CRIAÇÃO E IMPLEMENTAÇÃO DE UM NOVO REGULADOR DE CRESCIMENTO ALTAMENTE EFICAZ PARA RESTAURAR A FERTILIDADE DO SOLO NAS REGIÕES ÁRIDAS DO CAZAQUISTÃO**DEVELOPMENT AND INTRODUCTION OF NEW HIGH-POTENCY GROWTH REGULATOR FOR RESTORING SOIL FERTILITY IN ARID AREAS OF KAZAKHSTAN****СОЗДАНИЕ И ВНЕДРЕНИЕ НОВОГО ВЫСОКОЭФФЕКТИВНОГО РЕГУЛЯТОРА РОСТА ДЛЯ ВОССТАНОВЛЕНИЯ ПЛОДОРОДИЯ ПОЧВ В АРИДНЫХ ОБЛАСТЯХ КАЗАХСТАНА**

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RESUMO

O objeto da pesquisa são os fertilizantes minerais orgânicos obtidos a partir da hulha castanha e do vermicomposto para aumentar a produtividade das culturas de grãos e hortaliças, além de diversas variedades de árvores. O objetivo do trabalho é criar e introduzir um novo fertilizante orgânico-mineral para restaurar a fertilidade do solo e das florestas, reduzir os processos de desertificação e aumentar o rendimento das culturas agrícolas. Nesse processo, foram realizados os estudos para selecionar as condições ideais de obtenção dos fertilizantes minerais orgânicos, determinar sua composição e estrutura, bem como estabelecer a concentração de ação do produto. Como resultado do trabalho realizado, vários fertilizantes minerais orgânicos com efeito de estimulação do crescimento foram sintetizados a partir de uma matéria-prima complexa: hulha castanha e vermicomposto, contendo enzimas, aminoácidos, vitaminas, ácidos orgânicos, fitohormônios, bem como um complexo de minerais e microelementos. Foram realizados os testes de laboratório e de campo sobre o efeito do novo fertilizante mineral orgânico em vegetais, grãos e algumas variedades de árvores. Foi estabelecido que o uso do novo fertilizante aumenta o rendimento das culturas de grãos em 4,2-4,7 c/ha (*c – cem quilogramas*), e das hortaliças em 2,4-3,2 t/ha. O uso desse produto no cultivo agrotécnico de árvores coníferas proporciona um acréscimo de 4,0-4,7 cm em comparação com o caso base. No viveiro de mudas de instituição pública "Bakanasskoe lesnoye khozyaystvo" ("Silvicultura de Bakanas"), os testes do efeito da fertilização orgânico-mineral nas sementes do saxaul preto são realizados em uma área de 1,0 hectares. O grau de implementação – foram apresentados os pedidos de patentes da República do Cazaquistão e do Escritório de Patentes da Eurásia (EAPO). Com base nos resultados do trabalho realizado, prevê-se o desenvolvimento e introdução de 1 produto na prática do cultivo de plantas. Os resultados da investigação podem ter aplicação nas seguintes áreas: agricultura e silvicultura, ecologia de solos e agroquímica, biotecnologia. Eficiência – simplicidade de tecnologia de produção, complexidade (de vários componentes), boa solubilidade em água, baixa dose de aplicação – 0,01% do ingrediente ativo (0,1 g por 100 l de água) ou longa vida de prateleira, segurança, ampla gama de culturas abrangidas.

Palavras-chave: *hulha castanha, biohumus, agricultura, culturas de grãos e hortaliças, variedades de árvores coníferas.*

ABSTRACT

The object of the study is organic mineral fertilizers obtained from brown coal and vermicompost to increase the yield of grain and vegetable crops, as well as various tree varieties. The purpose of the study is the development and implementation of a new organomineral fertilizer to restore the fertility of soil and forests, reduce

