Major and Minor elements: Introduction, source, deficiency symptoms and their

- .An element is essential if a plant cannot complete its life cycle without it, if no other element can perform the same function, and if it is directly involved in nutrition.
- An essential element is known, without which the plant cannot complete its life cycle.
- This element is absolutely necessary for supporting normal growth and reproduction of plant.
- All the 40 elements obtained by the analysis of plant ash are not essential for the nutrititon of plant but a few are essential for the growth and development of plant.
- Essential elements are divided into two groups depending upon the requirement.

A) **Macroelement- or Major elements-** An essential nutrient required by the plant in large amounts is called a macronutrient, ex.C, H,O,N,S,P,K,Mg,Ca and Fe.

B) Microelement or minor element- An essential nutrient required by the plant in in

very small amounts is termed a micronutrient. Ex, B,Mn,Zn,Cu Mo and Cl.

Missing or inadequate supplies of nutrients adversely affect plant growth, leading to stunted growth, slow growth, chlorosis, or cell death.

Occurrence , Function and Deficiency symptomsof Essential elements

Macroelements

1- Carbon(C)-

It obtained from the air in the form of CO2. Carbon is the main constituent of the plant material.

The main part of the plant consists of it. It is usually half of plant's dry weight.

Carbon is found in all organic compounds present in the plant.

The plants get carbon from the atmosphere in the form of carbon dioxide. Usually, .03% carbon dioxide is found in the atmosphere, but this percentage goes down even to .01% in day time, because of its use in the photosynthesis.

2- Hydrogen(H) – It is obtained from the soil, in the form of H2O.

- Free hydrogen does not play any role in the plant life.
- When it combines with oxygen, water is formed, which is absorbed by the plants.

- The hydrogen is found in so many organic and inorganic compounds of the plant

3- Oxygen- It is obtained from the air and soil in the form of O2 and H2O respectively.

- Free oxygen is taken from the atmosphere by the plants, which helps in the respiration of the living cells.
- Besides this, the oxygen is found in many organic compounds of the plant.

-C,H,and O mainly participate in the formation of protoplasm and cell wall of plants

4-Nitrogen-

- It is obtained form the soil in the form of NO_2^-, NO_3^- or NH_4^-.
- Occurrence –it is found in all plant body. Seeds nd food storing regions of both organic and inorganic forms
- Functions-
- Nitrogen is found in the constituents of proteins, chlorophyll, protoplasm, nucleic acids, vitamins and hormones.
- For proper and normal growth of leaves of plants, it is one of the most essential elements.
- Important element in protein synthesis. Play and vital role in the formation of NAD, NADP coenzymes,.
- Deficiency symptoms-
- Lowering of respiration rated . Late and less or no flowering. Necrosis of tissues at advanced stage
- Nitrogen deficiency causes yellowing of older leaves (chlorosis).
- Production of erect leaves in grasses, potato, cerreals etc.
- Development of anthocyanin pigment in the stem, petiole and veins of leaves due to which they become red.
- The plant growth is stunted as protein content; cell division and cell enlargement are decreased.
- It also causes dormancy of lateral buds, late flowering, purple colouration and shoot axis surface and wrinkling of cereal grains.

5-Sulphur (S):

- Source-

It is obtined form soil solutions in the form of sulphate ions or through the activity of microorganism by biological oxidation

- Occurrence-

It is usually found in the complex proteins of the plants. It is found in sufficient quantity in the mustard oil. It is also found in the protoplasm.

Sulphur is present in two amino acids, i.e., cysteine and methionine. It is main constituent of several coenzymes, vitamins {i.e., thiamine, biotin, CoA) and ferredoxin.

In inorganic form it is present in the form of sulphate ions.

Function-

- Formation of sulphur containing amino acids like cysteine, cystine and methionine
- Synthesis of S containing vitamins like biotin, thiamine and co-enzyme A
- It impart distinctive colour and flavour to garlic onion and mustard oil
- Increases growth, cell division and fruiting.

Deficiency Symptom

- Sulphur deficiency causes yellowing (i.e., chlorosis) of leaves, younger leaves are affected first, tips and margins of leaves roll inward, and stem becomes hard due to development of sclerenchyma.
- These symptoms are similar to those of nitrogen deficiency symptoms, as sulphur and nitrogen are constituents of proteins.
- Retarded cell division and growht.
- Development of anthocyanin pigment in the stem and leaves.
- Supresion of fruit formtion and delaying in repening.

