MINERAL NUTRITION IN PLANTS

Green plants are called autotrophs. Only green plants have the potential to synthesise their own food during photosynthesis. Plants take carbon dioxide from the air and water from soil to form organic compounds such as carbohydrates. Almost all plants absorb water and Minerals from soil. Inorganic substances are present in form of minerals in the soil. These are called mineral elements or nutrients elements and their nutrition is called Mineral nutrition.

Most of the mineral elements present in soil, enter into the plant through their roots. According to facts, out of 118 mineral elements discovered so far more than 60 have been found in different plants. They are found in different concentrations in different plants. Most of the mineral elements are essential for plants and are therefore called essential or necessary elements. But there are some elements which though present in plants, do not play any significant role. Some plant species accumulate Selenium, some have gold and some growing near nuclear testing sites have radioactive substances such as strontium in them. Techniques are now available to determine minimum concentration of mineral elements in plants. Arnon in 1938, prescribed the following parameters for determining essentiality of any mineral element:

1. The element should be essential for the normal growth and reproduction in plants. In the absence of the element the plant is unable to complete its life cycle and bear seeds. Absence of the element may also result in development of disease in plants.

2. The essentiality of the element should be specific and could not be replaced by any other element.

3. The element should have direct role in plant metabolism.

Classification of essential elements

Based on the above criteria, only some elements have been found to be essential for growth and development in plants. On the amount of essential minerals required, it has been classified into broad groups:

1. **Macronutrients or major nutrients**
   Macronutrients are those elements which are present in concentration of 1-10 mg/lit. of the total dry matter of the plant. The elements in this category are carbon (C), hydrogen (H), oxygen (O), phosphorus (P), Nitrogen (N), sulphur (S), Potassium (K), Calcium (Ca) and Magnesium (Mg). Among these C, H, O are obtained mainly from CO_2 and H_2O, whereas other elements are absorbed by soil.

2. **Micronutrients or trace elements**
   They are required in very low amount in plants and their concentration is usually 0.1 mg/lit or less of total dry weight. The elements are iron (Fe), magnesium (Mg), copper (Cu), molybdenum (Mo), zinc (Zn), Boron (B), chlorine (Cl), nickel (Ni).

   Besides these seventeen essential elements there some other beneficial elements for plants such as- sodium (Na), silicon (Si), cobalt (Co) and Selenium (Se). These are essential for only some higher plants.

Functions of macro and micronutrients

Essential elements play significant role in metabolic processes of plants. The form in which they are absorbed and the role of essential elements in plants along with their deficiency symptoms are as follows:

1. **Nitrogen:** This element is required in large amount in the plant. Roots of plant absorb Nitrogen mainly in form of nitrate (NO_3) and some amount in form of nitrite (NO_2) and ammonium ($NH4^+$). It is required by all parts of the plant especially meristematic tissues and in metabolic activities. Nitrogen is the main component of proteins, nucleic acids, vitamins and hormones. Deficiency of nitrogen results in growth inhibition, yellowing of leaves and reduction in their size, delayed flowering and poor development of flowers.
2. **Phosphorus:** Phosphorus is absorbed in the form of phosphate ion (H_2PO_4) or HPO_4. It is the component of cell membrane, some proteins, all nucleic acids and nucleotides. It has important role in phosphorylation reactions. Deficiency of phosphorus results in premature leaf fall and development of anthocyanin pigments in leaves. Necrotic areas develop in the plant associated with inhibition of plant growth.
3. **Potassium:** Potassium is absorbed in the form of Potassium ion (K^+). Meristematic tissues, buds, leaves and fruit requires large amount of Potassium. It helps in maintaining cation-anion balance in the cell. It is also involved in protein synthesis, opening and closing of stomata, enzyme activation and maintaining turgid state of the cells. Its deficiency leads to dwarfing of plants, incapability to repair damage within cells, yellow spots on leaves and stem lodging of cereal crops in wind and rain.
4. **Calcium:** Plants absorb Calcium in form of Calcium ions (Ca^{++}). It is required in greater amount in dividing and differentiating tissues. It is used in the synthesis of cell walls during cell division. It is present in the form of Calcium pectate in the middle lamella. It is also required in the formation of spindle fibres during cell division. Ca gets accumulated in older leaves. It is involved in normal function of cell membrane. It activates some enzyme and has important role in regulation of plant metabolism. In its deficiency, chlorophyll does not perform its function properly. Flowers are malformed, fall early and chlorosis occurs in leaves.
5. **Magnesium:** It is absorbed in form of magnesium ion (Mg^{++}) by the plant. It is involved in activation of respiratory and photosynthetic enzymes. It is a component of ring structure of chlorophyll and also has role in synthesis of DNA and RNA. It is a component of ring structure of chlorophyll and also has role in ribosomal organisation. It deficiency results in chlorosis which later appears in young leaves also. Anthocyanin content in leaves increases and many necrotic spots appear in plants.
6. **Sulphur:** Plants absorb Sulphur in form of sulphates. Sulphur is present in amino acids like methionine and cysteine. It is an important component of many vitamins (thiamine, biotin). Deficiency of this element results in chlorosis, accumulation of anthocyanin in leaves, inhibition of their growth and stunting of the plants.
7. **Iron:** Iron is absorbed in the form ferric ion (Fe^{+3}). As compared to other micronutrient, iron is required in larger amount. It is an important component of ferrodoxin and cytochrome which are involved in electron transport. It undergoes reversible oxidation from Fe^{++} to Fe^{+++} during electron transport. It activates catalase enzyme and is responsible for chlorophyll biosynthesis. Shortage of iron causes yellowing of leaves, dark coloured veins, chlorosis and slow rate of chlorophyll synthesis.

8. **Manganese:** It is absorbed in form of magnous ion (Mn^{++}). It activates many enzymes involved in photosynthesis, respiration and nitrogen metabolism. Its main function is photolysis of water and release of oxygen in photosynthesis. Deficiency symptoms first appear in order leaves. Interveinal chlorosis and necrotic areas appear in leaves.
9. **Zinc:** Plants absorb zinc in the form of zinc ion (Zn^{++}). It activates many enzymes especially carboxylase. Zinc is also required in the synthesis of auxin. In its absence, leaves get deformed. Leaf apex shows chlorosis. Flowering is also not proper.
10. **Copper**: It is absorbed in the form of cupric ion (Cu^{++}). It is essential for metabolism in plants. Just like iron, it is also associated with enzymes of redox reactions. Copper shifts between cuprous and cupric forms. In citrus, its deficiency causes dieback disease and in paddy reclamation disease. Necrotic areas appear in young leaves.
11. **Boron:** It is absorbed both in form of BO_3^{---} and $B_4O_7^{--}$ ions. Boron is required for intake and use of calcium ions, functioning of membranes, pollen germination, cell elongation and differentiation and translocation of carbohydrates. Its deficiency results in death of shoot apex, inhibition of flowering, blackend leaf tips and stoppage of growth of different organs.
12. **Molybdenum**: Plants absorb it in the form of molybdate ion. It is an important component of several enzymes such as nitrogenase and nitrate reductase etc. Its deficiency results in accumulation of various amino acids and inhibition of flowering. In cauliflower deficiency of molybdenum results in whip tail disease.
13. **Chlorine:** it is absorbed in the form of chloride ion (Cl^-). Chlorine along with potassium and sodium helps in the determination of solute concentration and cation-anion balance in the cell. It is required in hydrolysis of water during photosynthesis. Its deficiency results in wilting of leaves, chlorosis, development of necrotic areas and reduction in root length.
14. **Nickel:** It is rapidly absorbed in the form of nickel Ni^{++} ions by plants. Dalton placed it in the category of essential elements. It is the main component of enzyme urease. It plays important role in seed germination. It is required in traces. Deficiency of nickel results in chlorosis in plants and development of necrotic spots on leaves.

Hydroponics J. Von sachs in 1860, first of all demonstrated that plants can grow and mature in special nutrient solution even in absence of the soil. This type of soilless culture or solution culture of plants is called hydroponics.