desertification, and increase the yield of agricultural crops. In the process, studies were carried out to select the optimal conditions for obtaining organomineral fertilizers, determine their composition and structure, and establish the optimal concentration of the compound. As a result of the work carried out, several organomineral fertilizers with the effect of growth stimulation have been synthesized from a complex feedstock: brown coal and vermicompost, containing enzymes, amino acids, vitamins, organic acids, phytohormones, as well as a complex of minerals and trace elements. Laboratory and field experiments on the effect of the new organomineral fertilizer on vegetables, grain crops, and some trees were carried out. It has been discovered that the use of the new fertilizer increases the yield of grain crops by 4.2-4.7 dt/ha and vegetable crops by 2.4-3.2 t/ha. The use of this compound in the agrotechnical cultivation of coniferous trees increases 4.0-4.7 cm compared to the basic version of fertilizer. At the forest nursery of MPI "Bakanasskoe Forestry", experiments on the effect of organic fertilization on the seeds of black saxaul are carried out on the territory of 1.0 hectares. Degree of implementation - applications for patents of the Republic of Kazakhstan and the Eurasian Patent Office have been submitted. Based on the research results, it is planned to develop and introduce 1 compound into the practice of plant growth. The research results can find application in the following areas: agriculture and forestry, soil ecology and agrochemistry, biotechnology. Efficiency – the simplicity of production technology, multicomponent, good solubility in water, a low dose of application – 0.01% of the active ingredient (0.1 g per 100 l of water) or long shelf life, safety, a wide range of crops covered.

Keywords: *brown coal, biohumus, agriculture, grain and vegetable crops, coniferous tree varieties.*

АННОТАЦИЯ

Объектом исследования является органоминеральные удобрения, полученные из бурого угля и вермикомпоста для повышения урожайности зерновых и овощных культур, а также различных сортов деревьев. Цель работы – создание и внедрение нового органоминерального удобрения для восстановления плодородия почвы, лесов, снижения процессов опустынивания земель и повышения урожая сельскохозяйственных культур. В процессе проводились исследования по выбору оптимальных условий получения органоминерального удобрения, по определению их состава и структуры, а также по установлению оптимальной концентрации действия препарата. В результате проведенных работ синтезированы ряд органоминеральных удобрений с эффектом ростстимулирования из комплексного исходного сырья: бурого угля и вермикомпоста, содержащий ферменты, аминокислоты, витамины, органические кислоты, фитогормоны, а также комплекс минералов и микроэлементов. Были проведены лабораторные и полевые испытания действия нового органоминерального удобрения на овощные, зерновые культуры и некоторые сорта деревьев. Установлено, что применение нового удобрения повышает урожайность зерновых культур на 4.2-4.7 ц/га, а овощных культур 2.4-3.2 т/га. Применение данного препарата в агротехнической культуре обработки хвойных пород деревьев обеспечивает прирост на 4.0-4.7 см по сравнению с базовым вариантом. На лесном питомнике КГУ «Баканасское лесное хозяйство» проводятся испытания влияния органоминерального удобрения на семена черного саксаула на территории 1.0 га. Степень внедрения – поданы заявки на патенты РК и Евразийского патентного ведомства. По результатам проведенных работ планируется разработать и внедрить в практику растениеводства 1 препарат. Результаты исследований могут найти применение в следующих областях: сельское и лесное хозяйство, экология почв и агрохимия, биотехнология. Эффективность – простота технологии производства, многокомпонентность, хорошая растворимость в воде, низкая доза применения – 0.01% по действующему веществу (0.1 г на 100 л воды) или длительные сроки хранения, безопасность, широкий спектр охватываемых культур.

Ключевые слова: *бурый уголь, биогумус, сельское хозяйство, зерновые и овощные культуры, хвойные сорта деревьев.*

1. INTRODUCTION:

New conditions for the interaction of living and non-living matter have developed in the surrounding world – as a result of human interaction with the technosphere, the technosphere with the biosphere (nature), and other elements. It is appropriate to talk about the emergence of a new field of knowledge – “Ecology of the technosphere”, where the main “actors” are – man, the technosphere created by man, and the

natural environment (Stevenson, 1994). There have been significant changes in the human environment. The biosphere is gradually losing its dominant position, and in the regions of the Earth inhabited by people, it is increasingly turning into a technosphere. In the modern world, environmental problems in their social significance have come to one of the first places, pushing aside even the danger of a nuclear war (Lavrukov, 2012). The rapid development of human economic activity has led to an intensive, often destructive

impact on the environment. Human influence on nature occurs both through the transformation of natural systems that have developed over millennia and as a result of pollution of soil, water, and air, which led to a sharp deterioration in the state of nature, and often with irreversible consequences (Shchetkin, 2004; Golovkov *et al.*, 2017). Ecological problems that take on a global character and lead to a deterioration in the conditions for the development of mankind threaten its existence. This is manifested in a shortage of energy, loss of biodiversity and stability of ecosystems, deforestation and soil degradation, dehumidification, imbalance in the biogeochemical cycles of carbon and nitrogen (Dobrovolskiy, 2002; Semenov and Kogut, 2013).

