MICRONUTRIENT ELEMENTS

IRON

Source. It is fairly present in the form of its oxides giving red or brown colour to the soil. In well-irrigated areas ferric compounds are predominantly found and in water-logged soils, ferrous compounds are formed. The availability of iron to plants increases with acidity and is depressed by phosphates. It is absorbed in ferric state but metabolically it is active in ferrous state.

Functions. Though iron is not a constituent of chlorophyll, yet it is closely concerned with it and probably plays the role of a catalyst. Iron also acts as a catalyst and electron carrier in respiration. Iron is a constituent of cytochromes, ferredoxin, *catalase*, *peroxidase*, fluorochrome, hematin, globoids of aleurone grains etc. It also acts as an activator of *nitrate reductase* and *aconitase*.

Iron is relatively immobile in plant tissues and its mobility is affected by several factors such as the presence of magnesium, potassium deficiency, high phosphorus and high light intensity. Lack of mobility accounts for iron deficiency first developing in younger leaves.

Deficiency symptoms. These are as follows:

1. Interveinal white chlorosis of the leaves occurs and young leaves are always most severely affected. Principal veins may remain green.
2. Chlorosis may produce a mottled pattern or the leaf may show complete bleaching, or often become necrotic.
3. In extreme conditions scorching of leaf margins and tips may occur.

Disease. One common disease is *lime induced chlorosis*. The younger leaves become white or yellow white. The disease is commonly met in fruit trees but sometimes also found in beet, spinach, brassicae and cereals.

Corrective measures. Agricultural crops rarely suffer with iron deficiency. In such cases, foliar spray of ferrous sulphate (0.5%) along with lime (half quantity)

for maintaining a sufficient iron status are carried out. The chelated iron compounds such as Fe-EDTA give a very good response in ameliorating iron deficiency. For long term cases a process should be adopted to increase the pH of soil which would increase the iron availability.

MANGANESE

Source. Like iron, the oxide forms of manganese are common in soil but the more highly oxidised forms (manganese dioxide) are of very low availability to plants. Its solubility increases with the increased acidity and in strongly acid soils, it is frequently present in toxic concentrations. It may be one of the chief causes of crop failure ascribed to soil acidity. The non-availability of manganese seems to be affected by organic matter and drainage conditions. Sometimes, oxidising bacteria in soils may be largely responsible for rendering manganese non-available in the soil over the range of pH 6.5 to 7.8.

Functions. It acts as an activator of some *oxidases*, *peroxidases*, *dehydrogenases*, *kinases*, *decarboxylases* etc. and is essential for the formation of chlorophyll. It also decreases the solubility of iron by oxidation hence in certain cases abundance of manganese leads to iron deficiency in plants.

Deficiency symptoms. These are as follows:

1. Chlorosis of leaves is one of the most common symptoms of manganese deficiency.
2. Dead tissue spots are found scattered over the leaf.
3. Deficiency symptoms develop in older leaves.
4. In oats, development of Grey Speak Disease due to manganese deficiency causes total failure of the crops.
5. Severely affected tissue turn brown, the brown areas may twist in the form of spirals and they may also wither.
6. The root system is often poorly developed and badly affected. Plants may die.
7. Grain formation is also reduced and the heads may be blind.

Diseases. Some common diseases caused due to manganese deficiency are as follows.

(*i*) *Grey spec.* It is also called grey stripe, grey spot or dry spot and found in oats, barley, wheat, rye and maize. Common symptoms are appearance of greyish spot, chlorotic spot in lower half of the leaf. These fuse together and form an elongated brown streak, found mostly in third and fourth leaves.

(*ii*) *Pahla blight of sugarcane.* Chlorotic spots develop as long streaks, commonly in young leaves. The chlorotic spots turn red and coalesce to form long streaks from which the lamina may split.

(iii) Marsh spot of pea. Brown, black spots or cavities develop on the internal surface of cotyledons. So the disease is found in seeds.

(*iv*) *Speckled yellow of sugar beet.* It is characterised by interveinal chlorosis in the leaves and leaf margin may curl upward over the upper surface of leaf.

