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THE IMPORTANCE OF MINERAL ELEMENTS IN PLANT GROWTH AND DEVELOPMENT

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Abstract
This article highlights the role of mineral elements in the processes of plant growth and development. The main focus is on macro and microelements essential for plants, their physiological functions, and the conditions arising from their deficiency or excess. The article analyzes the importance of key elements such as nitrogen, phosphorus, and potassium in metabolism, cellular structure, and energy production. Additionally, it provides information about the mechanisms of mineral nutrient uptake from the soil and methods for regulating this process through agro-technical practices. This article is intended for professionals and students engaged in agriculture, biology, and ecology.

Keywords: Plant growth, development, mineral elements, macroelements, microelements, nutrition, soil fertility, physiological functions, agrotechnics, element deficiency.

INTRODUCTION

Plant life proceeds through complex and continuous processes of growth and development. For these processes to proceed normally, plants absorb various mineral elements from the external environment, especially from the soil. These elements play a crucial role in the formation of plant tissues, cell division,

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metabolism, and energy production. Each mineral element has a specific biological function, and its deficiency or excess can negatively impact plant growth and productivity. Therefore, a thorough understanding of the mineral requirements of plants and their optimal management is a key scientific and practical issue in modern agriculture. This article examines the significance of mineral elements in plant growth and development, their functional roles, deficiency symptoms, and methods for addressing these problems.

In addition to essential nutrients, plant bodies also contain numerous chemical elements known In addition to major nutrients, plant bodies also contain many trace elements, known as microelements, which—although present in small quantities—are highly biologically active. Each of these microelements performs specific physiological functions, making them irreplaceable. They are involved in the active centers of enzymes and enhance plant resistance to diseases and adverse environmental factors. A deficiency of microelements can result in a sharp decline in yield, increased susceptibility to disease, stunted growth and development, and even plant death.

LITERATURE REVIEW AND METHODOLOGY

The main components of plants are oxygen, hydrogen, and carbon, which are absorbed from water and carbon dioxide in the air. Plant cells, specifically the slimy substance known as protoplasm, contain various elements such as oxygen, hydrogen

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Mineral fertilizers are salts and other inorganic, industrial, or mined substances that contain essential elements to support plant growth and increase soil fertility.

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More than 70 chemical elements are involved in plant tissue formation, growth, and development. Among them, carbon, oxygen, and hydrogen are the most important, comprising 90% of the plant's dry mass. Nitrogen, phosphorus, potassium, magnesium, sulfur, sodium, and calcium make up another 8–9%, known as macroelements. The remaining 1–2% includes boron, iron, copper, manganese, zinc, molybdenum, cobalt, and others, which are required in very small amounts (0.001–0.0001%) and are called microelements.

While plants absorb carbon, oxygen, and hydrogen primarily from air and water, other elements are taken from the soil. However, much of these absorbed elements are not returned to the soil as they are removed with the harvested crop. For example, 1 ton of maize removes about 14 kg of nitrogen, 2.5 kg of phosphorus, 3.5 kg of potassium, and 1.5 kg of sulfur from the soil. Many nutrients are leached away with water or become chemically bound in the soil, making them unavailable to plants. As a result, nutrient deficiency occurs, reducing soil fertility.

If these lost nutrients are not replenished through fertilization, crop yields decrease significantly.Therefore, fertilizer production and application are vital. Fertilizers can increase crop yields by 50–60%. For instance, about one-quarter of the world's food production and nearly half of cotton production are made possible thanks to fertilizers. Nitrogen in fertilizers plays a key role in mineral nutrition—it is part of proteins and nucleic acids and is a component of chlorophyll, which facilitates photosynthesis.

Phosphorus is found in the cell nucleus and participates in plant respiration. It also supports flowering, fruiting, and seed development. Potassium strengthens plant stems, supports full fruit development, and promotes starch accumulation. Calcium promotes root growth; its deficiency causes root rot. Magnesium is a component of chlorophyll granules.

RESEARCH RESULTS

Fertilizers improve the mobility and solubility of nutrients in the soil, increasing their absorption by plants and enhancing soil fertility. Fertilizers also improve the physical properties of soil. When applied to the soil, fertilizers alter the properties

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of soil solutions, making nutrients more soluble—critical for plant absorption through the roots.This is especially important in Uzbekistan, where soils often have low organic matter and nutrients. Fertilizers significantly increase the yields and overall productivity of wheat, cotton, and other crops. Therefore, when using chemical fertilizers, it is essential to consider soil type, fertility, properties, the specific crop being grown, the plant's nutrient requirements, and the timing of nutrient uptake.Each crop has unique nutrient demands. Deficient nutrients in the soil must be supplemented through appropriate fertilizers.

CONCLUSION

Applying fertilizers not only increases the availability of nutrients for plant uptake but also affects the physical, chemical, and biological properties of the soil, improving its fertility. The acidity or alkalinity of fertilizers can affect soil pH. For instance, regular application of ammonium sulfate ($(NH_4)_2SO_4$) or ammonium chloride (NH_4Cl) acidifies the soil, as plants absorb cations and release hydrogen ions, leading to acid accumulation (e.g., chloride and sulfate acids). Conversely, fertilizers like sodium nitrate ($NaNO_3$) cause OH^- ions to accumulate, making the soil alkaline.Hence, fertilizers must be assessed not only by their chemical composition but also by their physiological properties, such as the relative use of cations and anions. Based on these characteristics, fertilizers are classified as physiologically acidic, physiologically alkaline, or physiologically neutral. The latter does not alter soil pH.

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