

NUTRIO PHYSIOLOGY

17.1 DEFINITIONS:

Nutriophysiology deals with metabolic and biochemical functions of the chemical elements and their interaction with other aspects of plant physiology and plant biochemistry. It deals with initial acquisition of chemical elements, their distribution within the plant and interactions of the plant with its chemical media.

The supply and absorption of chemical compounds needed for growth and metabolism of plants may be defined as **Plant Nutrition** and the chemical compounds required by the plants are termed as **Nutrients**.

Higher plants are autotrophic organisms that can synthesize their organic molecular components out of inorganic nutrients obtained from their surroundings. For many mineral nutrients, this process involves absorption from the soil by roots and incorporation into the organic compounds that are essential for growth and development. This incorporation of mineral nutrients into organic substances such as pigments, enzyme cofactors, lipids, nucleic acids and amino acids is termed as **nutrient assimilation**. Nutrition and metabolism are thus very closely related.

17.2 ESSENTIAL PLANT NUTRIENTS AND CRITERIA OF ESSENTIALITY:

Plants contain about 80 to 90 percent of water by weight and the remaining 10 to 20 percent is the dry weight. The dry matter consists of a number of organic compounds such as carbohydrates, proteins, lipids and others. Nearly 90 percent of the dry weight of the plant consists of carbon, hydrogen and oxygen. All the mineral elements together contribute only about 6 percent of the dry weight of the plant.

The finding of certain element in plant does not signify that this element is essential for the growth of the plant. For finding out whether an element is essential or not, **Arnon and Stout** (1939) proposed the **criteria of essentiality**. These criteria are as follows.

- A. A deficiency of the element makes it impossible for a plant to complete its life cycle.
- B. The functions of an element cannot be replaced by another element.
However, recent studies have shown that some of these elements can be partially replaced by others for example magnesium (Mg) by manganese (Mn) and Potassium (K) by rubidium (Rb)
- C. The essential element must be directly involved in the metabolism of plant or it may be required for the activation of an enzyme system.

Based on the above criteria the following elements are now known to be essential for higher plants.

Carbon	C	Magnesium	Mg
Hydrogen	H	Iron	Fe
Oxygen	O	Manganese	Mn
Nitrogen	N	Copper	Cu
Phosphorus	P	Zinc	Zn
Sulphur	S	Molybdenum	Mo
Potassium	K	Boron	B
Calcium	Ca	Chlorine	Cl
		Sodium	Na
		Silicon	Si
		Cobalt	Co

17.3 MACRO AND MICRO NUTRIENTS:

Based on the element concentration in plant material, the essential plant nutrients may be divided into **macronutrients** and **micronutrients**. Macronutrients are found or needed in relatively higher amounts than micronutrients. For example, the content of the macronutrient N is thousand times greater than the content of micronutrient Zn in plant tissue. Following this classification C,H,O,N,P,K,Ca,S,Mg,(Na, Si) may be defined as macronutrients. The micronutrients are Fe,Mn,Cu,Zn,Mo,B,Cl.

BENEFICIAL ELEMENTS:

Sodium has beneficial effect and in some cases it is essential. There are some plant species, particularly the chenopodiaceae plants and species adapted to saline conditions that take up this element in relatively high amounts. Na is also required for turnips, sugar beets and celery. The same is true for Si, which is an essential nutrient for rice. Cobalt is an essential element for the growth of the blue-green algae, but it has not been shown to be essential for other algae or for higher plants. It is also required by certain legumes to fix atmospheric nitrogen. Here, however the cobalt ion is necessary for the symbiotic bacteria present in the nodules associated with the roots.

This division of the plant nutrients into macro and micro nutrients is somewhat arbitrary and in many cases differences between the contents of macronutrients and micronutrients are considerably lower than the example cited above. For example, the Fe or Mn content of plant tissues is some times nearly as high as the content of S or Mg. The content of micronutrients is often far in excess of their

physiological requirements. In many plant species, chloride also occurs comparatively in high concentrations. Yet it is only needed in minute quantities in photosynthesis. This particular example demonstrates clearly that the content of plant nutrient in plant organs (Leaves, stems, fruits, roots) does not give any indication of the quantity effectively needed for physiological and biochemical process.

17.4 CLASSIFICATION OF PLANT NUTRIENTS BASED ON THEIR BIOCHEMICAL ROLE AND PHYSIOLOGICAL FUNCTION: Essential elements are now classified according to their biochemical role and physiological function. Based on the biochemical behavior and physiological functions, plant nutrients may be divided into four groups.

Nutrient elements	Uptake	Biochemical function
1 st group C,H,O,N,S	In the form of CO ₂ , HCO ₃ ⁻ , H ₂ O, O ₂ , NO ₃ , NH ₄ ⁺ , N ₂ SO ₄ ²⁻ , SO ₂ . The ions from the soil solution, the gases from the atmosphere.	Major constituents of the organic compounds of the plant. Essential elements of atomic groups which are involved in enzymatic processes. Assimilation by oxidation reduction reactions.
2 nd Group P, B, Si	In the form of phosphates, boric acid or borate, silicate from the soil solution.	They are important in energy storage reactions or in maintaining structural integrity. Elements in this group are often present in plant tissues as phosphate, Borate and silicate esters in which the elemental group is bound to the hydroxyl group of an organic molecule (i.e sugar-phosphates) (Esterification*). The phosphate esters are involved in energy transfer reactions.
3 rd Group K, Na, Mg, Ca, Mn, Cl	In the form of cations from the soil solution except chlorine	Present in plant tissues as either free ions or ions bound to substances such as the pectic acids present in the plant cell wall. Of particular importance of their roles as enzyme cofactors and in regulation of osmotic potentials.
4 th Group Fe, Cu, Zn, Mo	In the form of ions or chelates from the soil solution	Present predominantly in a chelated form Incorporated in prosthetic groups. Enable electron transport by valency change.

Esterification:

Compounds formed by condensation of an acid and alcohol with elimination of water ADP + Pi = ATP

(Source : Taiz and Zeiger 2002)