For the south-east of the Trans-Baikal Territory, as well as for the territory of Central Asia as a whole, advance desertification is characteristic, associated both with global warming and with the phase of reduced moisture in the regional climatic cycle ongoing since the early 2000s (Budantsev, 1987; Shchetkin, 2004). Climate aridification through changes in soil properties and hydrological conditions leads to a permanent loss of ecosystem services and poses a serious threat to the sustainable development of agricultural production.

The rapid development of human economic activity has led to an intensive, often destructive impact on the environment. Human influence on nature occurs both through the transformation of natural systems that have developed over millennia and pollution of soil, water, and air, which led to a sharp deterioration in the state of nature, and often with irreversible consequences (Solovev, 2013). The ecological crisis poses a real danger since there is a rapid development of crisis situations in each region. Many modern methods of industrial, agricultural production are anti-ecological. The presence of monoculture causes them overgrazing of livestock, large-scale use of pesticides with excessively high doses of mineral fertilizers, continuous plowing of the soil. They lead to disruption of the normal functioning of ecosystems, simplification of their structure, instability, and catastrophic changes in nature. The most advanced direction of modern agriculture is the transition from the principles of confrontation with nature to cooperation with it (Shchetkin, 2004; Popov, 2004). This means maximum adherence to environmental laws in agricultural practice. The noted is directly related to animal husbandry in general, and in particular, to poultry farming, the most intensively developing

and functioning branch of agricultural production. Waste from poultry farms is practically not processed, so the land, water bodies, and air closest to the poultry farms are polluted (Review of the market..., 2018).

Efforts are being made both by governments of different countries and numerous scientists to solve these complex environmental problems (Zherebtsov, 1998). One of the promising ways to combat these phenomena is developing green chemistry technologies based on the use of substances obtained from biomass. In particular, compounds based on humic substances, a complex mixture of high molecular weight organic compounds of natural origin, resistant to biodegradation, which are formed during the decomposition of plant and animal residues, are widely used (Orlov, 1990; Savicheva and Inisheva, 2003). At present, there is an increased interest in humic substances all over the world, which is explained by their use in crop production as a safe, in terms of environmental impact, an alternative to fertilizers and, in some cases, pesticides (Romanchuk, 2008). Production technologies are being improved; the raw material base is expanding, which involves all new types of coal, peat, shale, peloids, production wastes (Orlov, 1997). Based on humic substances, active humic compounds are obtained, which find various applications (Timoshina, 2003).

Based on the variety of humic substances in the biosphere, humic compounds have found wide application in agriculture and issues of reclamation and detoxification of territories. Humic compounds can be divided into 3 groups: fertilizers, growth stimulants; land-improving (soil structure-formers, stimulators of microbiological activity); detoxifying agents (Oil industries..., 2018). Numerous studies have established a stimulating effect of humic substances, especially humic acids and their salts, on the growth and development of plants, increasing their resistance to unfavorable environmental factors, stimulating seed germination, increasing the productivity of cattle and poultry (Androkhanov *et al.*, 2004; Shchadov, 2007; Androkhanov and Kurachev, 2010).

2. THEORETICAL OVERVIEW:

Rashid (1985) devoted to developing methods for the chemical modification of peat humic acids (HA), the identification of the nature of the effect of modification on the structural parameters of HA. To enrich the soil with organic and mineral substances and restore the fertility of

degraded lands, a complex organic fertilizer has been created (Proydaikov *et al.*, 2005). Chitosan in the fertilizer has high growth-stimulating efficiency, combined with the antibacterial and antifungal activity of a systemic nature, which manifests itself in a prolonged manner and without harm to the environment (Prihodko *et al.*, 1980).

Fertilizer increases the bioproductivity of low-productive arid and permafrost soils, accelerates biochemical processes, and increases the number and activity of microbial communities, increasing the yield of forage crops, and sown grasses accelerate their ripening, and improves their qualitative composition (Klein *et al.*, 2007). To increase the level of growth-stimulating activity of humates, it is proposed to hydroxylate humified lignin – ligno-humate with reagents, which are aqueous solutions of iron sulfate and hydrogen peroxide (Radchevsky *et al.*, 2010). Tripoli treated with a solution of $K_3[Al(OH)_6]$ is used as an adsorption additive (Yarkova, 2007). Selenium-containing peat-zeolite fertilizers can increase the yield of corn, intensify biochemical and microbiological processes, increase efficiency, and solve environmental protection problems from pollution with chemical fertilizers.

