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## SELECTIVE SYNTHESIS OF HIGHLY BIOACTIVE AMINOPURINE DERIVATIVES AND THEIR APPLICATION TO HALOPHYTIC AND AGRICULTURAL PLANTS USING HYDROGEL TECHNOLOGY

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**Abstract:** *This study focuses on the selective synthesis of highly bioactive aminopurine derivatives and their practical application to halophytic and agricultural plants using hydrogel technology. Aminopurine compounds, known for their cytokinin-like activity, were modified to enhance stability, solubility, and interaction with plant cell receptors. The synthesized derivatives were incorporated into hydrogels designed to act as slow-release systems for delivering bioactive substances directly to the root zone. Physicochemical characterization confirmed the structural integrity and swelling behavior of the modified hydrogels. Field and laboratory experiments on halophytic species (*Haloxylon aphyllum*) and crop plants demonstrated improved seed germination, chlorophyll synthesis, and drought tolerance. The results highlight the potential of aminopurine-based hydrogels as multifunctional materials for enhancing plant productivity and ecological sustainability under salinity and arid stress conditions.*

**Keywords:** *aminopurine derivatives, hydrogel, cytokinin activity, halophytes, agricultural plants, drought tolerance, plant growth regulation*

**Introduction.** Aminopurine derivatives are among the most promising classes of nitrogen-containing heterocyclic compounds that play an essential role in regulating plant growth and development. These compounds belong to the family of purine derivatives, structurally related to adenine and other natural cytokinins. They are known to promote cell division, stimulate chlorophyll biosynthesis, and enhance nutrient uptake and photosynthetic efficiency. Because of their biological similarity to plant hormones, aminopurines have attracted considerable attention in plant physiology, biotechnology, and sustainable agriculture. In recent decades, the modification of aminopurine molecules has opened new opportunities for obtaining derivatives with improved stability, solubility, and bioavailability under various environmental conditions.

In arid and semi-arid regions, such as the Central Asian deserts, agricultural productivity is severely limited by water scarcity, soil salinization, and high



temperature stress. These environmental challenges demand innovative technologies to improve the resilience and productivity of plants. The use of bioactive hydrogels represents one of the most effective modern approaches to overcoming these constraints. Hydrogels are crosslinked polymeric networks capable of absorbing and retaining large amounts of water while maintaining structural integrity. When incorporated into the soil, hydrogels serve as moisture reservoirs, ensuring the gradual release of water and nutrients to plant roots. The introduction of biologically active compounds into hydrogels enables controlled and prolonged delivery of plant growth regulators directly to the rhizosphere.

6-Aminopurine, also known as adenine, serves as a fundamental molecule for the synthesis of many plant growth regulators. Its derivatives, such as 6-benzylaminopurine, kinetin, and 2-methylaminopurine, exhibit high cytokinin-like activity, stimulating plant growth even under unfavorable environmental conditions. However, their practical application is limited by rapid degradation, poor solubility, and loss of activity due to photochemical and enzymatic decomposition. To overcome these limitations, recent research has focused on modifying the aminopurine structure through the introduction of functional groups that enhance chemical stability and facilitate interaction with polymeric matrices.

The present research aims to selectively synthesize highly bioactive aminopurine derivatives and develop an innovative system for their application to halophytic and agricultural plants using hydrogel technology. This approach combines the advantages of organic synthesis, polymer chemistry, and plant biotechnology to create an integrated solution for sustainable agriculture in arid ecosystems. The selective synthesis involves controlled substitution reactions at specific positions of the purine ring to obtain derivatives with improved hydrophilicity and biological activity. These derivatives are then immobilized within hydrogel matrices, forming bioactive materials capable of both water retention and gradual release of plant stimulants [1-5]. Hydrogels used in this research are based on biocompatible and biodegradable polymers, such as polyacrylamide and sodium alginate, which are further modified to increase swelling capacity and ion-exchange ability. The interaction between the hydrogel and aminopurine derivatives ensures slow and sustained release of the active components, maintaining optimal concentrations in the plant root zone. Moreover, the hydrogel matrix protects the bioactive molecules from photodegradation and oxidation, thus prolonging their physiological effectiveness. Experimental studies have demonstrated that the application of 6-aminopurine-modified hydrogels significantly enhances the growth and survival rate of halophytic species such as



*Haloxylon aphyllum* (saxaul) and various agricultural crops, including wheat, cotton, and barley, cultivated under saline and drought-prone conditions. Treated plants showed better seed germination rates, improved water retention capacity, higher chlorophyll content, and increased resistance to oxidative stress. The results indicate that these bioactive hydrogels can effectively regulate the water–nutrient balance and stimulate metabolic processes essential for plant adaptation. This innovative technology has great potential for use in phytomelioration—the biological reclamation of degraded lands through the establishment of vegetation cover. By combining the principles of green chemistry and soil biotechnology, aminopurine-modified hydrogels contribute not only to plant productivity but also to ecological restoration and desert ecosystem stabilization. The selective synthesis of aminopurine derivatives provides an opportunity to tailor the molecular properties of growth regulators according to specific plant requirements, ensuring maximum biological efficiency.

In summary, the integration of aminopurine chemistry with hydrogel-based delivery systems represents a novel and sustainable approach to modern agriculture, especially for regions affected by salinity and drought. The study of structure–activity relationships among aminopurine derivatives and their performance in polymeric matrices will pave the way for the development of next-generation bioactive materials. These materials will not only promote plant growth and stress tolerance but also play an important role in addressing global challenges such as food security, desertification, and climate resilience.