# IMPORTANCE OF IRON, COPPER, MOLYBDENUM AND CHLORINE MICRONUTRIENTS IN PLANTS

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There are 7 essential nutrient elements defined as micronutrients [boron (B), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), molybdenum (Mo), chlorine (Cl)]. They constitute in total less than 1% of the dry weight of most plants. The following discussion focuses primarily on the soil characteristics for three of these micronutrients, i.e. iron, copper, molybdenum, and chlorine.

## I. Iron (Fe)

In most cases, plant iron deficiency is not due to the lack of iron in the soil, but due to soil conditions that reduce its plant availability, such as:

- High soil pH
- Low soil oxygen levels caused by either soil compactions or water-logging
- Prolonged periods of excessive soil moisture
- High temperatures
- High soil phosphorous, copper, manganese, and zinc levels

Based on these soil influencing factors plus the lack of a correlation between Mehlich No. 1-extractable iron and plant response, the extractable-iron concentration in the soil is not reported.

Crops that may exhibit iron deficiency symptoms are pecan (when over fertilized with zinc), centipede grass, blueberry, and certain ornamentals, such as azaleas and camellia. A foliar application of iron is the most effective way to correct an iron deficiency by either applying a 1% solution of ferrous sulphate [$FeSO_4$ - adding a little sulfuric acid ($H_2SO_4$) to keep the iron in solution], or a 2% solution of chelated iron.

Some plants have been designated as “iron sufficient” due to the ability of their roots to acidify the rhizosphere and/or to secrete phytosiderophores that complex iron at the root-soil interface, and thereby enhance iron uptake.

Iron exists in the soil solution as either the ferrous ($Fe^{2+}$) or ferric ($Fe^{3+}$) cation, the valence form being determined by soil conditions.

**List of Iron-containing Commercial Fertilizers:**

| Source | Formula | Water Solubility | %Fe |
|---|---|---|---|
| Ferrous ammonium phosphate | $Fe(NH_4)PO_4 \cdot H_2O$ | Soluble | 29 |
| Ferrous ammonium sulfate | $NH_4SO_4.FeSO_4 \cdot 6H_2O$ | Soluble | 14 |
| Iron chelates | NaFeEDTA | Soluble | 5 – 11 |
| | NaFeHPDTA | Soluble | 5 – 9 |
| | NaFeEDDHA | Soluble | 6 |
| | NaFeDTPA | Soluble | 10 |
| | FeHEDTA | Soluble | 5 – 9 |
| | FeEDDHA | Soluble | 6 |
| Iron polyflavonoids | Organically bound Fe | | 9 – 10 |
| Ferrous sulfate | $FeSO_4 \cdot 7H_2O$ | Soluble | 20 |
| Ferric sulphate | $Fe(SO_4)_3 \cdot 4H_2O$ | Soluble | 23 |

## II. Copper (Cu)

Copper is included in the Standard Soil Test. Copper deficiency is likely to occur on organic soils, mineral soils high in organic matter content (> 5%), and on very sandy soils that have been over-limited and thus have a high soil pH (>6.0 or 6.5, depending on soil type).

Copper is retained in available forms in clay soils. Copper can be leached from very sandy soils low in organic matter content. Correcting a copper deficiency from occurring in organic soils requires application rates of 9 to 22 kilograms copper sulphate ($CuSO_4 \cdot 5H_2O$) per acre or a foliar application at the rate of 0.4 to 0.9 kilograms $CuSO_4 \cdot 5H_2O$ per acre. There is a very narrow range between deficiency and toxicity for copper, and either soil or foliar-applied recommendations should be based on a deficiency verified by a plant tissue analysis. Copper exists in the soil solution as the cupric ($Cu^{2+}$) cation.

**List of Copper-containing Commercial Fertilizers:**

| Source | Formula | Water Solubility | %Cu |
|---|---|---|---|
| Basic copper sulphates | $CuSO_4 \cdot 3Cu(OH)_2$<br>General Formula | Soluble | 13 – 53 |
| Copper chelates | $Na_2CuEDTA$<br>NaCuHEDTA | Soluble<br>Soluble | 13<br>9 |
| Copper sulphate (monodydrate) | $CuSO_4 \cdot H_2O$ | Soluble | 35 |
| Copper sulphate (pentahydrate) | $CuSO_4 \cdot 5H_2O$ | Soluble | 25 |
| Cupric ammonium phosphate | $Cu(NH_4)PO_4 \cdot H_2O$ | Soluble | 32 |
| Cupric chloride | $CuCl_2$ | Soluble | 17 |
| Cupric oxide | CuO | Soluble | 75 |
| Cuprous oxide | $Cu_2O$ | Soluble | 89 |
| Copper polyflavonoids | Organically bound Cu | Partially soluble | 5 – 7 |

**III. Molybdenum (Mo)**

Molybdenum is recommended for legumes growing on acid soils when a deficiency is suspected. Molybdenum is not recommended for application on non-legume crops.

Soil pH is the major soil factor affecting molybdenum plant availability. Generally, if the soil pH is greater than 6.0, a deficiency is not likely to occur. If the soil pH is below 6.0 and molybdenum deficiency is suspected, the recommended application rate for most legume crops is 55 to 225 grams molybdenum per acre applied as either a seed treatment or foliar spray.

Molybdenum exists in the soil solution as molybdate ($MnO_4^{2-}$) anion.

**List of Molybdenum-containing Commercial Fertilizers:**

| Source | Formula | Water Solubility | %Mo |
|---|---|---|---|
| Ammonium molybdate | $(NH_4)_6Mo_7O_{26}$ | Soluble | 53 |
| Molybdenum trioxide | $MnO_3$ | Soluble | 66 |
| Molybdenum dioxide | $MnO_2$ | Soluble | 75 |
| Sodium molybdate | $Na_2Mo_4\ 2H_2O$ | Soluble | 39 |

**IV. Chlorine**

Chlorine is an essential plant nutrient element, existing in the soil as the chloride ($Cl^-$) anion. This anion is abundant in nature and chloride excesses are more common that its deficiency. Crop quality can be affected by the use of chloride-containing fertilizers. For tobacco as well as potato and tomato, either potassium sulfate ($K_2SO_4$) or potassium nitrate ($KNO_3$) is the recommended potassium fertilizer source rather than potassium chloride (muriate of potash, KCl). For blueberries, acid-forming fertilizers that do not contain chloride are preferred.

Chlorine exists in the soil solution as the chloride ($Cl^-$) anion.

**List of Chlorine-containing Commercial Fertilizers:**

| Source | Formula | Water Solubility | %Cl |
|---|---|---|---|
| Calcium chloride | $CaCl_2$ | Soluble | 50 |
| Potassium chloride | KCl | Soluble | 48 |

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