6-Phosphorus (P)

Sources-

it is obtained from soil solution in the form of phosphate ions (H_2PO_4 and HPO_4)

Occurance –

It is more abundantly found in the meristematic tissues and storage region as fruits and seeds. In inorganic form it is found in the form of H_2PO_4 and HPO_4. while in organic forms it is present in nucleus . In phospholipids, hexose PO_4 , coenzymes NAD, NADP and ATP, GTP and CTP. It is usually found in nucleoproteins and

protoplasm

Function-

- It also helps in the division of nucleus and the cell.
- It also helps in the decomposition of carbohydrates during respiration.
- Phosphorus is a constituent of cell membranes, nucleic acids and nucleotides.
- This is needed for all phosphorylation reactions.
- It plays a very important role in the ripening of the grains and fruits.
- This also helps a lot in the development of root system.
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- For the development of underground parts of radish, beet root, and potato, etc., this element is required.
- Phosphorus is absorbed from the soil in the form of phosphate H_2PO^- ions.
- Synthesis of Nucleoproteins
- Formation of NAD, NADP which are involved in photosynthesis, respiration, synthesis of fatty acids and protein etc.

Deficiency symptoms-

- Phosphorus deficiency causes premature leaf fall.
- Dead necrotic areas develop on leaves or fruits, and leaves turn dark to blue-green in
- colour.
- It also causes delay in seed germination.
- Plant show stunted growth due to abnormal cell division
- If favours healthy root growth by helping the translocation of solutes
- development of dead necrotic spots on the leaves, petiole and fruit which ultimately

cause falling of the leaves.

Development of anthocyanine pigmentation.

6-Potassium (K):

Sources-

It is found in soil solution in non exchangeable for fixed form and in the cell in free ionic

Form. The plants take potassium from the soil in the form of potassium nitrate and potassium chloride, etc.

Occurrence-

Potassium is mostly found in all cells except cork cells. It is most common in cytoplasm and vacuoles more abundant in apical meristems of roots ands shoots and absent from

nucleolus and nucleus

Function-

- Potassium helps to determine anion-cation balance in cells, and is involved in protein synthesis, opening and closing of stomata, activation of enzymes, and maintenance of turgidity' of cells. It is absorbed as K^+ ion by plants from the soil.
- It is one of the constituents of the protoplasm. It is related to metabolic activities. This helps in the synthesis of carbohydrates and proteins. The plant grows normally in its presence, and the fruits and seeds remain quite healthy.
- It control the enzymatic activities or various enzymes like diastase, catalase, reductase and invertase.
- Plants become fleshy and succulent in its proper supply.
- Affect the synthesis of sugars, starches fats and proteins.
- Potassium neutralizes the effects of organic acids.
- It enhance the meristematic acitivities

Deficiency Sympotms-

- Mottled chlorosis of leaves occurs.
- Necrotic areas are developed at the tips and margins of leaves, and they curve downwar
- Intemodes become short, and plants adopt bushy habit.
- It also causes loss of cambial activity, disintegration of plastids and increase in rate of respiration.
- Growth become stunted and inernodes become very much short.
- At early stage the leaves become slender and light green

- Plant becomes less resistant to pathogens

7-Calcium (Ca):

Sources-

In soil it is present in the form of cations or in minerals salts like amorthite and calcite

Occurrence-

- Abundantly found in leaves, fruit and seed coats. It is found in the form calcium pectate. In the leaves os ficus species and other plants calcium is presne in the form of caco3 and ca- oxilalate respectivley.
- Function-
- the permeability of the protoplasm is maintained by calcium.
- Usually for the growth and development of the fruits, the calcuim is very essential.
- Calcium is required by meristematic and differentiating tissues
- It is also used in the mitotic spindle in cell division.
- It activates certain enzymes and plays an important role in regulating metabolic activities.
- Calcium accumulates in older leaves. Calcium is absorbed by the plants from the soil in the form of Ca^{+} ions.
- Ca initiates the development of root hairs
- it neutralises the organic acids like oxalic acid
- Formation of lipids and cell membrance
- Ca helps in te binding of nucleic acids with proteins
- It helps in the metabolism of fats
- Help in the formation of chromosome
- Deficiency Symptoms
- In its deficiency the cells of the plant become disorganized, and the growth of the plant is also checked. But, usually the leaves become chlorotic, when its overdose is present in the soil
- Calcium deficiency causes disintegration of growing meristematic regions of the root, stem and leaves.

- Chlorosis occurs along the margins of the younger leaves, and malformation occurs. This also leads to stunted growth of the plant.
- The roots become short stubby and brown
- Hooking of leaf tip and leaf apex killed
- Cell wall remain weaker due to decreases in the cell cytoplasm.

