Possibility of Using Copper and Copper Oxide Nanoparticles as Plant Growth Stimulators in Conditions of Depletion of Soil Resources

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ABSTRACT

Currently, more and more often there are processes of soil depletion: the depletion of soil nutrients as a result of its irrational use. At the same time, it is an obvious fact that it is necessary to look for new approaches to agriculture that would ensure the maximum reduction of the dependence of the volume and quality of the crop on external factors. The use of nanopreparations in crop production is the most promising. The development of new technologies and techniques using nanomaterials that would ensure high yields and quality of crop production is relevant and of great practical importance (Chernikova O. et al., 2019).

The research was carried out in the lysimeters of the NSRIHEA design with undisturbed soil profile. The area of stationary field lysimeters is 1.3 m². Lysimeters are charged with gray forest soil. Taken soil samples from a depth of 0 - 25 cm at the beginning of the experiment characterize the soil with a low content of organic matter from 3.8% to 5.4% (on average 4.6% ± 0.6) (Fig. 1). The acid-base reaction of the soil refers to slightly acidic, pH from 5.3 to 6.4 (on average 5.7 ± 0.1). The supply of soil with mobile nutrients on average was as follows: potassium content - 833.5 mg / kg, total nitrogen - 0.12%, mobile phosphorus - 128 mg / kg that characterizes this soil as medium provided with these elements.

Figure 1. Lysimetric experiment on gray forest soil

The biological activity of metal nanoparticles is directly related to their physicochemical characteristics: particle size, their shape, phase state of particles (Olkhovskaya I.P. et al., 2019). As the result, for the successful use of nanoparticles and nanomaterials for the crop industry, their physicochemical properties must be taken into account.

The used nanoparticles are single crystal structures of circular regular shape and have the following characteristics: Cu - 40-60 nm, phase composition: Cu° - 100%; CuO– 40-60 nm, phase composition: CuO - 100%. A suspension of nanoparticles was obtained by dispersion by ultrasound in an aqueous solution. Nanopowders of copper and copper oxide contained 0.01 g per hectare seed rate in the solution. Barley seeds were soaked 30 minutes before sowing in bidistilled water (control variant), as well as in a suspension of nanoparticles. Barley is a culture of versatile use, which has great feed, food, technical and agricultural value. Barley spring variety "Kati" was chosen as the object of research. The species is nutans. The experience diagram is shown in table 1.

Linear plant growth is an important environmental indicator that indirectly characterizes the intensity of cell division or extension. The highest plant height was noted at 77.01 cm in the variant using copper

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nanoparticles at a dose of 0.01 g/ha. The increase in this indicator compared to the control version of the experiment was 7.19%. It is likely that copper nanoparticles contributed to an increase in the adaptive potential of plants, which led to stabilization of growth processes and increased resistance to lodging.

Table 1. The setup of the experiment

Lysimeter number	Variant name	Abbreviation
1,5,9,13	Suspension of nanopowder of copper oxide at a dose of 0.01 g /ha	CuO 0,01
2,6,10,14	Suspension of copper nanopowder in a dose of 0.01 g / ha 0,01 r/ra	Cu 0,01 $N_{60}P_{60}K_{60}$
3,7,11,15	Suspension of copper nanopowder in a dose of 0.01 g / ha	Cu 0,01
4,8,12,16	Control	C

Indicators of linear growth and productivity in our experiment were directly dependent on each other. Thus, the highest yield was noted in the variant with the use of Cu NPs - 44.8 c / ha. The mass of 1000 seeds in this variant was less, however, the number of spikelets and grains in the ear at the time of harvesting was more. Plants during using copper nanoparticles were more resistant to lodging and shedding of seeds that probably led to an increase in this indicator in comparison with the control variant, as well as other experimental variants.

It should be noted that the largest mass of 1000 seeds was in the variant with the use of copper nanoparticles with the joint application of mineral fertilizers and amounted to 71.7 g that was 6.3 g (8.79%) more in comparison with the control variant of the experiment. The use of only nanoparticles of copper and copper oxide at a dose of 0.01 g per hectare seed rate also contributed to an increase in this indicator: 0.6 (0.91%) and 0.8 (1.21%) g, respectively. Digestible protein is a crude protein that is absorbed into the bloodstream and lymph from the digestive tract of cattle. Its amount was in the same stages on all variants of the experiment and ranged from 58.1 to 67.1 g per 1 kg of fodder.

The amount of energy in the fodder is the most important indicator of its value. The value of this indicator in all variants of the experiment, with the exception of Cu 0.01 $N_{60}P_{60}K_{60}$, was at the same level and amounted to 10.79 MJ. A slight increase was observed during using copper nanoparticles with the joint application of mineral fertilizers and it amounted to 10.84 MJ that is 0.05 MJ more in 1 kg. The moisture content of the presented samples was within the base humidity, which is from 13.5 to 15%. On average, for all variants of the experiment, it amounted to 14.2%. From the obtained data, it can be concluded that the pre-sowing treatment of barley seeds with copper and copper oxide nanoparticles does not have a toxic effect and contributes to an increase in yield.

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