10 IRON

10.1 Role in citrus production

Plant roots are in contact with at least three ion species of iron in the soil namely Fe^{++}, Fe^{+++} and Fe-chelates. Plants utilise Fe^{++} and sometimes also Fe-chelates directly. Fe^{+++} is insoluble in water and need to be reduced before plants can absorb it.

Absorption is governed by the metabolism of the plant and can be influenced by other cations. Iron chloroses is frequently induced by other factors such as poor aeration and high pH. Absorption of iron is also suppressed by high concentrations of bicarbonates and phosphates. Bicarbonates are absorbed by the plants and react with the iron already absorbed by the plant rendering it inactive inside the plant, for physiological processes. The total iron content in the plants is therefore not necessarily in the active form. Under such adverse conditions iron will accumulate in the leaf but the leaf might still suffer from a deficiency. Deficiencies induced by bicarbonate cannot be corrected by applying iron chelates. Only lime induced chloroses can be corrected by chelates.

Over irrigation results in accumulation of bicarbonates and will induce iron deficiencies.

Iron is fairly immobile in the plants and reduction does not occur readily. Symptoms of an iron deficiency therefore develop on young and shaded leaves. Chlorotic leaves do not necessary contains low concentrations of total iron.

Due to the ease of conversion of Fe^{++} to Fe^{+++}, and visa versa, iron is involved in many oxidation reduction reactions in the plant. The most important functions are in the electron transport chain and in cytochrome synthesis.

Iron deficiency
Most soils contain ample iron but a deficiency in available iron can be induced by many factors.

Free lime will induce an iron deficiency due to formation of insoluble iron carbonate. This is called lime induced iron chloroses. The reaction can be written as follows.
$CaCO_3 + Fe^{++} \leftrightarrow FeCO_3 + Ca^{++}$

The $FeCO_3$ will be oxidised further to form Fe_2O_3 (iron oxide) a reddish completely insoluble product, which cover soil particles.

The concentration of available iron can be reduced in the soil solution but also in the plants. This is caused by bicarbonate. Bicarbonate is present in alkaline soils but can also accumulate during water logged conditions caused by poor drainage. Under water logged conditions the partial pressure of CO_2 in the soil increases and more HCO_3 is formed and absorbed. This could also happen when the irrigation water contains too much HCO_3.

A complete lack of iron is restricted to white, acid and sandy soils where all the Fe has been dissolved and leached.

Iron deficiencies limit the production of citrus by reducing both the total mass and fruit size. Fruit formed under deficient conditions are flat with a light yellowish colour.

Foliar application of iron is not effective in correcting a deficiency. Soil applications are more effective and economically justifiable permitted more than 20% of the canopy is chlorotic. However, it is more often better to treat the conditions (drainage and pH) that induced the iron deficiency.

Therefore it is important to establish the cause of the iron deficiency in order to select the most effective treatment.

Symptoms of iron deficiency appear during winter and usually first on the shady or inside of the canopy. The new leaves have a normal size and the veins, even the very fine ones are green on a light green to yellow back ground of the blade (lamina).

Excess iron
An excess of iron is rare and like all other heavy metals will damage the roots before it influence the leaves. Excesses are limited to reducing conditions like water logging as well as acidic conditions.

10.2 Sources of iron

Applications of iron chelates to the soil are very effective. The chelates can be applied by hand or through microjets and drippers. Iron deficiencies are usually associated with alkaline conditions and treatment includes the selection of the appropriate chelate (Table 23). Some iron chelates are not stable at the high pH conditions of alkaline soils.

Table 23. The most suitable chelate at different pH values of the soil.

Chelate	pH(water)
DTPA	7,50
EDTA	6,00
HEEDTA	5,90
EDDHA	8,50

10.3 Fertilisation with iron

Soil applications

Applications to the soil are very effective and should be done during August. Apply 30g Fe-EDDHA per m^2 to total not more than 300g per tree. This one application should correct the deficiency and increase the number of fruit economically. This chelate is sensitive to sunlight and should be washed into the soil soon after application.

Fertigation with microjets

The same application rate and conditions as mentioned above are applicable. Apply 30g Fe-EDDHA per m^2 to total not more than 300g per tree during a short period, followed by enough water to wash it into the soil. This one application should correct the deficiency and increase the number of fruit economically. This chelate is sensitive to sunlight and should be washed into the soil soon after application. In sandy soils the application can be split and both applied in August.

Fertigation with drippers

If the pH of the nutrient solution is kept between 6,00 and 6,50 any chelate can be applied, even iron sulphate. The concentration of iron in solution is much lower namely 2,5 to 5,00mg per litre water. Chelates must not be mixed with acids or solutions if the pH is below 5,00. The organic component might be disrupted.

10.4 Foliar sprays with iron

It is claimed that 500g citric acid per 100 litres water, can correct iron deficiencies. The precipitated iron in the cytoplasm will be dissolved by the acids and mobilised rendering it available for physiological processing. A combination of organic acids (citric acid + malic acid + sorbitol) plus iron sulphate also gave good results (Rambola et al, 1999). The acids form chelates with the iron in iron sulphate but the cost of these mixtures are higher than the commercial products.

The lack of relocation of iron in the plant makes foliar sprays an ineffective method to maintain or correct the iron status of the plants.