Optimizing color and appearance by by micronutrients

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Content

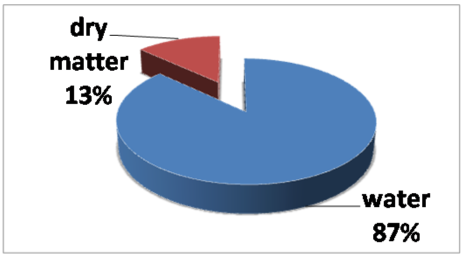
- Micronutrients: small quantities
- Availability to the roots: pH and chelates
- The different micronutrients
  - Fe
  - Mn
  - Zn
  - Cu
  - B
  - Mo
  - (Ni)
  - (Co)
  - (Cl)
- Conclusions

Micronutrients: small quantities

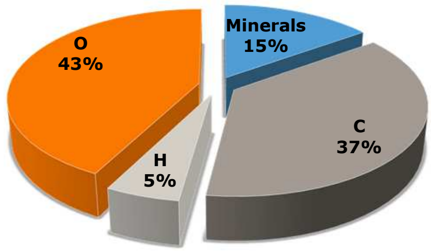
Micronutrients

- Fe, Mn, Zn, B, Cu, Mo, (Ni, Co, Cl)
- Elements in small quantities
- Essential for plant
- Deficiency as well as toxicity
- No building blocks for the plant like macro nutrients
- Roles in metabolic processes

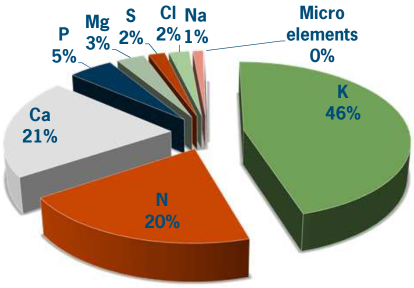
Composition of plants
The total plant



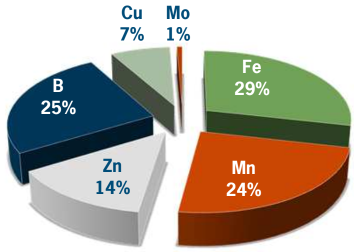
Composition of plants
The dry matter (13% of total)



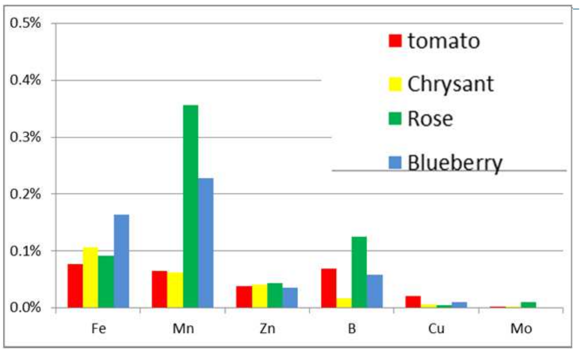
Composition of plants
The minerals (2% of total)



Composition of plants
The micronutrients (0.01% of total)