A mixture of an organic nitrogen-containing fraction with a complex sorbent increases the efficiency of the fertilizer effect on soil fertility while simultaneously absorbing toxic components and radioactive elements from the soil with high selectivity. The complex sorbent is a solution of a hydroxo complex of aluminum with potassium $K_3[Al(OH)_6]$ with tripoli, neutralized with phosphoric acid. The organic nitrogen-containing fraction is peat treated with 50% potassium hydroxide solution and 30.7% H_3PO_4 solution. The following ingredients are introduced into the mixture: crushed dry peat, ammonium nitrate NH_4NO_3 , and trace elements, in the form of boric acid H_3BO_3 , magnesium sulfate $MgSO_4$ and acid ammonium molybdate, $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$ (Efimov, 1986). Slow-release fertilizer, environmentally friendly, can restore and improve soil structure (Inisheva, 2006).

A mixture of mineral components selected from the variety of carbamide, diammonium phosphate, ammonium nitrate, superphosphate, double superphosphate, ammonium sulfate, potassium chloride, potassium sulfate, potash, phosphate rock; mineral components containing trace elements: Mg, B, Mn, Zn, Cu, Ni, Co, Cr, Mo, and an organic component from several humic substances (HS) allows the formation of nanoscale complexes of HS with mineral components. Grained organomineral nanofertilizer

s have the properties of growth stimulants, prolonged action, and increased biological activity (Alekseeva *et al.*, 1999).

As an organomineral, the nutrient filler can be used humus, peat, biocompost, sapropel, clay, if necessary, balanced by the content of NPK mineral fertilizers and trace elements, and by the content of soluble humic substances with potassium humate and sodium. The moisture-accumulating compound ensures vegetation cultivation on sandy soils in the semi-desert zone to fix the sands (Sorokin *et al.*, 2007). As a result of intensive dispersion and homogenization of vermicompost in water, a homogeneous mixture with fine particles is formed, enriched with NPK nutrients, humic substances, and beneficial soil microflora in the form of a stable compound (Hoffmann and Hoffmann, 2007). Fertilizer provides an increase in soil fertility and environmental sustainability and increases yields (Gondek, 2009). The use of the bio-organomineral complex as a fertilizer provides an increase in soil fertility without damage due to the elimination of synthetic mineral fertilizers, as well as a decrease in yield losses from drought and an increase in the resistance of stress factors (Gladkowska and Kielbowicz, 2011). In this case, a decrease in the size of particles occurs, accompanied by a change in their chemical properties, an increase in reactivity, and an increase in solubility (Gao *et al.*, 2017).

Thus, in the work of Klein *et al.* (2007), the possibility of obtaining physiologically active humic substances from secondary coal raw materials using basidiomycetes was considered. In the study, G.V. Pirogovskaya *et al.* (1993) revealed the effectiveness of using such a combination of fertilizers. The tests were carried out on potatoes and root crops, i.e., with the crops in the first group by their responsiveness to mineral fertilizers (Naumova *et al.*, 2007; Panov *et al.*, 2010; Sorokin, 2015). In addition to the direct effect of KOH, the use of humic acids as a “matrix” for the introduction of microelements into the soil is of interest (Sorkina *et al.*, 2007; Sorokina *et al.*, 2008). All this can complicate the predictability of the effect of the compound used (Yakimenko, 2004).

3. MATERIALS AND METHODS:

More and more new humic organomineral fertilizers (NOF) have been registered for use in agriculture every year. While NOF from coal has its positive properties (high concentration), liquid fertilizers obtained from peat or biohumus

(vermicompost) have other valuable properties, such as biologically active substances: enzymes, amino acids, vitamins, organic acids, phytohormones. This study aimed to obtain liquid NOF from a combined raw material while preserving all the positive properties of its components. For this, two separate liquid NOFs were obtained from brown coal and vermicompost and mixed to obtain relatively high concentrations of humic acids and the presence of biologically active substances of vermicompost. Since vermicompost is produced in Kazakhstan by many companies, it was a local raw material, and peat was imported mainly from the Russian Federation. Prototypes of the compound were accumulated by combining vermicompost and brown coal.