Corrective measures. Direct supply of Mn salts in soils remains many times ineffective. Infact, it should be accompanied with lowering of soil pH which enhances its availability. Foliar spray of $MnSO_4$ (0.5 per cent) plus half the quantity of lime

and a spreader is quite effective, but its application should be at an early stage of crop growth. In soil dressing, 15-30 kg $MnSO_4$ per hectare is sufficient.

COPPER

Source. Copper is found in small quantities in soils resulting from additions from the growing plants and added residue. Soils neighbouring the copper deposits are normally toxic to plants. Factors affecting its availability to plants are little known but organic matter, soil organism and pH are all important.

Functions. Its specific function in plants largely remains to be determined but its role as a catalyst and regulator is quite evidenced. It is a constituent of *ascorbic acid oxidase, laccase, tyrosinase, phenoloxidase*, plastocyanin etc. and is essential for photosynthesis, respiration and carbohydrate/nitrogen (C/N) balance.

Deficiency symptoms. Some of these are as follows.

1. Both vegetative and reproductive growth are reduced.
2. Wilting of terminal shoots occur which is followed by frequent death.
3. Leaf colour is often faded due to reduction of carotene and other pigments.
4. The foliage may, however, show burning of the margins or chlorosis or resetting and multiple bud formation and gumming may also occur.
5. In crops, the younger leaves wither and show marginal chlorosis (yellowish grey) of the tips. The disease is known as *yellow tip* or *reclamation disease.*
6. Heads are dwarfed, distorted and tips tend to be chlorotic.
7. Grain formation is more severely restricted than vegetative growth.

Diseases. Following are important diseases caused due to copper deficiency.

(*i*) *Exanthema* or *die back of fruit trees.* It is commonly found in citrus, plum, apple and pear. The pathological symptoms include formation of strong watershoots bearing large leaves, gummous tissue or the bark and longitudinal breaks. Fruits become brown, glossy and splitted. Affected shoots lose their leaves and die back and lateral shoots produce bunchy appearance.

(*ii*) *Reclamation disease.* It is also called white tip disease and is found in cereals, oats, beet and legumes. The tips of leaves become chlorotic followed by a failure of the plants to set seed.

Corrective measures. Soil application of $CuSO_4$ (5–10 kg/hectare) or 0.1–0.2 % of $CuSO_4$ foliar spray with half lime give good results.

ZINC

Source. Like copper, it is also found in soils in very small quantities and largely results from concentration and addition from growing plants and added residue. In the neighbourhood of zinc deposits, it is generally found to be toxic. Its uptake is reduced due to large or prolonged supply of phosphate fertilisers.

Functions. Its function is little known like that of iron, manganese or copper but it is a component of enzymes like *carbonic anhydrogenase, alcohol dehydrogenase, lactic dehydrogenase, glutamic dehydrogenase, alkaline phosphatase, carboxypeptidase,* etc. It has been found essential for carbon dioxide evolution and utilisation, carbohydrate and phosphorus metabolisms and synthesis of RNA and auxins. A close relationship is found between zinc and chlorophyll formation.

Deficiency symptoms. Some symptoms are as follows:

1. Leaves show chlorosis or necrosis and become leathery.
2. Plants show rosetting and premature shedding.
3. Whitish chlorotic streaks between the veins are found in older leaves.
4. Whitening of upper leaves in monocots and chlorosis of lower leaves in dicots are often found.
5. Leaf margins are distorted, become twisted or wavy which later curl and look sickle shape.
6. Seed production and fruit size is greatly reduced.

Diseases. These are as follows.

(*i*) *Khaira of paddy.* The entire seedling looks brown (due to chlorosis) and ultimately dies.

(*ii*) *White bud (tip) of maize.* Unfolded newer leaves are often pale yellow to white. There is appearance of light yellow streaks between the veins of older leaves followed by white necrotic spots.

(*iii*) *Rosette of fruit trees.* It is also called little leaf caused due to zinc deficiency. Yellow mottling of leaves, reduction in leaf size with rosette appearance and die back of the affected branches are important symptoms of disease.

