**2.PHOSPHORUS (P)**

It is the 2nd most limiting primary nutrient. It constitutes 0.2% of plant dry weight. In soil, its range of concentration is 0.02-0.15% where as in plant it ranges between 0.1-0.4%.

**A) Available forms of P**:

H2PO4- (Primary orthophosphate)

HPO4-2 (Secondary orthophosphate)

**B) Uptake of phosphorous**

It uptake by proton orthophosphate symport H+/HxPO4x- in roots. In leaves is uptake by bicarbonate phosphate antiport HCO3-/HPO4X-.

In plant phosphorous occurs in two different forms i.e. **Ortho phosphates:** Primary orthophosphate and secondary orthophosphate; and **Pyrophosphate (PPi)**: it is present as soluble form or as PPi .

**Types of uptake systems**

There are two uptake systems that operate in plants (Figure 3)

1. High affinity transport system (HATS)
2. Low affinity transport system (LATS)

**1. HATS**: (High affinity transport system)

It operates when P concentration in soil is low less than 2 ppm.it is more energy intensive process.

**2. LATS**: (Low affinity transport system)

It operates when P conc. in soil is sufficient. At initial growth stages both systems operating for root development but at later growth stages HATS remain only in efficient plants.

**C) Redistribution and remobilization**

P in phloem is mobile but first P deficiency symptoms occur in older and then in both older and younger leaves therefore it is said that its phloem loading and movement and then unloading is partial in nature. P is immobile in soil because it is fixed.

**D) Physiological and metabolic roles**

**1. Energy storage and transport:** Its biggest role in energy storage and transfer because it is integral part of ATP, ADP and AMP. Phosphate storage mechanism is the form of energy storage in plants because when de-phosphorylation occurs, energy is released.

**2. Phosphate bond and membrane structure:** P provides linkages in the form of phosphate bonds so makes different types of structures.

i. Phosphodiester bond present between nucleotides of DNA

ii. It is an integral part of membrane as phospholipids that make plasma membrane, tonoplast and membranes of cellular organelles.

iii. Phosphoproteins

iv. Phosphate sugars (Kreb’s cycle and Calvin cycle).

**3.** All active nutrient uptake is due to ATP whose essential component is P.

**3. POTASSIUM or POTASH (K):**

**Importance:**

It is third most limiting nutrient after N and P. The 2.4% of earth of earth crust contains K. 10% plant dry weight is occupied by K. It is principle inorganic constituent of cytosol 40–200 mM. It never becomes integral part of plant body or any metabolite because it is never assimilated in plant body or organic compound and not a structural component. It is free and highly mobile cation in plant. It is 5-10% higher in cytoplasm then vacuole. It is be non-toxic to the plant but higher concentration may cause ionic imbalance.

**A) Available forms:**

K+ (monovalent cation).

**B) K uptake:**

There are two types of transport system.

1. High affinity transport system.

2. Low affinity transport system.

**1. HATS**

Proteins are pumped out of the root cell by proton ATPase.

It operates at low k concentration in the soil when concentration <1 milli mole m-3.

It is carrier-mediated transport. The mechanism of its uptake is shown in Figure 4.

**2. LATS**

* It operates when k concentration in soil is high (>1mole m-3).
* It is passive transport and towards concentration gradient.
* It is channel-mediated transport.
* Facilitated diffusion occur (channel mediated).
* The plants in which both the systems operate will be more efficient because at low HATS and at high conc. LATS operate.
* K competes with (protons, Ca2+, Mg 2+ and Na).
* Na is most disturbing cation for K uptake.
* Sometimes Mg2+ also disturbs.
* K uptake is more at early growth.
* K is partially mobile in soil. Therefore, it is applied basally and not splitted.
* K has number of plenty roles of metabolic than any other.

**C) Metabolic roles / functions**

There are 2 types of metabolic roles of K.

1. Non-specific roles /functions
2. Specific roles /functions

**a) Non-specific roles / functions:**

1. K acts as osmoticum (solute which carriers out osmotic adjustment). There are three component of water potential:
2. Osmotic potential
3. Matric potential
4. Turgor pressure

* The things that are dissolved in water decrease its osmotic potential.
* The things that are not dissolved in it decrease its matric potential.
* Maximum osmotic potential is zero. Osmotic potential is always negative.
* Matric potential is negligible in plant.
* Due to increase osmotic potential, turgor pressure becomes less.
* In drought condition, turgor pressure becomes less.

2. It also regulates opening and closing of stomata. Stomatal conductance is maintained for longer period even under drought conditions if K is adequate in plant thus producing drought tolerance.

3. It acts as counter ion (balancing the charge between cytosol and vacuole as well as plant organ e.g. malate in phloem, nitrate in xylem. More than 90% ions involved in osmotic adjustment are K+ and others solute constitute only 10%.

**b) Specific roles / functions**

These are the functions that no other nutrients can perform. These functions are:

1. **Help in transport of photosynthates (sucrose, glucose):** K is required for ATP synthesis and can cause symport of sucrose along with proton (Figure 5). In addition to sugar, amino acid loading and unloading requires potash.
2. **K play major role in transport of water and nutrients through the plant xylem:** when K supply is reduced, translocation of nitrates, phosphate, Ca, Mg and amino acids is depressed. K is competitor of calcium and magnesium. K affects xylem transport through influencing specific enzyme and plant growth hormone.
3. **Role in photosynthesis:**

i. Photosynthesis is ultimately being carried out by Rubisco and K is the activator of this enzyme. K is required for the biosynthesis of Rubisco.

ii. It promotes phosphorylation (synthesis of ATP from ADP).

iii. If phloem loading is inhibited, photosynthetic rate is reduced due to feedback mechanism.

iv. In some plants, leaf blade re-orient towards light source to increase light interception or away to avoid damage by excess light thus regulating the rate of photosynthesis. These movements are brought about by reversible change in turgor pressure through K movements into and out of specialized leaf tissues.

1. **K is the activator more than 80 enzymes:** K is activator of nitrogen assimilating enzymes e.g. glutamine synthase, glutamate synthase, Rubisco and nitrate reductase. K changes the physical shape of enzyme molecule thus exposing the appropriate chemical active site for reaction. K also neutralizes various organic ions and other components within plants to stabilize pH (7 to 8) that is optimum for most enzyme reaction. It has synergistic effect with auxins, gibberellins and cytokinins.
2. **Protein synthesis:** K is required for every step of protein synthesis especially in reading of genetic code that is translation in plant cell to produce protein and enzyme that regulates all growth processes.
3. **Starch synthesis:** K is activator of starch synthase, an enzymes responsible for starch synthesis.

**Deficiency symptoms of K**

1. It shows hidden hunger.
2. In severe cases chlorosis and necrosis of the leaf margin and tips occur.
3. Lodging of plants
4. Reduce disease resistance
5. Reduce winter hardness in perennial or winter annual
6. Quality of fruit / grain is affected.

**Excess symptoms of K**

1. It shows competition with calcium, magnesium so abundant K supply may reduce Ca, Mg uptake.
2. Cause sometime ionic imbalance.