduction of hydrogen molecule.

# Mugineic acid

Chelate substance which solubilize iron effectively.
Secreted from the root of gramineous plants.

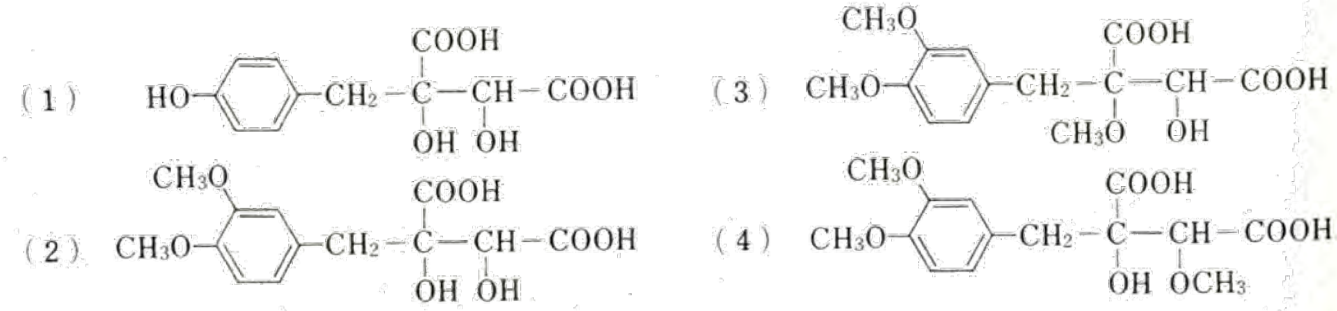



Natural chelater: Mugineic acid

# Iron releasing ability of Piscidic acid and its related compounds.

Iron release (μg-P/ml) from iron phosphate

| Compounds | P 放 出 能 (μg-P/m l) |
|---|---|
| Control (water) | 1.48 |
| piscidic acid (1) | 4.37 |
| dimethyl fukiic acid (2) | 4.44 |
| trimethyl fukiic acid-A (3) | 3.27 |
| trimethyl fukiic acid-B (4) | 3.23 |




Ae et al. (1990)

# Manganese deficiency

- Susceptible to occur in soil with high pH containing large amount of organic matter.
- Chlorosis (whitening) in dirty color.
- Small brown spots between leaf stalks.
- Gray spot disease in oats.
- Browning of cotyledon of green peas and broad bean.
- Yellow spot disease in sugar beet.

# Roles of manganese

- Emission of oxygen in photosynthesis.
- Dehydrogenation, decarboxylation, and hydrolysis reactions in glycolysis and citric acid cycle (TCA cycle).
- Activation of RNA polymerase in the chloroplast.

# Manganese deficiency in water melon

# Manganese deficiency in tomato

Similar to iron deficiency with the pale color of higher leaves (at 6$^{th}$ leaf stage, 5 weeks after depleting Mn).

Manganese is relatively hardly translocated in plants, and its deficiency symptom appears in new leaves.

# Manganese deficiency in tomato

Brown decay spots appear between leaf stalks of middle position leaves (at the 4$^{th}$ leaf stage after 5 weeks of Mn depletion).

# Mn and Fe deficiency


Interveinal chlorosis, a symptom of manganese deficiency in red maple.


Interveinal chlorosis typical of iron deficiency in river birch.

# Zinc deficiency

- Susceptible to occur in soil with high pH and low in organic matter.
- Availability of Zinc decrease in the soil with high phosphate content due to the formation of Zinc phosphate.
- Repression of the growth of young leaves.
- Length between the nodes is shortened.
- Small leaves grow dense in rosette.
- Chlorosis of leaves.

# Zinc deficiency

- Frequently occur in onion and corn grown on Fulvic Andosols and in corn and adzuki bean grown on Cambisols derived from the rhyolitic tuff in Hokkaido, Japan.

