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PRODUCTIVITY AS INTEGRAL VALUE OF EFFICIENCY IN THE TECHNOLOGY NANOMETAL SOYBEANS

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The results of studies on soybean yield black soils typical steppe of Ukraine, depending *on the method of application and concentration of the solution of complexmulti-componentmetal nanoparticles*. *It is established that the technology is effective treatment of soybean seeds before planting nanometal solution at a concentration of 240 mg/L and addition a spraying of crops in the budding stage*. *Using nanometal for pre-treatment of soybean seeds in a concentration of 240 mg/L in the norm of 0,1 l/ha of seeds and addition a spray ing of crops with a solution at a concentration of 240 mg/L in the budding stage against the backdrop of mineral fertilizers in normal* $N_{60}P_{60}K_{60}$ *provides increased crop yield.*

Soy, nanoparticles of metals, fertilizers, crop.

Modern trends in world agricultural production aimed to develop sustainable technologies for plant production. Now days urgent needs to reorient agriculture of our country to the standards of the European market which involve comprehensive development and implementation in practice paradigm intensification of biological processes in plant organism [2, 11, 12]. In recent years interest in the formation of ecologically balanced agrocenosis and increase adaptive capacity of agriculture in the existing systems of agricultural production has increased tremendously. In the global theory of organic farming, agro-ecosystems should be created not only as high performance but also to be environmentally sustainable; with ability to adapt ontogenetic processes of plants according to the fluctuation of weather conditions and anthropogenic factors with aim to get environmentally clean products [8].

The systematic study of adaptative reactions of plants in the modified environmental conditions which occurs via changing climatic factors, transformation with a prevalence of degradation processes in the soil and water systems, contamination by various pollutants are demonstrates the feasibility of using nanoparticles adaptative strategies to optimize agriculture and sustainability productivity [1].

Literature data [8, 11] found that nanoscale state of matter characterized by significant change and the emergence of new properties that are not inherent to the material in a compact state. Specificity of nanostructured materials is reflected in the thermodynamic characteristics; when a decrease in size significantly increases the difference between the model of the solid phase which adopted in classical thermodynamics and real nanoparticles and distribution on the bulk and surface component are arbitrary. Arsentyeva and Gluschenko has been observed increasing the Gibbs free energy of nanoparticles under

conditions of constant temperature and pressure which due to a significant increase of surface area, or surface distribution of phases in nanostructured materials [1,2].

In this case the large surface area of all nanomaterials have large surface energy – increased by at least three orders of magnitude relative to compact of material, thus being in an unstable or metastable state and tend to form agglomerates. The use of nanoscale biogenic metals together with organic compounds which are soluble with membrane-acting properties is definitely a great perspective and an opportunity to combain biogenic nanoparticles of metals directly into living cells [4, 10].

Biogenic metal nanoparticles are used as aqueous solutions. Doses which entered per 1 ton of seeds or 1 ha of crops is extremely small, so it is important that nanoparticles should be uniformly dissolved in the working solution. The stock nonionic colloidal solution of metal nanoparticles diluted with water at a ratio of 1:100. Experimental results S. M. Kalenskoyi and colleagues has been showed possibility of mixed use of pesticides and metals nanoparticles solution, because under these conditions, both pre-treatment and spraying of crop during the growing season increases the effectiveness of the dressers, fungicides, insecticides and herbicides [4, 5].

Experimental technological tests has been conducted that solution of metal nanoparticles is compatible with all types of NPK – fertilizer and pesticides [3, 6, 9]. To use biogenic metal nanoparticles compensates the missing of trace elements in plants, increases plant resistance, improves metabolic processes of plants under conditions during the growing season; while improve the quality of the final product. In addition, to use of metal nanoparticles improves efficiency of basic micronutrients – nitrogen, phosphate and potash. To use preparats with nanoparticles can help to get environmentally clean plant products.

Aim and objectives of research. The aim of research is to study of the effect of biologically active products based on nanosized particles of metals on soybean plants during growing period. Objective of studies is to propose optimization method of application different concentrations of the metal nanoparticles on soybean crops with purpose to study their effectiveness for plant productivity.

Materials and methods. In experiments has been used patented (Patent of Ukraine for useful model № 38459) stock colloidal solution of the complex (Fe, Mn, Mo, Co, Cu, Zn, Ag) metal nanoparticles [7]. Field experiments which study effects of multicomponent colloidal solution of metal nanoparticles on soybean yield formation has been performed at the Department of Crop fields of National University of Life and Environmental Sciences of Ukraine "Agronomic Research Station". Agrotechnics in the experiment were typical for the Northern Forest region. Soybeans were sown in the soil temperature at a depth of seeding 10-12 ° C with support of vegetable seeder COH-4,2. The total area of the experimental area – 84 m_2, accounting – 52,8 m_2. Experiment replication four times. Seeding soybeans – 700 thousand seeds per 1 ha. To protect against weed harrowing has been performed to use a mixtures of herbicides aramo (1,0 L/ha) and bazahran (2,0 L/ha).

