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Using a Colloidal Solution of Metal Nanoparticles as Micronutrient Fertiliser for Cereals

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We have developed the technology of using the colloidal solution of metal nanoparticles as fertilizers, which characterized by easiness to use, environmental safety and absence of corrosive properties. Colloidal solutions of biogenic metals, water-based, such as Fe, Mn, Zn, Mo, Co, Cu, and Ag, produced by a patented method of bittern natural colloidal solutions of the above metals were used. Seed treatment with colloidal solution of metal nanoparticles stored genetic purity grade, increased plant immune status via regulation of oxidative metabolism, photosynthetic activity, resistance to pathogens, and optimization of water regime of various winter wheat ecotypes during ontogenesis. Results of industrial tests proved that it is environmentally safe and economically feasible, since the cost of one liter of colloidal solutions of nanoparticles of metals ranges from 50-70 USD providing 500% level profitability. So, for the first time managed to optimize the function of biogenic metals through the use of physical and chemical characteristics of colloidal nanoparticle solutions to realize the productive potential of plants.

Keywords: Nanomaterials, Micronutrients, Fertilizer, Cereals.

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Nanotechnologies in agriculture involve the use of fertilizing and plant protection preparations latest generation. Colloidal solutions of biogenic metals become widely used to enhance productivity and resistance to abiotic and biotic environmental factors.

Traditionally in Ukraine and worldwide the problem of fertilizer and animal feed enrichment with vital micronutrients solve by salts of heavy metals and chelating compounds which on the structure and properties are of small biological meet the needs of plants and animals, and only slightly absorbed by the latter. The result is the accumulation of heavy metals in the environment, its ecological condition worsens, decreased quality of food received.

By applying nutrients nutrition Ukraine significantly lags behind Western countries. There is a steady increase in production and a wider outspread of micronutrients over the last 30-40 years in almost all developed countries. But there is a reverse process in our country: the production of micronutrients by domestic industry take place in small quantities, without purpose. Therefore for our country production of a wide range of micronutrients with balanced content of elements and their application in the production of environmentally friendly products with high content nutrients is an actual problem.

The use of nanomaterials in crop and livestock production is a very responsible task because it dealing with living objects. Now it is necessary to study the impact of nanomaterials on biological, biochemical, and genetic levels and developing the appropriate methods of their exact application. The substances in electrically neutral form (nanoatoms) pass through cytoplasmic membrane because of solubility in lipoprotein matrix more easily than in the ionic form. Biological activity of fine metal powders, minerals in the form of an aqueous suspension in vivo is higher compared with soluble salts of these metals.

Now widespread in crop science become foliary - aqueous solutions of salts, trace elements, which are used for foliar feeding. The permeability of these micronutrients through the leaf cuticle electrochemical potential is limited and incomplete solubility of salts. Using the smaller and electrically neutral elements, including metal nanoparticles will improve the efficiency of micronutrients. The aim of our study was to determine the content and redistribution of metal elements in plant tissues after pre-treatment of seeds and treatment of foliar aerial parts of seedlings of winter wheat with non-ionic colloidal solution of metal nanoparticles. Metal content in the roots and aerial parts of 10-day seedlings of wheat was determined by atomic absorption spectrometer equipped with an acetylene torch and a set of spectral lamps according to technique [1]. Data obtained showed that at seed treatment the individual elements of metal nanoparticles various elements distributed differently in the tissues of roots and aerial parts of seedlings (Fig. 1). So, in variant with treatment of seed by nanoparticles with iron, its content increased in root tissues and in photosynthetic tissues of seedlings by 16% and 26% respectively. A similar pattern is observed with the accumulation of zinc - its content in the roots increased by 34%, in leaves - 61%. Treatment with copper nanoparticles induced copper content increase (by 94%) in roots, but decrease (by 38%) in leaves. The content of manganese increased in leaves research options (30%) but in the roots remained at control level.

Thus, the results obtained indicate the ability of metal nanoparticles to penetrate through seed coat. The distribution of elements in plant tissues is determined by their ability to penetrate and peculiarities of transporting in the plant.

We have developed the technology of using the colloidal solution of metal nanoparticles as fertilizers, which characterized by easiness to use, environmental safety and absence of corrosive properties. Colloidal solutions of biogenic metals, water-based, such as Fe, Mn, Zn, Mo, Co, Cu, and Ag, produced by a patented method of bittern natural colloidal solutions of the above metals were used [2].