8-Magnesium (Mg):

Source-

Mg present in the soil solution in the form of magnesite dolomite and olivine. Magnesium is absorbed by the plants from the soil in the form of divalent M^{2+}.

Occurrence-

- Mg found in leaves, fruits, meristematic cells and seeds of pulses and cereals, this element is found in sufficient quantity.
- It is found in the chlorophyll. The chlorophyll does not form in its absence,
- The oilyseeds contain more Mg as compared to starchy seeds.
- Function-
- Magnesium activates enzymes in respiration and photosynthesis.
- It helps in synthesis of DNA and RNA.
- This also maintains ribosome structure.
- Chief role is the formation of chlorophyll
- Helps in the binding of ribosomal sub units during protein synthesis.

Deficiency Symptoms

- Magnesium deficiency causes interveinal chlorosis of the leaves.
- The older leaves are affected first, and dead necrotic patches appear on the leaves.
- This also causes premature leaf abscission.
- Development of anthocyanin pigments and necrotic spots in the leaves
- Reduction of protein synthesis
- Reduction in carbohydrate and fat synthesis
- cell size is reduced

- Pith cells become smaller.

9-Iron (Fe):

Source- It is absorbed in the form of ferrousions from the soil solution. In neutral and alkaline soil, it is resent in insolube form while in acidic soil in soluble form.

Occurance-

It is found in all the parts of plant and protoplasm but in very small quantities. Its greatest

concentration is found in side the vacuoles.

Function-

- This also plays an important role in the formation of chlorophyll, though it is not found in the constitution of the chlorophyll.
- This element is always found to be present in the chromatin material of nucleus and protoplasm.
- It is an important constituent of proteins like ferredoxin and cytochromes which are involved in transfer of electrons.
- It is reversibly oxidised from Fe^{2+} to Fe^{3+} during electron transfer.
- It activates catalase. Iron is absorbed by the plants from the soil in the form of ferric (Fe^{3+}) ions.
- Formation of ferridoxin which play important role in biological Nitrogen fixation .

Deficiency Symptoms-

- Iron deficiency causes rapid chlorosis of the leaves which is generally interveinal.
- Reduce respiration rate
- Chloroplast formation is checked
- Protein synthesis is stopped
- accumulation of large quantities of free amino acids and amides

10- Manganese (Mn):

Sources- it is found in the soil in the form of bi, tri or tetravalent ions of these ions only bivalent ions are found in soluble state in soil

Occurrence-It is found in the plant ash especially in the leaves

Functions-

- Manganese activates many enzymes which are involved in photosynthesis, respiration and nitrogen metabolism.
- Manganese helps in splitting of water to liberate oxygen during photosynthesis.
- Various vitamins are formed in the fruits, only because of its presence.
- The cabbage plants, pine trees and the leguminous plants require its optimum doses.
- Manganese is absorbed by plants in the form of manganous cation (Mn^{2+}).
- It helps in the formation of chlorophyll
- Acts as co-factor in oxidative phosphorylation

Deficiency Symptoms-

- Manganese deficiency causes chlorotic and necrotic spots in the interveinal areas of leaves.
- Retardation in chlorophyll formation
- Retardation in growth as in pea
- formation of seeds slowed down
- Respiratory rate is lowered due to reduction in oxygen carrying power of oxidase
- Retardation in Nitrogen assimilation.
- Disintegration of starch grains as in tomato.
- Browning of roots and leaves in barley

11-Zinc (Zn):

Source-

It is present in the soil in the form of divalent ions whicha re released by the weathering of minerals like magnetite, biotite and horn blende

Occurrence – Usually found in the seeds

Functions-

- Participated in the synthesis of auxin-IAA
- Acitvates the metabolism of enzyme alcoholic dedhydrogenese
- Enhance the production of chytochrome a and b

- Involved in the formation of enzyme carbonic anhydrase
- Participates in the protein synthesis
- Zinc helps in the formation of chloroplasts.
- It activates various enzymes, especially carboxylases.
- Zinc is required in synthesis of auxin. It is absorbed by plants from soil' in the form of (Zn^{2+}) ions,

Deficiency Symptoms

- Zinc deficiency causes chlorosis of older leaves which starts from tips and margins.
- Malformation of leaves takes place, and stunted growth of plant occurs.
- Its deficiency causes mottle leaf disease in apple, citrus, walnut, etc., and khaira disease in rice.
- Decrease in protein synthesis
- Creates hinderance in seed formation
- Causes diseases like rosette diseases ofwalnut
- Check growth of vegetative parts particularly size of internodes and leaves are reduced
- Results in an increase in the amide and free amino acids particularly aspargin and glutamine

