

Primary Nutrients (N, P and K) for Plant Growth: Functions, Deficiency Symptoms and their Management

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INTRODUCTION

Plants like all other living organisms, require nourishment for their growth and progress. They rely on 16 essential elements, with carbon, hydrogen and oxygen obtained from the atmosphere and soil water. The remaining 13 essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, manganese, copper, boron, molybdenum and chlorine) are obtained from soil minerals, soil organic matter or organic/inorganic fertilizers. Among these, nitrogen, phosphorus and potassium are known as primary nutrients due to their higher demand for plant growth and development. To efficiently utilize these nutrients, plants need sufficient light, heat and water. Each plant species has its unique optimal range and minimum requirement for nutrients. When nutrient levels fall below the minimum, plants exhibit signs of nutrient deficiency. Excessive nutrient uptake can also hinder growth due to toxicity. Thus, it is crucial to apply the appropriate amount and place nutrients properly. Soil and plant tissue tests are available to assess the nutrient content in the soil and plants. By analyzing this data, plant scientists can determine the specific nutrient requirements of a given plant in a particular soil. In addition to soil nutrient availability, soil pH plays a vital role in nutrient accessibility and elemental toxicity.

1. Nitrogen (N)

Plants can access nitrogen in the form of nitrate (NO_3^-) and ammonium (NH_4^+) ions.

Functions of N:

- Nitrogen is combined with carbon (C), hydrogen (H), oxygen (O) and sulphur (S) to form amino acids, which are the building blocks of proteins. Amino acids play a crucial role in the formation of protoplasm, which is essential for cell division, plant growth and development.

- Since plant enzymes are composed of proteins, nitrogen is required for all enzymatic reactions in plants.
- Nitrogen is a key component of the chlorophyll molecule, making it necessary for photosynthesis.
- It is also a vital component of several vitamins and improves the protein quality in grain-based foods.
- Nitrogen enhances the quantity and quality of dry matter in leafy vegetables, protein in grain crops and overall quality of leafy vegetables and fodders.

Deficiency symptoms:

- Nitrogen deficiency is characterized by yellowing or chlorosis of plant leaves.

- Initially, pale green to light yellow chlorosis appears on older leaves, typically starting at the tips. Depending on the severity, this chlorosis can lead to the death or shedding of older leaves. This occurs due to the translocation of nitrogen from older tissues to younger ones.
- Reduced nitrogen levels result in decreased protein content in seeds and vegetative parts, and severe cases can significantly reduce flowering.
- Nitrogen deficiency can cause premature maturation in certain crops, resulting in reduced yield and quality.



Fig 1: Nitrogen deficiency symptom on wheat crop

Management:

- ❖ Ensure proper soil drainage.
- ❖ Use balanced fertilizers.
- ❖ Apply organic matter such as farmyard manure (FYM), compost, and vermicompost.
- ❖ Conduct soil testing before seeding.
- ❖ Perform plant tissue analysis to identify nitrogen deficiencies.
- ❖ Utilize nitrogen-containing fertilizers like urea and ammonium sulphate.

2. Phosphorus (P)

Plants can access phosphorus in the form of primary and secondary orthophosphate ions (HPO_4^{2-} , H_2PO_4^-).

Functions:

- Phosphorus plays a major role in energy storage and transfer through molecules like ADP, ATP, DPN and TPN, which are involved in photosynthesis and respiration. ATP, containing phosphorus, is often referred to as the energy currency of the plant.
- Phosphorus is an integral part of RNA and DNA structures, which carry genetic information and facilitate the transfer of genetic characteristics between generations.
- Seeds contain the highest concentration of phosphorus in a mature plant and it is

required in large quantities in rapidly dividing cells like shoots and root tips, aiding in root development, flower initiation and seed and fruit development.

- Phosphorus has been shown to reduce disease incidence in certain plants and improve the quality of specific crops.

Deficiency Symptoms:

- Since phosphorus is crucial during the early stages of cell division, a common symptom of deficiency is slow, weak and stunted growth.

- Phosphorus is relatively mobile within plants and can be relocated to new growth sites, leading to dark to blue-green coloration on older leaves of some plants. Severe deficiency may result in purple discoloration of leaves and stems.
- Phosphorus-deficient plants exhibit intense green coloration due to carbohydrate accumulation.
- Insufficient phosphorus can cause delayed maturity and poor development of seeds and fruits.



Fig 2: Phosphorus deficiency on guava leaf

Management:

Apply phosphorus sources such as bone meal, rock phosphate, manure and phosphate fertilizers (e.g., superphosphate, ammonium phosphate, ammonium phosphate sulphate).

3. Potassium (K):

Potassium is available to plants as the ion K^+ .

Functions:

- K is an essential nutrient for plants and is available to them in the form of K^+ ions. Unlike nitrogen (N) and phosphorus (P), potassium does not form crucial organic compounds within the plant. Nevertheless, its presence is crucial for plant growth as potassium acts as an enzyme activator that facilitates metabolism.

- One of the key functions of potassium is its role in regulating water usage by plants through the control of leaf stomates, which are responsible for the release of water to cool the plant.
- Additionally, K^+ plays a crucial role in maintaining the electrical charge balance during photosynthesis at the site of ATP production.
- It also facilitates the translocation of sugars (photosynthates) for plant growth or storage in fruits and roots.
- Furthermore, potassium is involved in protein synthesis through its assistance in ATP production.
- K enhances disease resistance in plants, improves the size of grains and seeds,

and enhances the quality of fruits and vegetables.

- Potassium is responsible for activating and synthesizing the nitrate reductase enzyme, which plays a role in protein formation.

Deficiency symptoms:

- When plants lack potassium, common deficiency symptoms include chlorosis

along the edges of leaves (leaf margin scorching). This initially occurs in older leaves because potassium is highly mobile within the plant.

- Insufficient potassium levels also result in slow and stunted growth due to its importance in photosynthesis and protein synthesis.
- Additionally, the size and quantity of seeds and fruits produced are reduced.



Fig 3: Potassium deficiency symptoms on tomato leaves

Management:

- ❖ To manage potassium deficiency, it is recommended to spread organic mulch beneath plants and apply potassium fertilizers such as muriate of potash and potassium sulphate.
- ❖ Slow-release forms of potassium, such as potassium silicate or sulphur- or polymer-coated potassium products, are preferred.
- ❖ Potassium sulphate can also be utilized and organic matter and clay particles can help retain potassium within the soil.

CONCLUSION

Nitrogen (N), phosphorus (P) and potassium (K) are primary nutrients that are vital for plant growth, development and productivity. Understanding their functions, recognizing deficiency symptoms and adopting appropriate management strategies are essential for ensuring optimal plant health and maximizing crop yields. By providing plants with the

necessary nutrients and maintaining proper soil conditions, farmers and gardeners can foster healthy and vigorous plant growth, leading to bountiful harvests and thriving landscapes.

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