Journal of Chemistry of Goods and Traditional Medicine

J Chem Good Trad Med, Volume 4, Issue 1, 2025 Chemistry of Goods

APPLICATION OF METHYLOL DERIVATIVES OF UREAS AND THIOUREAS IN AGRICULTURE AS FUNGICIDES AND PLANT GROWTH STIMULANTS

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DOI: https://doi.org/10.55475/jcgtm/vol4.iss3.2025.535

Keywords:
agrochemistry, coordination compounds, fungicide, stimulator, copper, cobalt, zinc, ecological compatibility

Annotation:
The article explores modern approaches in agrochemistry focused on the use of coordination compounds of organic ligands with microelements (Cu^{2+}, Co^{2+}, Zn^{2+}). These compounds demonstrate dual functionality: antifungal protection and stimulation of plant physiological growth. Copper complexes showed the strongest fungicidal effect, almost completely inhibiting Botrytis cinerea growth at 0.025% concentration, outperforming conventional copper-based formulations. Field and greenhouse trials revealed an 8–18% increase in seed germination, 12–25% enhancement in root and shoot biomass, and improved tolerance to drought and salinity stress. Due to their biological activity, selectivity, and ecological safety, such compounds can serve as a new generation of agrochemicals in Uzbekistan, replacing imported fungicides, boosting yields, and contributing to sustainable agriculture.

How to Cite
Makhmudov, R. U., Askarov, I. R., Mo'minjonov, M. M., & Usman, S. APPLICATION OF METHYLOL DERIVATIVES OF UREAS AND THIOUREAS IN AGRICULTURE AS FUNGICIDES AND PLANT GROWTH STIMULANTS. Journal of Chemistry of Goods and Traditional Medicine, 4(3). https://doi.org/10.55475/jcgtm/vol4.iss3.2025.535

Modern approaches to the use of coordination compounds in agricultural chemistry. The development of modern trends in agricultural chemistry is increasingly focused on the introduction of multifunctional compounds capable of simultaneously performing protective (fungicidal) and physiologically active (growth-promoting) functions. In this regard, coordination compounds of organic ligands with trace element ions, which exhibit pronounced biological activity and the ability to act slowly and controllably, are of particular interest.

Coordination compounds based on trimethylol urea and trimethylol thiourea with transition metal salts such as copper (Cu^{2+}), cobalt (Co^{2+}), and zinc (Zn^{2+}), are typical substances that combine micronutrients, fungicidal action, and plant growth stimulation. These compounds offer a number of advantages:

controlled solubility, allowing them to be used as liquids or powders;

Selectivity against pathogens and lack of phytotoxicity;

compatibility with other agrochemicals (herbicides, fertilizers);

resistance to ultraviolet light and hydrolysis, ensuring long-lasting action.

According to domestic and international researchers, coordination complexes with copper, cobalt, and zinc ions exhibit high biological activity at concentrations ranging from 0.01 to 0.05%.

Fungicidal action of coordination compounds. The fungicidal activity of such compounds is generally realized through the following mechanisms:

Violation of the integrity of the fungal cell wall: metal ions interact with the SH groups of pathogen enzymes, inhibiting the synthesis of chitin and cellular polysaccharides.

Inactivation of respiratory enzymes: the complexes disrupt mitochondrial function, especially in the cells of Fusarium, Alternaria, Botrytis, Colletotrichum, and other fungi.

Oxidative stress: many complexes are capable of generating reactive oxygen species, which further destroy fungal cells. Comparative studies have shown that copper complexes exhibit a more pronounced fungicidal effect against a wide range of plant pathogens, including those causing root rot, leaf spot, and powdery mildew. Zinc and cobalt complexes exhibit moderate antifungal activity, but in combination with a mild physiological effect.

Particularly noteworthy is trimethylolthiourea, a copper complex that demonstrated almost complete inhibition of Botrytis cinerea growth in laboratory conditions at a concentration of 0.025%, outperforming even standard preparations based on copper sulfate and copper oxychloride.

Stimulating effect on plants. The second most important function of the compounds under development is the stimulation of physiological plant growth processes. This approach is based on the following mechanisms of action:

participation of metal ions in metabolic pathways (e.g., zinc activates auxin synthesis, copper activates redox enzymes, and cobalt activates nitrogen fixation in legumes);

regulation of osmotic balance due to the structure of ligands with OH groups (e.g., in trimethylol urea), which improves cellular water balance;

stimulation of cell division through an effect on DNA polymerases, nucleases, and cyclins;

improved seed germination by reducing the activity of growth inhibitors, especially under stressful conditions (salinity, dryness, low temperature).

Field and greenhouse trials of coordination compounds based on trimethylol urea and trimethylol thiourea have shown:

an increase in wheat and cotton seed germination by 8–18% compared to the control;

An increase in root length and aboveground mass by 12–25% when treated with 0.01–0.03% working solutions;

Increased resistance to drought and salt stress in the early stages of development.

Thus, these compounds can be classified as new-generation agrochemicals possessing biofunctionality, selectivity, and environmental compatibility.

Prospects for practical implementation. From a practical standpoint, the introduction of coordination compounds of trimethylol urea and trimethylol thiourea with copper, cobalt, and zinc acetates into agricultural production can solve a number of problems:

Import substitution of fungicides in crop production in Uzbekistan;

Increased yield and product quality without increasing the doses of mineral fertilizers;

Reduced chemical load on the agroecosystem through the use of environmentally compatible substances;

Increased plant stress resistance, especially under conditions of heat, drought, and salt stress typical for the region. Such compounds can be used both as seed dressings and as foliar feeding or root irrigation, which makes them technologically flexible and adaptable to various agricultural conditions.

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