Two solutions were prepared to obtain the proposed organomineral fertilizer: A – concentrated solution of coal sodium humate and B – extract of biohumus (vermicompost). To obtain solution A, 15 liters of tap water and 5 kg of crushed (hydromodule 1:3) brown coal powder with a particle size of less than 0.2 mm were loaded into a laboratory reactor with a stirrer, and the water was heated to a temperature of 70 °C with stirring. Then 300 g of NaOH, 100 g of carbamide, and 50 g of Trilon B were added, and the temperature was brought to 90 °C. With constant stirring, the extraction process is carried out for 2 hours at a temperature of 80-90 °C. The solution was filtered through a cloth, and a concentrate was obtained with a dry matter content of at least 25% in a volume of 15-16 liters of the first component of the liquid fertilizer. The compound was left overnight to cool and stabilize (Figure 1).

To obtain solution B (vermicompost extract), 15 liters of tap water were poured into a reactor with a stirrer, 5 kg of vermicompost was added and heated to 35-38 °C and stirred for 2 hours, infused for 10-12 hours for fermentation at a temperature of 20-30 °C. After fermentation, coarse filtration was carried out, as a result, 14-15 liters of the second component of liquid fertilizer are obtained (Figure 2). The first and second components were mixed (A + B) in a ratio of 1:1 to ensure a dry matter content of at least 10% in the final compound. The resulting mixture was aged for 3 days to complete the biochemical processes, then packed in containers for shipment to consumers. The resulting product contained dry matter 12-15%, ash content 3-5%, humic acid content not less 2.5%.

The obtained samples were studied with the use of a JSM-6490LV scanning electron microscope with INCA Energy dispersive

microanalysis and HKL-Basic structural analysis systems and IR spectroscopy on a Shimadzu IR Prestige-21 FTIR spectrometer with an attached Miracle total internal reflection (ATR) by Pike Technologies. The samples were pre-dried, the data on the dry residue are presented in Table 1. A field experiment to determine the effectiveness of NOF for grain and vegetable crops was carried out in the fields of the experimental farm "Svetlana" in the Zhambyl district of the Almaty region.

1. Cultivar: "Kazakhstanskaya 10" spring wheat. The new synthesized humic organomineral fertilizer of the following composition was used: nitrogen – 2.156 mg/l, phosphorus – 300 mg/l, potassium – 400 mg/l, dry residue – 8.65%. Soil type – grey earth. Precipitation in mm during the growing season (May-August): long-term average – 314 mm, in the year of testing – 459 mm. Air temperature for the growing season (May-August): long-term average – 18.86 °C, in the test year – 23.52 °C. Area: experimental plot 21 m², replication – 4 times. Plot location: randomized. Experimental design: 1) control without fertilizer s; 2) NOF 0.01%. Fertilizer consumption rate: NOF – 0.2 l/ha, spray material consumption – 200 l/ha. Fertilizer application method: soaking seeds before sowing, two-fold foliage spraying. Sprayer Type: backpack sprayer.

2. Cultivar: "Svetlanka" spring barley. The new synthesized humic organomineral fertilizer was used with the following composition: nitrogen – 2.5 mg/l, phosphorus – 309 mg/l, potassium – 410 mg/l, dry residue – 8.7%. Soil type – grey earth. Precipitation in mm during the growing season (May-August): long-term average – 314 mm, in the year of testing – 459 mm. Air temperature for the growing season (May-August): long-term average – 18.86 °C, in the test year – 23.52 °C. Area: experimental plot 21 m², replication – 4 times. Plot location: randomized. Experimental design: 1) control without fertilizer s; 2) NOF 0.01%. Fertilizer consumption rate: NOF – 0.2 l/ha, spray material consumption – 200 l/ha. Fertilizer application method: soaking seeds before sowing, two-fold foliage spraying. Sprayer Type: backpack sprayer.

3. Cultivar: "Red Giant" carrot. The new synthesized humic organomineral fertilizer of the following composition was used: nitrogen – 2.23 mg/l, phosphorus – 298 mg/l, potassium – 405 mg/l, dry residue – 9.0%. Soil type – grey earth. Precipitation in mm during the growing season (May-August): long-term average – 314 mm, in the year of testing – 459 mm. Air temperature for the growing season (May-August): long-term average