# Roles of Zinc

- Involved in the metabolism mediated by the plant hormone auxin.
- Some enzymes contain Zinc as an essential component: carbonate dehydration enzyme, Cu-Zn super-oxide-dis-mutase (SOD), alcohol dehydrogenation enzyme.
- Contribute to photosynthesis by these enzymes.

# Zinc deficiency in tomato

In the tip and peripheral part of lower leaves, chlorosis appears first, then it turns rapidly to brown decayed spots (at $6^{th}$ leaf stage, 6 weeks after Zinc depletion).

# Zinc deficiency in corn

# Zinc deficiency in adzuki bean

# Zinc deficiency in rice leaf

# Copper deficiency

- Sterility of tomato, sun flower, wheat and barley.
- Plant disease occurring in wheat, vegetable, and sugar beet grown on newly reclaimed peatland.
- Copper deficiency of wheat grown on humic andosols in the north-east Japan and Hokkaido.
- Copper forms strong complex with organic matter.

# Roles of copper

- Contained in chloroplast, and mediates the transport of electron (plastocyanin, Cu-protein).
- Contribution in the respiration system. A constituting element of cytochrome a.
- Ascorbic acid oxidation enzyme.
- Polyphenol oxidation enzyme.

# Copper deficiency in wheat.


- Sterility of wheat is caused by Cu deficiency.
- Photo (right) shows the sterility symptom.

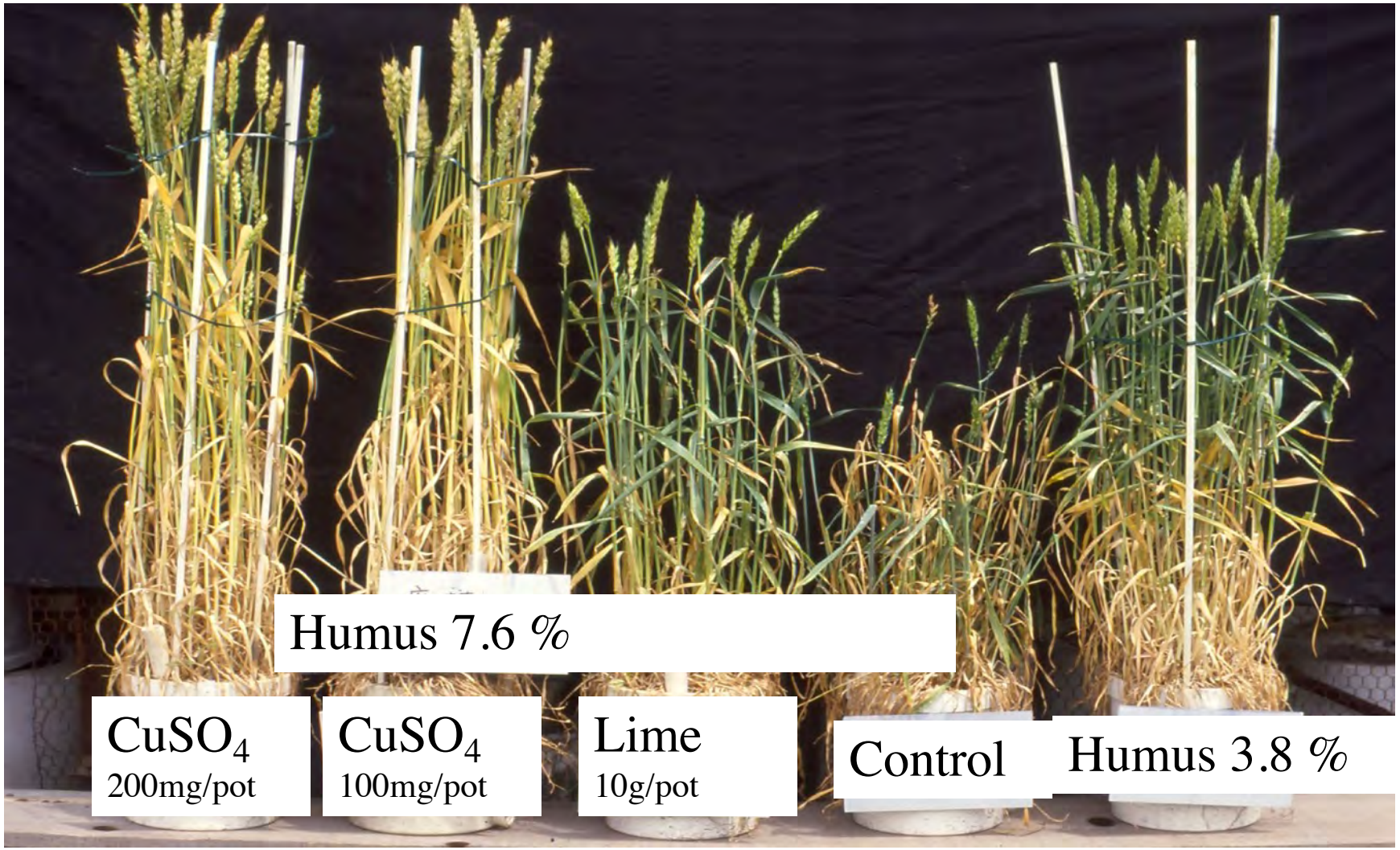
# Copper deficiency in wheat.

