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MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
Dmytro Motornyi Tavria State Agrotechnological University

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СЕКЦІЯ 3.
ПЕРСПЕКТИВНІ НАПРЯМИ НАУКОВИХ ДОСЛІДЖЕНЬ З БІОСИСТЕМНОЇ АГРОІНЖЕНЕРІЇ, АГРОТЕХНОЛОГІЙ ТА АГРОЕКОЛОГІЇ

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Svitlana Tsekhmistrenko, Doctor of Agricultural Sciences,
Professor, Head of the Department of Chemistry,
Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine
Volodymyr Bityutskyy, Doctor of Agricultural Sciences,
Professor, Head of the Department of Ecology and Biotechnology,
Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine
Yuliia Melnychenko, Candidate of Agricultural Sciences, Associate Professor,
Associate Professor of the Department of Ecology and Biotechnology
Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine
Olga Shulko, Candidate of Agricultural Sciences, Associate Professor,
Associate Professor of the Department of Ecology and Biotechnology,
Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine

HARNESSING THE POTENTIAL OF NANOPARTICLES FOR INNOVATIVE GREEN NANOTECHNOLOGIES IN AGROECOLOGY

Abstract. Nanoparticles introduced into the soil system can affect crop growth, yield and quality. This impact is determined by a number of factors, such as type, concentration, size, processing method, duration of exposure and plant species. Nanoparticles used in agroecology include nanoscale pesticides, herbicides, fungicides, nanofertilisers, etc. The integration of nanoparticles into agriculture is promising for the development of more sustainable agricultural systems.

Key words: green technologies, nanotechnology, nanofertilisers, nanopesticides, agroecology, bioremediation

Анотація. Наночастинки, введені в систему ґрунту, можуть впливати на ріст культур, їх врожайність і якість. Такий вплив обумовлений низкою факторів, як тип, концентрація, розмір, спосіб обробки, тривалість впливу та вид рослин. Наночастинки, які використовуються в агроекології включають нанорозмірні пестициди, гербіциди, фунгіциди, нанодобрива тощо. Інтеграція наночастинок у сільське господарство є перспективною для розробки більш стійких сільськогосподарських систем.

Ключові слова: зелені технології, нанотехнології, нанодобрива, нанопестициди, агроекологія, біоремедіація.

Harnessing the potential of nanoparticles for innovative ‘green’ nanotechnologies in agroecology is a rapidly developing field with significant prospects for transforming modern agricultural practices [1, 2]. Nanoparticles, with their unique properties, are being explored to increase yields, improve soil health and reduce the environmental impact of agriculture. Nanoparticles are being investigated for their potential to develop sustainable agricultural practices, including the development of nanoscale pesticides, herbicides, fungicides, fertilisers and sensors. The integration of nanotechnology with bioremediation, biomaterials science and smart technologies is providing innovative solutions for the treatment of micropollutants, the removal of organic pollutants and the development of holistic recycling systems. These advances have the potential to significantly reduce the environmental impact of agriculture while increasing efficiency and productivity [3]. The European Union's SCAR-WG report emphasises the need to give greater priority to research aimed at addressing consumption and developing sustainable food systems. It emphasises the importance of investing in knowledge and innovation, including biotechnology, nanotechnology and agroecology, to improve the efficiency and sustainability of agri-food systems [1]. Nanoparticles have been found to have antimicrobial properties that can be used in the food industry to reduce waste and increase sustainability. Assessing the carbon footprint of food processing systems is crucial to identify areas where nanotechnology can be applied to reduce greenhouse gas emissions and increase overall sustainability [7].

Nanoparticles used in agroecology include: nanoscale pesticides, herbicides and fungicides, which can be more targeted and effective in protecting crops [6, 8]; nanofertilisers, which can improve the uptake and use of nutrients by plants [5, 6]; metal nanoparticles, such as copper, iron, nickel, zinc, silver, and titanium, which are used to facilitate seed dormancy, promote germination, and enhance plant growth in agricultural and forestry crops [8]; nanosensors that can be used to monitor agroclimatic conditions in real time [5, 8].

These nanoparticle-based products have great potential to improve plant growth, soil quality, and overall sustainability of agricultural systems [5, 6]. However, more research is needed to address issues such as risk assessment, regulation, and farming systems to combat climate variability [6].

The use of nanoparticles in agriculture has several advantages over traditional methods, including improved nutrient uptake and utilisation by plants, which contributes to better growth and higher yields. Nanofertilisers can deliver nutrients more efficiently and precisely, reducing waste and environmental impact.

Nanoparticles can be used to develop targeted pesticides and fungicides that are more effective against pests and pathogens. Nanoparticles can also be used to create nanosensors that detect diseases at an early stage, allowing for more targeted and effective control measures.

Certain nanoparticles have been shown to improve plant resistance to environmental stresses such as drought, salinity and extreme temperatures. This can lead to more resilient crops and higher yields in difficult conditions.

Some nanoparticles can remediate contaminated soils and increase their fertility. They can also be used to develop nano-based soil amendments that improve soil structure and water holding capacity.

Nanoparticles have a significant impact on soil health and yields. Studies show that nanoparticles introduced into the soil system can affect crop growth, yield and quality. The effect of nanoparticles on soil health and yields depends on factors such as type, concentration, size, treatment method, duration of exposure and plant species. Studies have shown that nanoparticles can have both positive and negative effects on plants, affecting their growth, yield and overall quality. In addition, the potential of nanoparticles in soil remediation, changing soil quality and enhancing plant growth is being investigated. The integration of nanoparticles into agriculture holds promise for the development of more resilient agricultural systems and sustainable practices.

The use of nanoparticles in agriculture has both potential benefits and risks in terms of environmental impact. While nanoparticles offer opportunities to increase plant

production, improve soil and water quality, and remediate contaminated environments, they also raise concerns about their potential toxicological and environmental impacts. However, there are also concerns about the potential negative impacts of nanoparticles. Direct and indirect effects of nanomaterials have been identified that may have a toxicological impact on organisms and ecosystems [4, 9].

The interaction between nanomaterials and macro- and microorganisms in soil-water systems can affect soil, water and crop quality in unknown ways. Systematic research is needed to understand the long-term impact of nanoparticles on the environment and food production systems. To ensure the safe and effective use of nanoparticles, more research is needed to develop environmentally friendly, cost-effective and safe nanomaterials [10, 11].

In the context of the war in Ukraine and in the post-war period, nanotechnology is intended to contribute to the restoration of the agricultural sector of the economy, based on biosystemic agricultural technologies. It is necessary to improve soil quality and plant growth through the use of nanofertilisers and nanosensors. Increase crop yields and quality without harming the environment. Remediation of contaminated soil and water through the use of nanoparticles.

The use of nanoparticles in agroecology offers a promising avenue for developing more sustainable and efficient agricultural practices. By harnessing the unique properties of nanoparticles, researchers and practitioners can work together to create more targeted and environmentally friendly approaches to crop protection, soil health and food production. As the world's population continues to grow, the development of innovative environmental nanotechnologies will play a crucial role in ensuring food security while minimising the environmental impact of agriculture.

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