With aim to determine effectiveness of the solution of metal nanoparticles have been placed two experiments. In experiment 1 has been learned how to

use colloidal solution of metal nanoparticles for the technology of soybean cultivation. During pre-sowing cultivation made fertilizers in the combination $N_{30}P_{30}K_{30}$. The next forest soybean varieties were used for the experiment: ultra early cultivar Annushka (Scientific breeding and seed company "Soy age", Kirovograd) and early maturing Ustya (Institute of Agrarian Sciences farming, Chabany). Scheme of the experiment has been consisted from following options:

1. control 1 (seed treatment with distil water)
2. pre-sowing seed treatment with complex of metal nanoparticles single concentration (Single Conc)
3. pre-sowing seed treatment complex double metal nanoparticles concentration (Double Conc)
4. control 2 (seed treatment + water spraying crops in the phase of budding water)
5. pre-sowing seed treatment + complex nanoparticles spraying crops in the bud stage single metal complex nanoparticles concentration
6. pre-sowing seed treatment + complex nanoparticles spraying crops in the budding phase complex metal double nanoparticles concentration.

Complex metal nanoparticles for pre-treatment of seeds used with the normal flow 0,1 L/t (100 ml per 10 liters of water and for 10 tons of seeds). The working solutions of multi-preparats of nanoparticles of metals for foliar treatment in the phase of budding and flowering of soybean plants has been prepared in norm of 1 liter product soar to 100-300 liters of water (working solution) and for 1 ha.

Experiment 2 has been studied the effectiveness of two concentrations of the metal nanoparticles on soybean crops what include seed treatment and spraying of crops soybean by complex solution of single metal nanoparticles (120 mg per L) and double (240 mg per L) concentrations. The basic soil fertilizers were granular superphosphate (P_2O_5 – 19 %) and potassium salt (K_2O – 40 %) in the rate of 60 kg per ha. In spring time has been used ammonium nitrate (N – 30 %) in the norms $N_{30}P_{60}K_{60}$, $N_{60}P_{60}K_{60}$ and $N_{90}P_{60}K_{60}$.

Results. The criterion for evaluating the effectiveness of photosynthesis, biological nitrogen fixation and formation of plant productivity are indicators of individual plant productivity and value productivity of soybean. The experimental results with study using multi solution of nanoparticles together with fertilizing of soybeans (Fig. 1) has been revealed the most effective one. Thus, treatment of soybean seeds before sowing with nanoparticles multi-component solution at a concentration of 240 mg per L and additional spraying of crops in the budding phase complex metal double nanoparticles concentration on the fertilizers background $N_{30}P_{30}K_{30}$ provides increasing harvest crops compared with control on 1,5-3,0 kg per ha.

Variant 6 of experiment 1 with using solution of nanoparticles in the double concentration (Double Conc) for pre-treatment of soybean seeds and foliar treatment in the flowering phase has been shown higher yield of crops (the background of mineral nutrition $N_{30}P_{30}K_{30}$) for Ustya cultivar 2,44 t per ha and 2,49 t per ha for cultivar Annushka.

Comparing the efficiency of metal nanoparticles with the effect of fertilizers fertilizing crops has been established a positive relationship between yield of soybean and increasing the concentration of the preparat of metal nanoparticles.

Higher productivity results has been obtained for the pre-treatment of soybean seeds with solutions of nanoparticles of metals – 2.34 t per ha (Single Conc) for cultivar Anushka, 2,28 t per ha (Double Conc) for cultivar Ustya (Fig. 2). The highest results of crop productivity were revealed in the option processing seed crop spraying with Double Conc of metal nanoparticles plus foliar treatment in the flowering phase with Double Conc of metal nanoparticles – 2,46 t per ha for soybean cultivar Annushka and 2,39 t per ha for cultivar Ustya.