– 18.86°C, in the test year – 23.52 °C. Predecessor: cucumber. Soil preparation: in the fall, after harvesting the predecessor, disking, plowing to a depth of 20-22 cm. In the spring, cultivation was carried out to cover moisture and pre-sowing soil cultivation with AKSH-3.6 tillthmaker. Sowing seeds: the first decade of May with a combined sowing unit AKP-4, sowing pattern 62+8 cm. On ridges 18 cm high. Seeding rate: 2.5 kg/ha. Registration plot area: 14 m², replication - 4 times, the location of the variants was randomized. Experimental design: 1) control without fertilizer s (water); 2) NOF 0.01%. Consumption rate: NOF – 0.25-0.3 l/ha, spray material consumption – 250 l/ha. Phases of development of cultivated plants during the period of application of the compound: in the phase of 4-5 leaves of the culture and again 20 days after the first spraying. Method of application: spraying plants. Sprayer type: backpack sprayer. Accounting: accounting and observation of the growth and development of plants, the formation of the yield, and plant productivity were carried out according to generally accepted methods (Belik, 1992). Carrots yield accounting was carried out by weighing separately standard and non-standard products according to (GOST 1721-85, 1986). Tests to assess the effectiveness of the new organomineral fertilizer (NOF) on carrots ("Red Giant" cultivar) were carried out on the experimental field of the farm "Svetlana", Zhambyl district, Almaty region. The compound was applied twice: spraying of carrot plants in the phase of 4-5 leaves of the culture (06/15/2019) and again 20 days after the first treatment (05/07/2019).

4. Vegetable cultivar: white cabbage. The new synthesized humic organomineral fertilizer of the following composition was used: nitrogen – 2.054 mg/l, phosphorus – 302 mg / l, potassium – 410 mg/l, dry residue – 8.05%. Soil type – grey earth. Precipitation in mm during the growing season (May-August): long-term average – 314 mm, in the year of testing – 459 mm. Air temperature for the growing season (May-August): long-term average – 18.86 °C, in the test year – 23.52 °C. Soil and soil type: light-brown. Seedlings were grown in plastic cassettes with a cell volume of 65 cm³. Sowing cabbage seeds was carried out on April 25, 2019, to a depth of 1-1.5 cm. The cassettes were then placed in heated greenhouses on wooden blocks and covered with a translucent polyethylene film. When seedlings appeared, the film was removed. A week before planting, the seedlings were hardened by taking the cassettes with seedlings into the open ground. A day later, the seedlings were watered abundantly. Predecessor: cucumber. Soil

preparation: in the fall, after harvesting the predecessor, disking, plowing to a depth of 20-22 cm was carried out. In the spring, cultivation was carried out to cover moisture and pre-sowing soil cultivation with AKSH-3.6 tillthmaker. Registration plot area: 14 m², replication – 4-times, the location of the variants was randomized. Experimental design: 1) control without fertilizer s (water); 2) NOF 0.01%. Consumption rate: NOF – 0.25-0.3 l/ha, spray material consumption – 250 l/ha. Phases of development of cultivated plants during the period of application of the compound: the first treatment was spraying after the seedlings were fully established (10-15 days after planting), the second treatment was spraying 15-20 days after the first treatment, the third treatment was spraying in the phase of the mass setting of heads. Method of application: spraying plants. Sprayer type: backpack sprayer. Accounting: accounting and observation of the growth and development of plants, the formation of the yield, and plant productivity were carried out according to generally accepted methods (Belik, 1992). Accounting for cabbage yield was carried out by a continuous method, dividing it into standard and non-standard parts. Tests to assess the effectiveness of the new organomineral fertilizer (NOF) on cabbage crops were carried out on the experimental field of the "Svetlana" farm in the Zhambyl district of the Almaty region. The compound was applied three times: processing of cabbage seedlings (06/12/2019), in the phase of 6-7 true leaves of the culture (06/27/2019), and the phase of the mass setting of heads (21.07.2019).

5. Conifers: Scots pine, Tien Shan spruce. The new synthesized humic organomineral fertilizer was used with the following composition: nitrogen – 2.51 mg/l, phosphorus – 299 mg/l, potassium – 402 mg/l, dry residue – 8.8%. Soil type – grey earth. Precipitation in mm during the growing season (May-August): long-term average – 314 mm, in the year of testing – 459 mm. Air temperature for the growing season (May-August): long-term average – 18.86 °C, in the test year – 23.52 °C. Soil: grey earth. Planting time: May 2019. Agrometeorological indicators: air temperature – 30-32 °C, air humidity – 25-30%. Area: plants were planted on 10 acres (Figure 3)

Experimental design. Compound – NOF: 1) concentration – 0.01%, consumption rate of the compound – 0.5 l/ha; kg/ha, method of application – root feeding (watering of plants), number of treatments – 1; 2) concentration – 0.01%, consumption rate of the compound – 0.24 l/ha; kg/ha, method of application – top foliar dressing (spraying of plants), number of treatments – 2.

