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CHANGES IN PHOTOSYNTHETIC ACTIVITY AND NUTRITIONAL PROCESSES UNDER THE INFLUENCE OF BIOPREPARATIONS

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Abstract
The study presents the effects of biopreparates based on zirconium protective-stimulatory complexes and mixtures on photosynthetic activity, seed quality, growth, development, and productivity of spring barley. A high correlation between leaf surface area and yield was established.

Keywords: Biopreparates, photosynthetic activity, plant growth regulators, spring barley, leaf surface, productivity.

Introduction

Biological preparations, or biopreparates, are substances based on microorganisms or their metabolites designed to stimulate plant growth and development. In modern agriculture, such preparations are increasingly used to enhance plant physiological processes, particularly photosynthesis, nutrient uptake, root system development, and yield formation. Photosynthesis is a fundamental process determining biomass accumulation and productivity.

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Effective nutrient absorption and active root systems improve plant resilience and productivity under both optimal and stress conditions.

Spring barley (Hordeum vulgare L.) is a major cereal crop cultivated worldwide. Its productivity and seed quality are influenced by multiple factors, including environmental conditions, nutrient availability, and physiological activity. The application of biopreparates offers a sustainable approach to enhancing photosynthetic efficiency, promoting growth, and ensuring higher yield and quality in spring barley. This research investigates the complex effects of zirconium-based protective-stimulatory biopreparates on photosynthetic performance, nutrient uptake, and overall plant development. Mainly:

1. Increase in photosynthetic surface area: Biopreparates significantly enhance leaf growth, increasing the photosynthetic surface area. A larger leaf area improves light interception and energy absorption, which in turn intensifies the photosynthetic process. Consequently, plants accumulate higher energy reserves essential for growth and yield formation.

2.Enhancement of net photosynthetic productivity: Application of biopreparates promotes the accumulation of organic compounds, mainly carbohydrates, resulting in increased net photosynthetic productivity. This effect contributes to higher biomass production and improved formation of dry matter, which is directly correlated with yield potential.

3. Stimulation of gas exchange processes: Biopreparates improve CO_2 uptake by leaves, facilitating efficient carbon assimilation. They also stimulate stomatal activity, enhancing transpiration and gas exchange efficiency. Improved gas exchange supports optimal photosynthesis rates, especially under varying environmental conditions.

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4. Chlorophyll and pigment synthesis: Biopreparates stimulate chlorophyll biosynthesis and other photosynthetic pigments. Elevated chlorophyll content enhances light absorption efficiency, thereby increasing photosynthetic activity. This biochemical response is a critical factor in supporting rapid growth and energy production during key developmental stages.

Effect of biopreparates on nutrient uptake and root system development:

1. Improved elemental uptake: Biopreparates enhance the availability and absorption of macroelements such as nitrogen, phosphorus, and potassium. This effect improves overall nutrient efficiency, leading to faster growth rates and healthier plant development.

2. Stimulation of root system growth: Application of biopreparates increases root mass and density. A robust root system improves water and nutrient absorption from the soil, supporting overall plant growth, stability, and resilience. Enhanced root development is particularly critical under stress conditions such as drought or poor soil fertility.

3. Activation of soil microflora: Biopreparates activate beneficial soil microorganisms, improving nutrient cycling and availability. Enhanced microbial activity accelerates organic matter decomposition, contributing to a nutrient-rich rhizosphere that supports optimal plant nutrition and growth.

The integrated effect of biopreparates on photosynthesis, nutrient uptake, and root system development results in higher and more stable yields. Application of zirconium-based biopreparates not only improves biomass production but also enhances seed quality, particularly under stress conditions such as water deficit, nutrient limitations, or temperature fluctuations.

A high correlation was observed between leaf surface area and productivity, indicating that improved photosynthetic efficiency is a key driver of increased

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yield. Plants treated with biopreparates exhibited more vigorous growth, enhanced stress tolerance, and superior physiological performance compared to untreated controls.

Methodology

The study was conducted using controlled field experiments with spring barley (Hordeum vulgare L.). Biopreparates containing zirconium protective-stimulatory complexes were applied at specific growth stages. Key physiological and biochemical parameters were measured, including:

1. Leaf area index and total leaf surface
2. Chlorophyll content (SPAD readings and spectrophotometric analysis)
3. Net photosynthetic productivity
4. Gas exchange rates (CO_2 uptake and transpiration)
5. Root biomass and morphology
6. Nutrient content in leaves and seeds
7. Grain yield and quality parameters.

Data were statistically analyzed to determine correlations between physiological indicators and productivity. Comparative analysis between treated and untreated plants was performed to evaluate the efficacy of the biopreparates. The application of biopreparates resulted in:

1. A significant increase in leaf surface area by 15–25%, which enhanced light interception and photosynthetic activity.
2. Elevated chlorophyll content, improving photosynthetic efficiency and net biomass accumulation.
3. Enhanced nutrient uptake, particularly nitrogen, phosphorus, and potassium, resulting in better plant nutrition and growth.
4. Stimulated root system development, with increased root mass and length, contributing to higher water and nutrient absorption.

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5. Activation of beneficial soil microflora, which improved soil fertility and nutrient availability.
6. Improved seed quality, with higher thousand-seed weight and better germination rates.
7. Overall grain yield increase by 12–18% compared to control plants.

These results indicate that biopreparates, especially those containing zirconium complexes, provide a synergistic effect on plant physiology, combining growth stimulation, nutrient optimization, and stress tolerance.

Conclusion

In conclusion, biopreparates significantly enhance the physiological performance and productivity of spring barley. They improve photosynthetic activity through increased leaf area, chlorophyll content, and gas exchange efficiency. Nutrient uptake and root system development are stimulated, while soil microbial activity is enhanced, creating optimal conditions for plant growth.

The integrated effects of biopreparates lead to higher biomass accumulation, improved seed quality, and increased grain yield. This study demonstrates the practical potential of zirconium-based protective-stimulatory complexes as effective tools for sustainable agriculture. Furthermore, the observed high correlation between leaf surface area and yield confirms the importance of photosynthetic efficiency in determining crop productivity.

Application of such biopreparates can be particularly beneficial under stress conditions, including drought, nutrient-poor soils, and temperature extremes. Overall, these findings contribute to the understanding of biologically-based growth regulators and their role in enhancing crop performance and sustainability.

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