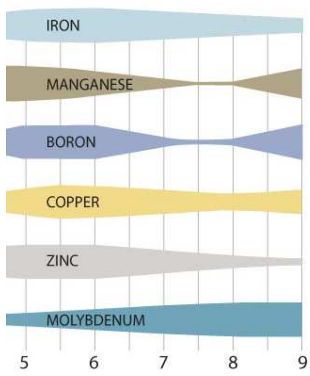


Differences among plant species

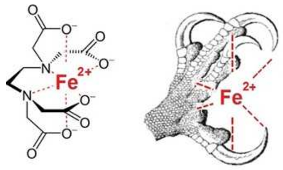


Availability to the roots: pH and chelates

pH important for nutrient availability

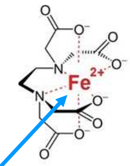


Micronutrients in chelates

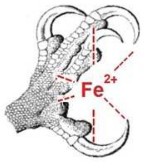


Fe-EDTA chelate **EDTA as a claw around iron ion**

Micronutrients in chelates



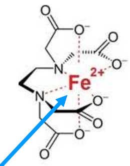
Fe-EDTA chelate



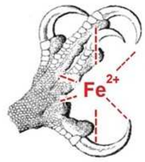
EDTA as a claw around iron ion

Cations
metal micro-elements:
Fe^{3+}, Mn^{2+}, Zn^{2+} Cu^{2+}
~~B, Mo~~

Micronutrients in chelates



Fe-EDTA chelate

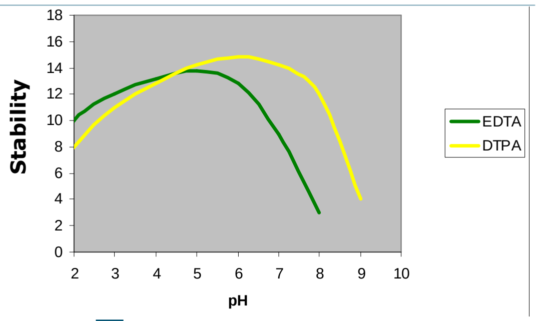


EDTA as a claw around iron ion

Cations
metal micro-elements:
Fe^{3+}, Mn^{2+}, Zn^{2+} Cu^{2+}
~~B, Mo~~

Fe-EDTA
Fe-HEEDTA
Fe-DTPA
Fe-EDDHA, EDDHMA

Stability of chelate is pH dependent
example of Fe



Stability of chelate is pH dependent
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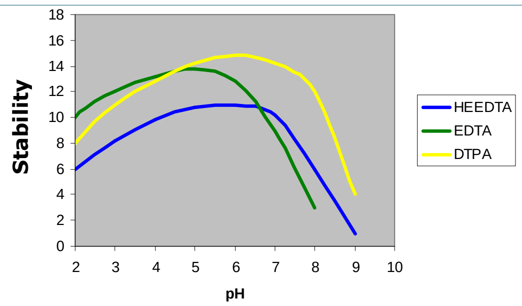
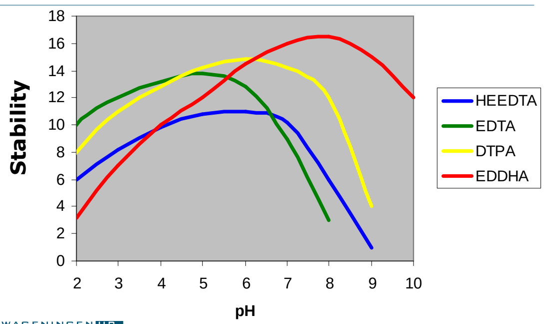


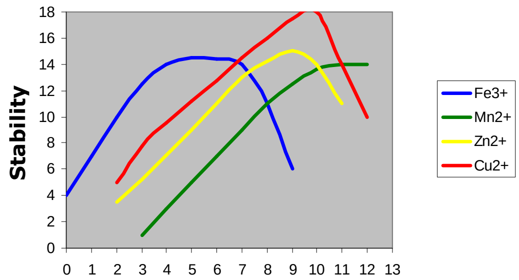
Stability of chelate is pH dependent

example of Fe

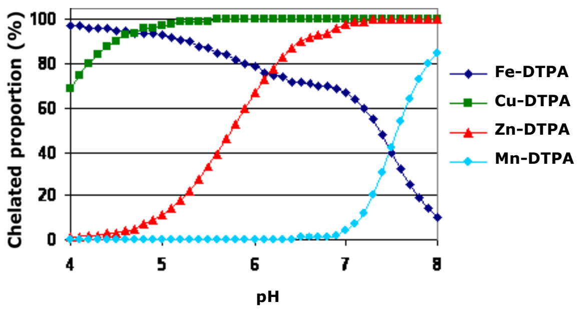


Stability of chelate differs per element

Example of DTPA



Relative chelated proportion per element



Fe-EDDHA

Effects

- Stable at high pH
- Fe-uptake stable
- Zn uptake increases
- Mn uptake supressed

Fe-EDDHA

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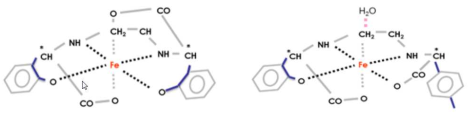
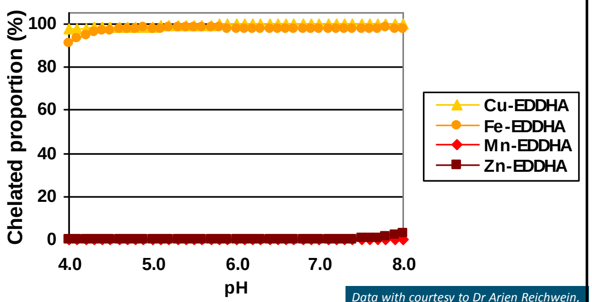
Pay attention to
- In tank pH > 4
- Expensive
- Three types:
  - ortho – meta - para