# Copper deficiency of wheat in the field.

# Copper deficiency of wheat in the lower part of northern slope.

# Growth of wheat
# in the upper part of the hill.

# Copper deficiency in wheat and its countermeasures



# Effects of Zinc sulfate application (50 kg $ha^{-1}$) in adzuki bean grown on Cambisols.

| **Soil** | **Treatment** | **Stem and pod yield** | **Bean yield** | **Available Zn in soil** |
|---|---|---|---|---|
| | | (Mg $ha^{-1}$) | (Mg $ha^{-1}$) | (mg $kg^{-1}$) |
| A: humus | control | 1.85 | 1.26 | 1.16 |
| 1.8 % | treated | 1.75 | 1.42 | 2.17 |
| B: humus | control | 2.27 | 2.38 | 1.10 |
| 1.9 % | treated | 2.77 | 3.18 | 3.70 |

# Effects of Copper sulfate application (100 kg $ha^{-1}$) in wheat grown on Cambisols.

| **Sil** | **Treatmenot** | **Stem and leaf yield** | **Grain yield** | **Available Cu in soil** |
|---|---|---|---|---|
| | | (Mg $ha^{-1}$) | (Mg $ha^{-1}$) | (mg $kg^{-1}$) |
| A: humus | control | 3.6 | 0.0 | 0.25 |
| 7.6 % | treated | 17.7 | 13.8 | 0.85 |
| B: humus | control | 4.7 | 0.0 | 0.25 |
| 10 % | treated | 17.5 | 14.3 | 0.65 |
| C: humus | control | 15.0 | 0.0 | 0.25 |
| 3.8 % | treated | 20.4 | 16.4 | 2.50 |

# Counter measure against Zn/Cu deficiency in the central hilly area (Biei) in Hokkaido.

| **Deficiency** | **Soil conditions causing the problem** | **Soil types** | **Counter measure** |
|---|---|---|---|
| Zn | Av. Zn < 1.5 mg $kg^{-1}$ | Medium texture, | Zinc sulfate |
| | Low in humus, High | Fine texture Cambisol | (50 kg $ha^{-1}$) |
| | pH, mixing of subsoil | Developed land field | Effective 5 years |
| Copper | Av. Cu < 1.5 mg $kg^{-1}$ | Medium textured | Copper sulfate |
| | High in humus | Cambisol with | (20 - 40 kg $ha^{-1}$) |
| | Mixing of subsoil | Dark colored top soil | Effective a few years |