(*iv*) *Frenching of Citrus.* Initially, yellow spots develop between the veins. Leaves become progressively smaller and develop chlorophyll at the basal end of midrib. Rarely, die back may be found.

Corrective measures. It is fairly common in soils with pH above 7.0. Soil application of zinc sulphate (10-30 kg/hectare) gives good results. Foliar spray (0.5% $ZnSO_4$) coupled with half the content of lime is quite beneficial. In alkaline soils, it should be supplied with sulphur or ammonium sulphate.

MOLYBDENUM

Source. It is found widely distributed in small amounts in soils and plants but its higher concentration occurs in mineral oils and coal ashes.

Functions. The function of molybdenum is partly known. It is an important constituent of the nitrate reductase system. It also acts as an activator of some *dehydrogenases* and *phosphatases* and as cofactors in the synthesis of ascorbic acid. It is found necessary to the nodule formation in legumes for the fixation of atmospheric nitrogen.

Deficiency symptoms. These are as follows:

1. In tomato, chlorosis appears in the form of mottling in the older leaves.
2. Leaves often show light yellow chlorosis and leaf blades fail to expand.
3. Deficiency symptoms develop from younger leaves in certain cases while from older leaves in other cases.
4. In acute deficiency cases, necrosis of léaf tissue occurs.
5. In oats, failure of grain formation occurs.

Diseases. Its deficiency produces two important diseases.

(*i*) *Whiptail of brassica.* The symptoms begin as appearance of translucent areas near the midrib which become ivory tinted or necrotic. The leaf margins become ragged with upward curling. Before the death of the growing point, the leaf elongates and lamina remains suppressed, thus giving a typical whiptail condition.

(*ii*) *Scald of legumes.* The leaf shows paling, wilting, marginal rolling or scorching.

Corrective measures. The deficiency of Mo is commonly found in herbage plants, legumes, oats, brassicae etc. which can be corrected by application of 0.5 to 1 kg of sodium or ammonium molybdate per hectare. Foliar spray (0.01 to 0.02%) may also be done to remove its deficiency.

BORON

Source. Boron occurs in rocks and marine sediments. It is absorbed in the form of borate ions and has some sort of antagonism with calcium, potassium and other cations.

Functions. To boron at least 18 roles have been assigned. It is necessary for translocation of sugars and is involved in the reproduction and germination of pollens. It is concerned with water reactions in cells and regulates the intake of water into the cell. It tends to keep calcium in soluble form within the plant and may act as a regulator of potassium ratios. It may be concerned with nitrogen metabolism and with oxidation reduction equilibria in cells.

Deficiency symptoms. These are as follows:

1. Plants dwarf, stunted with apical meristem blacken and die followed by general breakdown of meristematic tissues.
2. Terminal leaves become necrotic and shed prematurely.
3. Leaves show deficiency symptoms like appearance of white stripe, scorching, pimpling, splitted mid-rib, reduced growth and distortion like cupping and curling.
4. Stem shows deficiency symptoms like die-back of apex, abnormal tillering, appearance of various forms of deformities such as curling and brittle lesions, pimpling etc.
5. Flowers are produced in lesser numbers and are sterile or lacking.
6. Fruits when affected are severely deformed and useless or lacking.

1. **Chlorosis** is a physiological disease that occurs due to deficiency of mineral elements (*e.g.* Mn, K, Zn, Fe, Mg, N) or attack of parasites (*e.g.* Virus) when the plants are grown in light. Leaves or plant parts become abnormally yellow due to the reduction of chlorophyll contents.
2. **Mottled** is surface marked with coloured spots, (anthocyanin develops), *e.g.* due to deficiency of N, Mg, P, S.
3. **Necrosis** refers to a patch of dead tissues, due to deficiency of Mg, K, Zn, Ca and Mo.
4. **Etiolation** is an abnormal condition developing in vascular plants in sub-optimal light. The leaves are small and yellow and the internodes are abnormally long due to formation of etiolin compound.

Diseases. Several diseases are produced by boron deficiency.