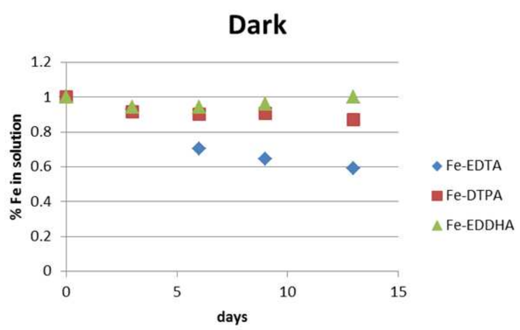


EDDHA: pH insensitive for Fe, Cu
No complexation of Mn, Zn
Risk of Mn deficiency

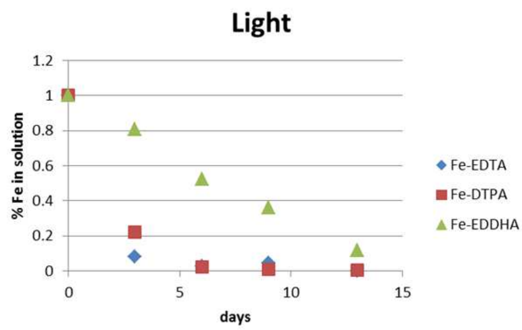


Data with courtesy to Dr Arjen Reichwein, AKZO Nobel Netherlands

Fe-chelates decomposition



Fe-chelates decomposition by light



Fe-chelates decomposition

- Light
- Microbes
- Disinfection
  - Ozone
  - UV

Conclusions on chelates

- High pH
  - Yield reduction
  - Decrease in micronutrient uptake
- pH 4.5 performed best
- pH control most effective in chlorosis prevention
- Fe-EDDHA more stable, higher Fe-uptake, however unable to prevent chlorosis
- **Fe-EDDHA enhance risk of Mn deficiency at high pH**

The different micronutrients: Fe, Mn, Zn, Cu, B, Mo, (Ni), (Co), (Cl)

Iron (Fe)

Iron (Fe)

- Young leaves: yellow
- Role
  - Chlorophyll
  - Photosynthesis (electron transport)
  - Enzymes
- Uptake as Fe^{2+}, Fe^{3+}
- Chelate essential for sufficient availability
- Immobile in plant
- Toxicity; rare (chelate toxicity?)

Fe deficiency

- Causes:
  - Low concentration
  - No or incorrect chelate
  - High pH
  - Lack of oxygen
  - Lack of young roots
  - Low temperature
  - Susceptible cultivar

Iron (Fe) deficiency → Chlorosis

Fe deficiency → Chlorosis

Fe deficiency → Chlorosis

Fe deficiency → Chlorosis

Manganese (Mn)

Manganese (Mn)

- Role
  - Photosynthesis process
  - Enzymes
- Uptake as Mn^{2+}
- Immobile in plant (slightly mobile)
- pH>6 : Mn^{2+} oxidizes to Mn^{3+} / Mn^{4+} → MnO_2 precipitation

Manganese (Mn)

- Deficiency:
  - resembles Fe (yellow, younger leaves, in between veins)
- Toxicity:
  - necrotic tips, edges older leaves

Manganese (Mn) deficiency

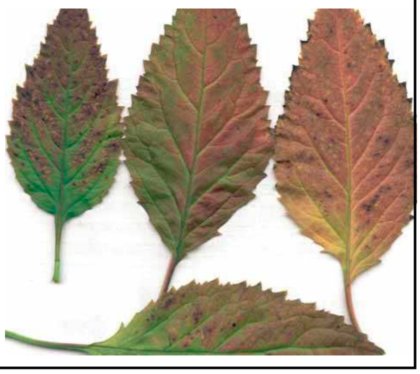
Manganese (Mn) deficiency

Manganese (Mn) deficiency

Manganese (Mn) toxicity

Manganese (Mn) toxicity

Manganese (Mn) toxicity



Zinc (Zn)

Zinc (Zn)

- Role
  - Enzymes
  - chlorophyll
- Uptake as Zn^{2+}
- Immobile in plant
- Deficiency:
  - Young leaves very small, short internodes
  - Chlorosis between veins
- Toxicity:
  - Bleaching, stunted growth