12-Boron (B):

Sources-

It is present in the soil in the form of boric acid, calcium and manganease borate and silicates. It is always absorbed in the form of borate anions or tetraborate ions

Occurrence –

The percentage of boron is higher in wood plants than herbs

Functions-

- This is also an essential element for the growth of nearly all the plants.
- The plants of tomato, tobacco, lemon, root, mustard, cotton and others are sufficiently benefitted by these elements.
- Boron also helps in the formation of the nodules of the leguminous plants.

- It also adds to the quantity of the sugar of beet root.
- The beet root becomes susceptible to various diseases, because of its deficiency.
- In its deficiency, the normal growth of the plant is obstructed and various leaf spots are developed. In its absence, the apices of roots and stems become brittle, and gradually they die.Boron is also required for uptake and utilisation of Ca^{2+}, membrane function, pollen germination, cell elongation, cell differentiation and carbohydrate translocation.
- Helps in the metabolism of nitrogen,phosphorous, fats and hormones
- Helps in the absorpiton of salts and in photosynthesis
- Deficiency Symptoms-
- Boron deficiency causes death of the shoot tip.
- Flower formation is suppressed, root growth is stunted and shoot apices die.
- Fruits become of small size and root nodules in leguminous plants are not formed, and leaves become coppery in texture.
- Checks flowering
- leaf veins become copper coloured
- causes shortening of roots
- causes top sickness diseases in tobacco
- retards the formation of root nodules in legume plants
- Causes disintegration and browning of internal tissues in sugar beet called as heart rot diseases

13-Copper (Cu):

Sources-

In soil the Cu ismainly present in chalcopyrite and copper sulphide.it is absorbed in the form of divalent copper cations

Functions-

- Copper helps in formation of starch.
- It is required for the overall metabolism in plants.
- It is associated with certain enzymes involved in redox reactions and is reversibly oxidised from Cu^{+} to Cu^{2+}.

- Copper is absorbed by plants as cupric ion(Cu^{2+}).
- Helps in the biosynthesis of chlorophyll
- Helps in absorption of Co2 in photosynthesis
- Acts as catalyst in oxidation processes
- Acts as fungicide to prevent various diseases as late blight of potato

Deficiency Symptoms-

- Copper deficiency causes necrosis of the tips of young leaves.
- It causes die-back of citrus and other fruit trees where leaves wither and fall, bark becomes rough and splits exuding gummy substances.
- Reclamation disease of cereals and leguminous plants is also caused due to its deficiency.

14. Molybdenum (Mo):

Sources-

It is absorbed from the soil solution in the form of molybdate inons

Function-

- This helps in formation of proteins.
- It also helps in fixation of nitrogen in soil by Azotobacter and Rhizobium.
- This is a constituent of several enzymes, including nitrogenase and nitrate reductase which take part in nitrogen metabolism.
- This is absorbed by plants from soil in the form of molybdate ion (MoO_2^{2+}).
- Increases carbohydrate metabolism
- Helps in the formation of pectic substancesThe chief role of Mo is to activate nitrate reductase enzymes during nitrogen metabolims
- Controls ascorbic acid synthesis
- Increases carbohydrate metabolims
- Helps in the formation of pectic substances.

Deficiency Symptoms-

- Molybdenum deficiency causes chlorotic interveinal mottling of the older leaves.
- This may cause nitrogen deficiency, as it is component of enzymes involved in

nitrogen metabolism.

- Flower formation is inhibited, and also causes whip tail disease in cauliflower plants.
- inhibition of flowering
- causes whiptail diseases of cauliflower
- Causes wilting of leaves
- Depression of ascorbic acid
- Reduction in sugar content in plants
- accumulation of amino acids and protein synthesis is stopped

Chlorine (Cl):

Sources-it is absorbed from the soil solution in the form of chloride ions .

Functions-

- **Chlorine is an essential factor in photophosphorylation**
- With Na^+ and K^+, chlorine helps in determining solute concentration and anion-cation balance in cells.
- It is required for cell division in roots and leaves.
- It is needed to perform water-splitting reaction in photosynthesis, which evolves oxygen
- It helps In transfer of electrons during photosynthesis.
- DeficiencySymptoms-
- The deficiency of chlorine in plants causes wilting of leaves, stunted root growth and reduced fruiting.

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