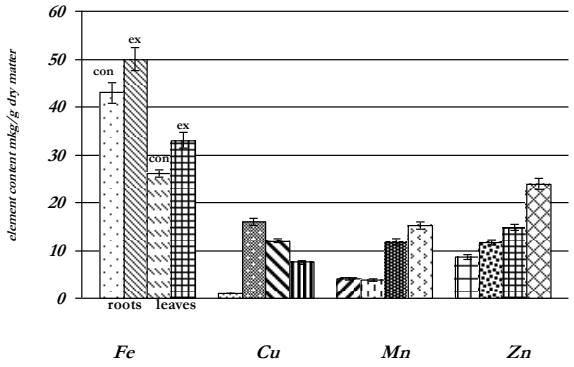

Fig. 1 – The content of metal elements in tissues of wheat seedlings treated by nanoparticles of the metals

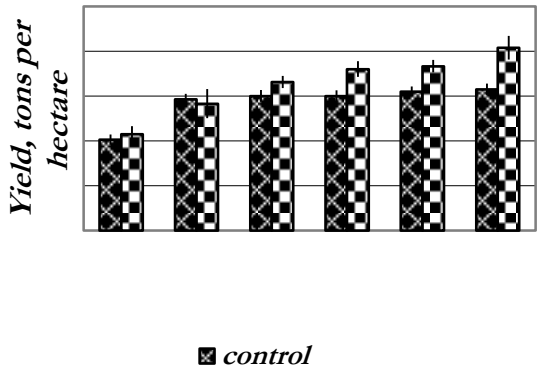

Fig. 2 – Yield of winter wheat varieties according to the National fertilization and pre-treatment of seeds, t / ha

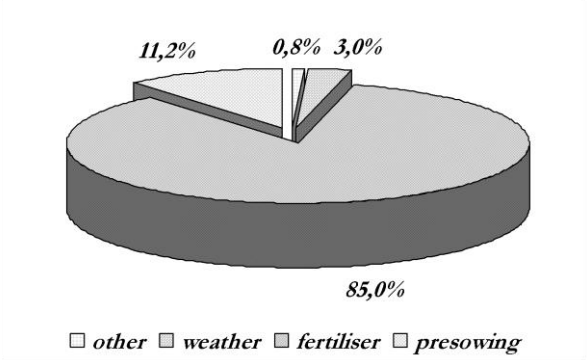

Fig. 3 – Share of the factor impact on yield of winter wheat National variety during 2011-2012

Aqueous solution of metal nanoparticles obtained by spark, is the core of the metallic phase, covered oxide shell, excellent for oxygen content. Separation of particle size is sufficiently narrow. The maximum size is no more than 100 nm. If necessary, possible modification of particles with other elements, the main condition is that they should be compatible and there no take place premature coagulation of colloidal solutions. Application rates are extremely small: 1 liter of solution per 3-4 ha for seedbed and 1-2 liters per ha for foliar application that corresponding to 1-3 mkh/m2, which is an order of magnitude lower than the rates of application of chemicals known.

Seed treatment with colloidal solution of metal nanoparticles stored genetic purity grade, increased plant immune status via regulation of oxidative metabolism, photosynthetic activity, resistance to pathogens, and optimization of water regime of various winter wheat ecotypes during ontogenesis [3].

Optimization of nutrient element supply through integrated use of traditional fertilizers and non-ionic colloidal solution of metal nanoparticles has an integrating effect on the technological quality of grain - grain quality rating changed from the fifth to the first. The protein content in grain increased from 10.6 to 14.2% gluten - from 21.9% to 30.9%.

Fertilization stimulated the growth of crops, although higher doses of 30 kg / ha proved ineffective, as the increased yield did not exceed 45% in all experimental variants. Treating seeds with metal nanoparticles contributed significantly increase crop only in combination with the use of fertilizers in dose-dependent manner. Thus, the yield indexes of plants grown from seeds treated with metal nanoparticles in the variant N150P150K150 were almost doubled (88%) compared with controls and by 28% higher compared to a version of the fertilizer (Figure 2).

Impact pre-sowing treatment with metal nanoparticles share on the yield was 11.2%, in contrast to fertilization showed 85% and the weather conditions were in this case is not significant, their share was only 3% (Figure 3).

Pre-sowing treatment of seeds and vegetative plant with colloidal solution of metal nanoparticles is possible in tank mixtures with pesticides. Because of the low cost of metal nanoparticle solution per hectare crop it makes real to provide a high level of economic efficiency.

Results of industrial tests proved that it is environmentally safe and economically feasible, since the cost of one liter of colloidal solutions of nanoparticles of metals ranges from 50-70 USD providing 500% level profitability. So, for the first time managed to optimize the function of biogenic metals through the use of physical and chemical characteristics of colloidal nanoparticle solutions to realize the productive potential of plants (yield increased by 20-25%).

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