Zinc (Zn) deficiency

Zinc (Zn) deficiency

Zinc (Zn) toxicity

Zinc (Zn) toxicity

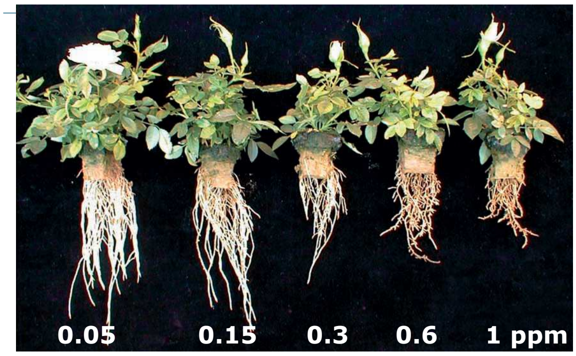
Copper (Cu)

Copper (Cu)

- Enzymes (in photosynthesis, lignin synthesis, pollen)
- Uptake as Cu^{2+}, or in complex
- Immobile in plant
- Deficiency: leaf deformation
- Toxicity: necrotic root tips

Copper (Cu) deficiency

Copper (Cu) toxicity



From: Youbin Zheng, University Guelph, Canada).

Copper (Cu) toxicity

Toxicity rarely occurs, except

- Copper pipes
- Disinfection with copper products
- Water from heat exchanger with copper wire

Boron (B)

Boron (B)

- Role
  - Cell wall (crosslinking pectin)
  - Vessels
  - Cell division (meristems)
  - Pollen tube growth
  - Sugar transport
- Uptake as HBO_3^{2-}
- Immobile in most plants
  - Some species mobile due to complex with polyol, e.g. radish, carrot, apple)
- Sometimes compared with Ca

Boron (B)

- Deficiency
  - stunted growth
  - heart rot
  - poor seed production
  - Necrotic root tips
  - Less uptake of nutrients (due to root and xylem problems)
- Toxicity: Necrotic root tips
  Necrotic spots in leaves (mainly older leaves)
  Leaves like paper

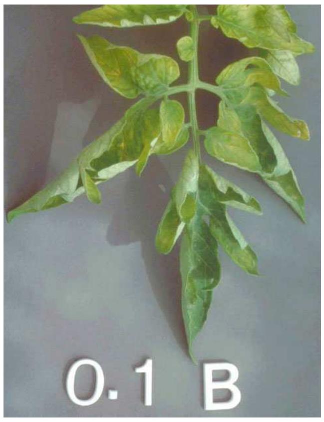
Boron (B) deficiency

Boron (B) deficiency

Boron (B) deficiency

Boron (B) deficiency

Boron (B) deficiency



Boron (B) deficiency

Boron (B) toxicity

Molybdenum (Mo)

Molybdenum (Mo)

- Role nitrogen metabolism
  (nitrate reduction, nitrogen fixation)
- Uptake as molybdate (MoO_4^{2-})
- Very immobile in de plant
- Deficiency:
  - symptoms of N-deficiency
  - Deformed leaves
- Toxicity (very rare)

Molybdenum (Mo) deficiency

Nickel (Ni)

Nickel (Ni)

Usually not any problem

- Essential element in enzyme urease
- Uptake as Ni^{2+}
- Deficiency:
  - leaf tip necrosis
- Toxicity (rare)

Nickel (Ni) deficiency

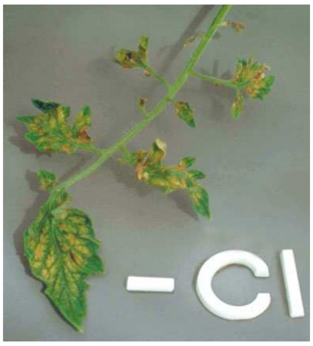
Cobalt (Co)

Cobalt (Co)

- N_2 fixation in Leguminosae
- Not relevant in horticulture

Chlorine (Cl)

- Photosystem II
- Stomata function
- Form of uptake: Cl^-
- Deficiency:
  - Wilting, necrosis
  - **Hardly ever occurs**
- Toxicity: salt stress



Conclusion

- Micronutrients very small concentrations
- Metabolic processes
- Deficiency as well as toxicity
- Availability dependent on pH
- Chelates important, but also pH dependent
  - Differences between chelates and nutrients
  - Chelates may degrade (light, UV, ozone)
- Deficiency or toxicity
  → first study pH, chelates

Questions?