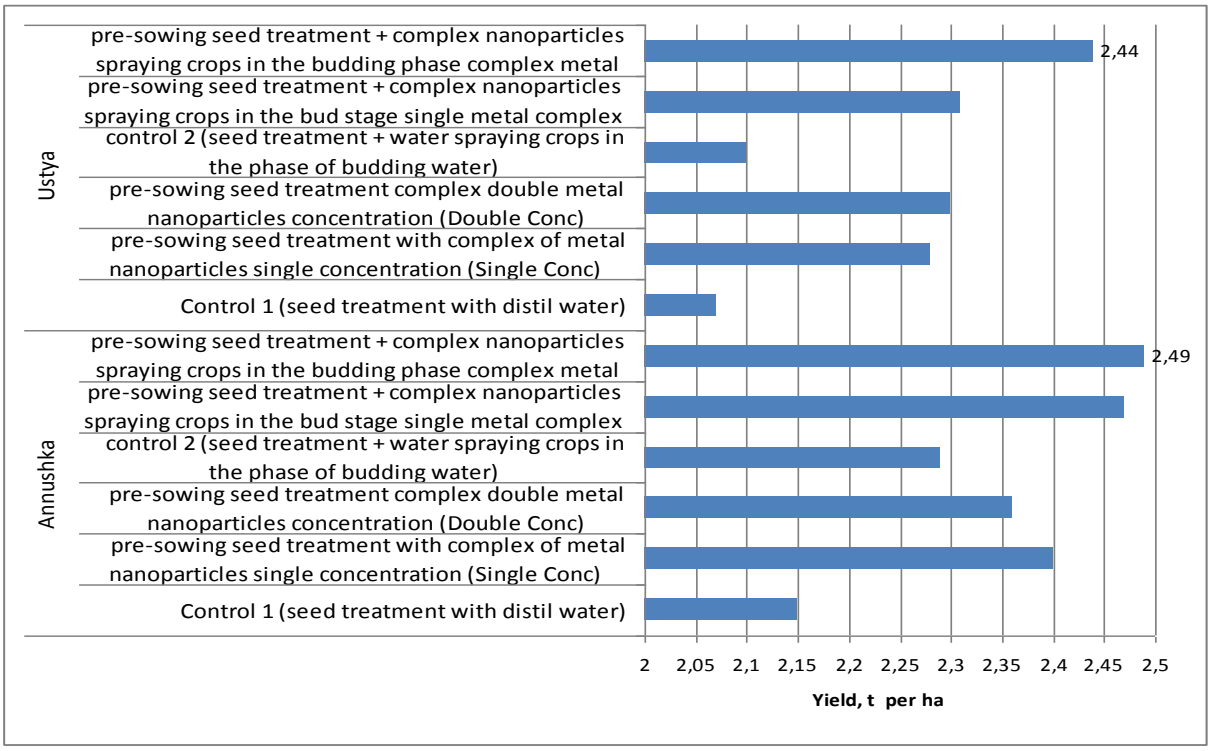
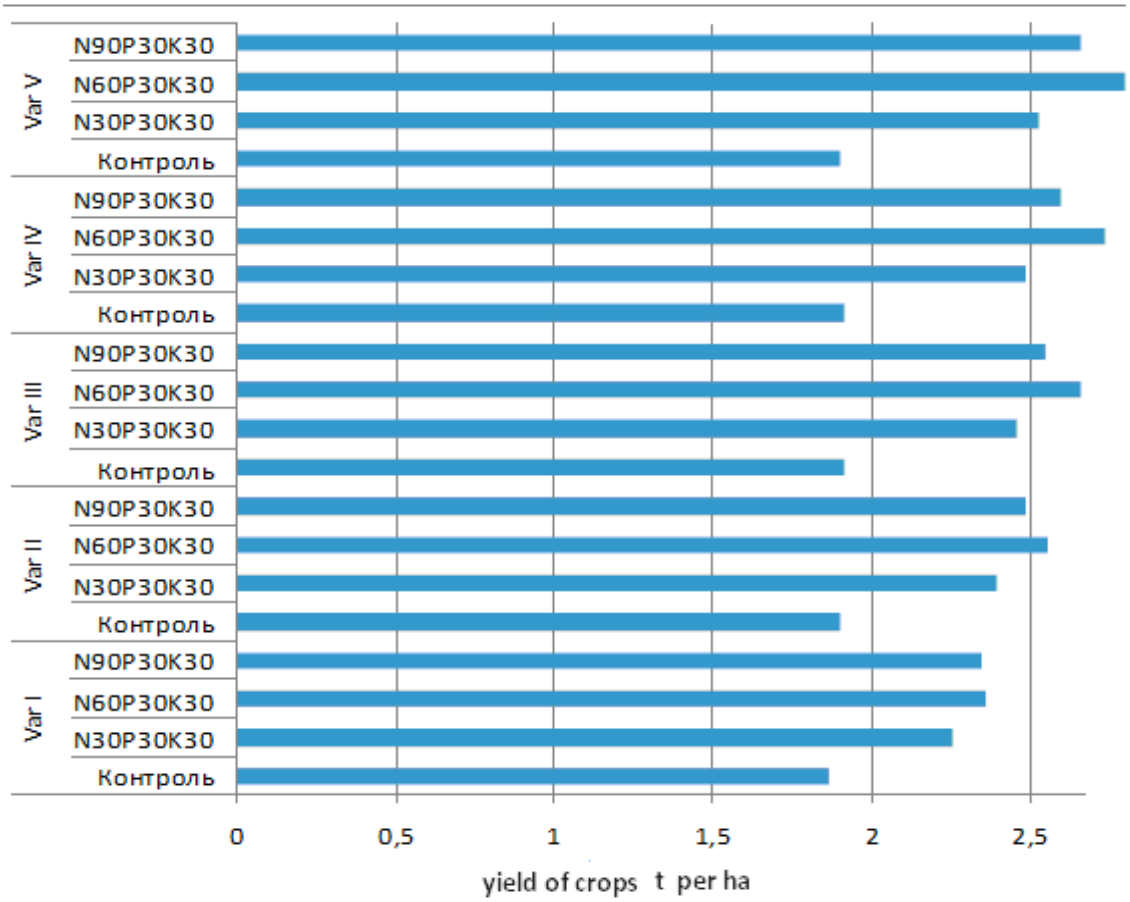