Terms of application of the compound: the first treatment was carried out – in the phase of active growth – June, the second – July, the third – August. Phases of plant development at the time of application of the compound: the phase of active plant growth. Method of application: watering and spraying of plants with the working solution of the compound. Surveys carried out: observations of seedlings during the experiments from May to September 2019; measurements of plant height before treatment and two weeks after the last treatment. Determination of the plant growth during the experiment. In the tested plots, the effectiveness of fertilization was tested – on 20 pine and spruce seedlings. The height of the plants was measured before applying the fertilizer. It was done with a ruler. After the treatments, 15 days later, the height of the plants was re-measured, and the growth of pine and spruce seedlings in height was calculated (by the addition method).

4. RESULTS AND DISCUSSION:

Chemical analysis was carried out, and the IR spectrum of the presented brown coal sample was taken. The results are presented under the code "1D" (code). A liquid suspension of coal sodium humate, the presented sample was filtered, then the residue and filtrate were analyzed separately. Before analysis, the filtrate was dried (100-105 °C), code "2A-F", residue under the code "2A-R". The initial coal sodium humate was separately dried (100-105 °C). The results are designated with the code "2A-ini." The rest of the samples, vermicompost extract (3), organomineral fertilizers (4), were studied according to Figure 4 above.

The chemical analysis results of the content of the main nutrients in the new liquid fertilizer and its components are presented in Table 2. The results of chemical analysis (elemental analysis) of the initial brown coal powder and after the processes of their separation on the Scanning electron microscope JSM-6490LV with energy dispersive microanalysis systems INCA Energy and HKL-Basic structural analysis are presented in Table 3. SEM data shows the contents of several useful macronutrients. However, given that the data are obtained only for a local point, we cannot extend this data to the weight of the sample having a colloidal system.

Figures 5-10 show the IR spectra of all obtained samples and components of the liquid fertilizer. The observed absorption bands at 1446

and 1389 cm⁻¹, caused by in-plane bending vibrations of the O-H group, interacting with the fan-shaped vibrations of C-H in the primary and secondary alcohol groups, and absorption bands in the so-called "polysaccharide" region (1170-950 cm⁻¹). The obtained data in terms of a unit of dry residue, we can expect a more active manifestation of the nutritional and stimulating properties of the combined liquid humic NOF. Fieldwork on the application of NOF on cereals, vegetables, forage crops, and seedlings (conifers and saxaul):

1. Cultivar: "Kazakhstanskaya 10" spring wheat. The results indicated that soaking of seeds before sowing and foliar feeding of wheat crops with a new organomineral fertilizer contributed to an increase in grain yield (Table 4). Two-fold foliar feeding of wheat with organic fertilizer s increased grain yield by 4.2 dt/ha. Fertilizer compatibility with pesticides: not studied. At the same time, there were no side effects from the studied fertilizer on vegetative wheat plants.

2. Cultivar: "Svetlanka" spring barley. According to the results, it was found that soaking seeds before sowing and foliar feeding of barley crops with a new organomineral fertilizer contributed to an increase in grain yield (Table 5). Two-fold foliar feeding of barley with organomineral fertilizer s increased the grain yield by 4.7 c/ha. Fertilizer compatibility with pesticides: not studied. Side effects of the fertilizer on vegetative barley plants: not observed.

3. Vegetable cultivar: "Red Giant" carrot. Biometric studies revealed that under the conditions of 2019 (in arid areas of Kazakhstan), as a result of the treatment of carrot crops with organic fertilizer, the length of the leaves in relation to the control variant increased by 7.4%, and the weight increased by 5.3%. The length of the root crop exceeded this indicator by 9.6%. Foliar treatments of carrot crops with NOF made it possible to obtain the highest yield – 47.6 t/ha. The yield increase relative to the control variant was 2.4 t/ha or 5.4%. Compatibility data: not available. Observed side effects: NOF does not have a phytotoxic effect on the culture, provided that the consumption rate of the compound and the concentration of the compound's working fluid are observed.

4. Vegetable cultivar: white cabbage. Biometric studies indicated that under the conditions of 2019, as a result of the treatment of cabbage crops with organic fertilizer, the number of leaves was 14 pieces, which exceeded the control specimen. The height of the plant was

38.9, the diameter of the head (18.7 cm) exceeded the control by 8.7%, and the rosette of leaves also exceeded the control by 5.3%. According to the results of field tests, it was found that foliar treatment of cabbage crops with organomineral fertilizer after complete survival of seedlings (10-15 days after planting) at a dose of 0.25-0.3 l/ha, 15-20 days after the first treatment (0.25-0.3 l/ha) and in the phase of the mass setting of heads of cabbage (0.25-0.3 l/ha) can significantly increase the yield of cabbage by 3.2 t/ha or 5.4% compared to the control. Compatibility data: not available. Observed side effects: NOF does not have a phytotoxic effect on the culture, provided that the consumption rate of the compound and the concentration of the compound's working fluid are observed.