Important types are as follows:

(*i*) *Heart rot of sugarbeet and marigold.* It is also called *crown rot* or *dry rot.* The most important symptom is the necrosis of tissue of the interior root. The youngest leaves are curled, veins becoming yellowish and petioles are brittle. The main growing points die.

(*ii*) *Canker and internal black spot of garden pea.* The presence of internal hard, black necrotic masses, irregular in size and shape, found in the central region or throughout the root, are important symptoms.

(*iii*) *Browning of cauliflower.* There appear water soaked areas on the developing curl which turn brown and become hard. The leaves become thicker, brittle and curl downward. Blisters on the petiole and midrib may be found.

(*iv*) *Yellow top of Lucerne.* Symptoms like uniform yellowing or interveinal bronzing, shorter internodes followed by death of growing points are found.

(*v*) *Top sickness of tobacco.* The terminal leaves become pale green, more towards the base of leaf. The basal tissue of young leaves breaks down and the bud dies. The older leaves become thicker and brittle, midrib may break and upper leaves droop down.

(*vi*) *Hard fruit of Citrus.* Symptoms like die back of apex, reduced flowering and shedding of fruits are found. The fruits are badly-shaped, thick-skinned and impregnated irregularly by gum around the central axis.

Corrective measures. In case of boron deficient soils, liming should be avoided and at times boron containing fertilisers should be supplied. However, a 0.2 per cent borax can be used as foliar spray for quick recovery of boron deficiency.

CHLORINE AND OTHERS

It occurs commonly in soils as chlorides and moves freely in soil solution from which it is available to plants. No general statement can be made regarding the role of chlorine in plant metabolism. In tobacco, it has been shown to increase the water content of cells and to affect carbohydrate metabolism. It has also been demonstrated that chloride may speed up photosynthesis *in vitro*. In chlorine deficiency, wilting of leaves occur followed by basipetal chlorosis, bronzing and necrosis.

It has been found, though present in plants in quite large quantities, Co is the seventh essential trace element (Broyer *et al.*, 1954). Though there is no definite proof due to extremely low required quantities, there are reasons to believe that Co is also an essential element. In absence of nitrogen supply, Co is needed by leguminous plant. It may be due to cobalt requirements of symbiotic bacteria. Some algae also need cobalt.

Indirect evidences in favour of the essentiality of Co are:

(*i*) Amount of Co present even in the most carefully purified media remains sufficient to supply the plant.

(*ii*) The addition of Cobalmin (Vit. B_{12}) under certain conditions favours the synthesis of an amino acid (serine) in primary root of *Zea mays* (Graser, 1965).

As a direct evidence, careful exclusion of contamination by traces of Co in air has succeeded in demonstrating a significant decrease in plant growth when Co was not knowingly added (Wilson and Nicholas, 1967).

Recently evidences have been produced by some workers for the essentiality of some other elements such as Al, Si and Se at least for certain plants but other workers have failed to get positive results. These results have been explained to be due to frequently observed stimulating effects of certain non-essential elements by counteracting the toxicity of certain elements present in the medium. Elements such as Al and Si have been called pallast elements. Some plants are also accumulators, *i.e.* they can accumulate large quantities of some elements such as Al and Se. Table 6.4 provides an idea of the essentiality or probable essentiality of elements of certain plants.

Table 6.4. Essential Elements for Certain Plants.

	Element	*Plants*
1.	*Macroelements*	In all plants
	K, N, P, Mg, Ca, S	
2.	*Microelements* (traces)	For all higher plants
	Fe, Mn, Cu, Co, B, Mo and Cl	
3.	*Apparently essential*	
	V	*Scenedesmus*
	Al	Ferns
	Si	Diatoms
	Na	Blue-green algae
	Se	*Atriplex*
		Astragalus (*A. racemosus* and *A. bisulcatus*)
	I	*Polysiphonia*

Complete absence of any of the essential elements will stop growth of the plants completely but under normal conditions, the elements are not completely absent and so when these elements present are in quantities lower than the optimum, certain abnormalities or deficiency diseases develop.

Sometimes it is difficult to distinguish between the deficiency symptoms of two elements. Different plant species may also show different deficiency symptoms for the same element.