Figure 1. Yield of soybeans experimental cultivars which growth under different type of treatment with solution of metals nanoparicles, (data for 2010-2013, experiment 1), LCD_{05}=0.12 t per ha

The results of our study has been shown that more effective ways to use multicomponent colloidal solution of metals in soybean cultivation technology is the use nanoparticles for pre- treatment of seeds at a concentration of 240 mg per L with normal hover 0,1 L per t seed and additional spraying of crops in concentration of 240 mg per L in the budding stage under background fertilization $N_{60}P_{60}K_{60}$. The proposed agrotechnology depending on the concentration of mineral fertilizers in the soil can provide increasing of crops yield on 1,5–2,5 %.

Conclusions. In cultivation technology of early soybean cultivars Annushka and Ustya on typical chernozem humus-poor forest-steppe Ukraine area is recommended to apply multicomponent colloidal solutions of metal nanoparticles as for pre- treatment of seeds and for plant treatment at phase of budding and flowering. The patented stock complex colloidal solution (Fe, Mn, Mo, Co, Cu, Zn, Ag) of metal nanoparticles (Patent of Ukraine for useful model № 38459) has been recommended to use in the concentration of 120 mg per L and 240 mg per L with normal flow 0,1 L per t seed (100 ml per 10 liters of water and 10 tons of seeds). For foliar treatment of soybean plants should be prepare

stock solutions of multi metal nanoparticles preparats of soar with the norm 1 liter product for 100-300 liters of water (stock solution) and for area 1 ha.



Var I	control 1 (seed treatment with distil water)
Var II	pre-sowing seed treatment with complex of metal nanoparticles single concentration (Single Conc)
Var III	pre-sowing seed treatment complex double metal nanoparticles concentration (Double Conc)
Var IV	**pre-sowing seed treatment + complex nanoparticles spraying crops in the bud stage single metal complex nanoparticles concentration**
Var V	pre-sowing seed treatment + complex nanoparticles spraying crops in the budding phase complex metal double nanoparticles concentration.

Figure 2. Yield of cultivar Annushka which growth under treatment of different concentration of complex multi-metal nanoparticles solution t / ha (data for 2010-2013, experiment 2), LCD_{05}=0.08 t per ha

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Представлены результаты исследований урожайности сои на черноземах типичных Лесостепи Украины в зависимости от способа применения и концентрации многокомпонентного комплексного раствора наночастиц металлов. Установлено, что в технологии выращивания сои эффективна обработка семян до посева раствором нанометаллов в концентрации 240 мг/л

и дополнительное опрыскивание посевов в фазу бутонизации. Использование нанометаллов для предпосевной обработки семян сои в концентрации 240 мг/л в норме 0,1л/т семян и дополнительное опрыскивание посевов раствором в концентрации 240 мг/л в фазу бутонизации на фоне внесения минеральных удобрений в норме $N_{60}P_{60}K_{60}$ обеспечивает увеличение урожайности культуры на 1,5-2,5 %.

Соя, наночастички металлов, минеральные удобрения, урожайность.

Висвітлено результати досліджень врожайності сої на чорноземах типових Лісостепу України залежно від способу застосування та концентрації багатокомпонентного комплексного розчину наночасток металів. Встановлено, що в технології вирощування сої ефективним є обробка насіння до сівби розчином нанометалів в концентрації 240 мг/л та додаткове обприскування посівів у фазу бутонізації. Використання нанометалів для передпосівної обробки насіння сої в концентрації 240 мг/л з нормою витати 0,1 л/т насіння та додаткове обприскування посівів розчином в концентрації 240 мг/л у фазу бутонізації на фоні внесення мінеральних добрив в нормі $N_{60}P_{60}K_{60}$забезпечує зростання врожайності культури на 1,5-2,5 %.

Соя, наночастки металів, мінеральні добрива, урожайність.