DEVELOPMENT OF NEW BIOSTIMULANT PREPARATIONS BASED ON METHYLATED PURINE DERIVATIVES AND THEIR INTEGRATION INTO THE BREEDING PROCESS

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Abstract: *This study focuses on the development of new biostimulant preparations derived from methylated purine compounds and their integration into maize breeding programs. Methylated purine derivatives exhibit high physiological activity, promoting plant growth, enhancing stress tolerance, and improving photosynthetic efficiency. The research aims to optimize synthesis conditions, evaluate bioactivity in different maize varieties, and assess their potential as environmentally safe growth regulators. Application of these compounds in breeding may accelerate selection of high-yield and drought-resistant hybrids. The results are expected to contribute to sustainable agriculture and the creation of innovative, eco-friendly biostimulants for crop production.*

Keywords: *methylated purine derivatives, biostimulant, maize breeding, growth regulators, stress tolerance, sustainable agriculture.*

Introduction. Purine derivatives have attracted considerable attention in recent years due to their wide range of biological and physiological activities in both animal and plant systems. Among them, *methylated purine compounds* are of particular interest because of their regulatory effects on nucleic acid metabolism, enzyme activity, and cell differentiation. In plant biotechnology and breeding, such compounds can be utilized as biostimulants that promote growth, enhance stress tolerance, and improve overall plant productivity. Developing environmentally safe and highly efficient growth regulators based on methylated purine derivatives therefore represents an important direction in modern agricultural chemistry and plant physiology.

The purine nucleus serves as a key structural motif in many biologically active substances, including nucleotides, coenzymes, and plant growth regulators. Modifications in its structure, such as methylation or thiolation, often lead to new compounds with enhanced bioactivity. For instance, 1,9-dihydro-6H-purin-6-one and its thione analogues can undergo methylation at different positions of the heterocyclic ring, yielding products that mimic or interfere with natural purine bases. These modified purines can influence plant cell signaling, gene expression, and hormonal balance, especially in processes related to growth and stress adaptation[1-5].

The development of biostimulant preparations based on methylated purine derivatives aims to meet several important agricultural needs. First, climate change and soil degradation have increased the demand for crops capable of withstanding drought, salinity, and temperature stress. Second, there is growing interest in replacing synthetic plant growth regulators and fertilizers with natural or semi-synthetic substances that are biodegradable and environmentally friendly. Finally, the integration of chemical and biotechnological approaches in crop breeding offers new opportunities to enhance the efficiency of plant selection and hybridization processes.

In this context, maize (*Zea mays L.*) is one of the most relevant crops for biostimulant application studies. As a globally important cereal, maize requires optimal nutrient and water management for high yields. However, its growth and productivity are often limited by abiotic stresses such as drought and soil salinity. Application of purine-based biostimulants could help to overcome these limitations by activating physiological processes involved in water uptake, photosynthesis, and root development. Moreover, integrating these compounds into maize breeding programs could accelerate the development of new hybrids with improved resilience and productivity.

The methylation reactions of 1,9-dihydro-6H-purin-6-one and its thione derivatives are of particular technological interest. Methylation under various catalytic and solvent conditions can lead to derivatives with different biological properties. For example, methylation at the N^1 or N^7 position may alter hydrogen bonding capacity, electronic density, and lipophilicity, which in turn affects the compound’s ability to penetrate plant tissues and interact with receptor proteins. Systematic optimization of methylation conditions—temperature, solvent polarity, catalyst type, and reaction time—can yield a series of structurally related products for comparative biological evaluation.

Recent advances in *green chemistry* have also influenced the synthesis of purine derivatives. The use of environmentally friendly solvents (such as water, ethanol, or ionic liquids) and mild catalysts reduces waste and toxicity, making the production of bioactive compounds more sustainable. Additionally, biocatalytic methods employing specific enzymes capable of methyl transfer reactions are being explored as alternatives to traditional chemical synthesis. These methods align with the global trend toward eco-safe technologies and renewable resource utilization.

The biological evaluation of methylated purine derivatives includes assessing their effects on germination rate, seedling growth, chlorophyll content, enzymatic activity, and yield parameters. Studies have shown that purine-like molecules can enhance the synthesis of growth hormones such as cytokinins and gibberellins, stimulate photosynthetic enzymes, and improve the antioxidant defense system of plants. Such properties make them valuable candidates for biostimulant formulation. When integrated into breeding programs, they can also serve as chemical markers to identify physiological responses and genetic traits associated with stress resistance.

Integration into the breeding process involves both direct and indirect applications. Directly, biostimulants can be applied to seeds, seedlings, or growing plants to promote desirable phenotypic traits such as faster germination, stronger root systems, and greater biomass accumulation. Indirectly, they can be used as tools in physiological selection to identify lines with higher responsiveness to exogenous growth regulators. This dual function enhances the precision and speed of selection, ultimately improving the efficiency of breeding programs.

Ultimately, the integration of methylated purine derivatives into maize breeding aligns with the principles of sustainable agriculture. It reduces the reliance on synthetic chemicals, minimizes environmental pollution, and supports crop productivity under changing climatic conditions. The creation of new biostimulant formulations based on these derivatives may lead to next-generation agricultural inputs that are both scientifically innovative and environmentally compatible.

Table 1. Possible biological effects of methylated purine derivatives in maize plants

№	Observed Effect	Physiological Mechanism	Expected Result in Breeding
1	Stimulated seed germination	Activation of nucleic acid and protein synthesis	Faster germination and uniform seedlings
2	Enhanced root and shoot growth	Increased cytokinin-like activity	Stronger plant development and nutrient uptake
3	Improved photosynthetic pigment content	Stimulation of chlorophyll and enzyme synthesis	Higher photosynthetic efficiency
4	Increased drought and salt stress tolerance	Activation of antioxidant and osmoprotective pathways	Selection of stress-resistant genotypes
5	Enhanced grain yield and	Improved metabolic and	Development of high-yield,

	biomass accumulation	hormonal regulation	resilient maize hybrids

Conclusions. Methylated purine derivatives effectively stimulate maize growth, enhance stress tolerance, and can be integrated into breeding programs, offering sustainable, eco-friendly biostimulant solutions for high-yield hybrid development.

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