5. Conifers: Scots pine, Tien Shan spruce. Table 6 shows data on the effectiveness of fertilization on pine and spruce seedlings used in spraying and watering plants.

It has been established that NOF is a highly effective fertilizer for the growth and development of seedlings of pine and spruce. A good growth effect was obtained with watering and spraying. This fertilization (application – watering the soil) stimulated the growth of spruce seedlings in comparison with the control by 152.2%, pine seedlings – 155.6%; in the variant with spruce – by 140.3% on average, in the variant with pine spraying – by 134.5% (Figures 11-12).

Combination with other compounds: not performed. No side effects in the form of phytotoxicity were observed. As a result of vegetation experiments, a high stimulating effect of NOF on the growth of pine and spruce seedlings was noted. The application of fertilizer (watering or spraying) provided an increase in plant height from 30 to 55% compared to the control. Based on the data obtained, the authors consider it possible to recommend NOF with a consumption rate of 0.5 kg/ha (irrigation with 0.001% solution), 0.24 kg/ha (spraying with 0.001% solution).

6. Tests of NOF efficiency on black saxaul (*Haloxylon aphyllum*). An agreement was concluded with the MPI "Bakanasskoe Forestry" to determine the effectiveness of the NOF on black saxaul. 1.0 hectares of land were allocated, seed consumption is about 80.0 kg, seed soaking method (duration: 3, 5, 7, 9 days). Sowing time October 2019; compound concentration 1.0 g per 10 l of solution (Figures 13-14).

5. CONCLUSIONS:

1. Based on the study of literature data on humic organomineral fertilizers, their high efficiency has been revealed for modern technologies to restore soil fertility and forests and reduce land degradation in arid, semi-arid, and desert regions increase crop yields. The prospects and high efficiency of brown coal, peat, and biohumus (vermicompost) for the production of humic organomineral fertilizers and their interconnection are shown.

2. The main methods (fertilizer application method; method of application; continuous method et al.) of physical and chemical analysis of humic compounds for studying their composition and structure were presented. The main methods of spectral analysis for establishing the structure of humic substances are presented; the most informative methods for studying the structure of target substances are nuclear magnetic resonance (NMR) methods on atomic nuclei of hydrogen (protium, ^1H) and carbon ^{13}C , as well as methods of IR spectroscopy.

3. A method for obtaining a new humic organomineral fertilizer from a combined raw material was developed: brown coal and vermicompost or peat. It was shown that the proposed method for obtaining liquid humic fertilizer allows combining in one compound the positive qualities of coal humates and liquid humic fertilizers based on biohumus or peat.

4. Laboratory and field tests of the effect of the new organomineral fertilizer on vegetables, grain crops, and some varieties of trees were carried out. It has been established that the use of the new fertilizer increases the yield of grain crops by 4.2-4.7 dt/ha and vegetable crops by 2.4-3.2 t/ha. It has been revealed that the use of this compound in the agrotechnical cultivation of coniferous trees provides an increase of 4.0-4.7 cm in comparison with the baseline variant.

6. REFERENCES:

1. Alekseeva, T. P., Perfiliev, V. D., and Krinitsyn, G. G. (1999). Complex organo-mineral fertilizers of prolonged action based on peat. *Chemistry of Vegetable Raw Materials*, 4, 53-59.
2. Androkhanov, V. A., Kulyapin, E. D., and Kurachev, V. M. (2004). *Soils of technogenic landscapes: Genesis and evolution*. Novosibirsk, Russian Federation: Publishing house of the SB RAS.

3. Androkhanov, V. A., and Kurachev, V. M. (2010). *Soil-ecological state of technogenic landscapes: Dynamics and assessment*. Novosibirsk, Russian Federation: Publishing house of the SB RAS.
4. Belik, B. F. (Ed.). (1992). *Methodology of experimental business in vegetable growing and melon growing*. Moscow, Russian Federation: Agropromizdat.
5. Budantsev, I. A. (1987). System of the genus *Dracocephalum* (Lamiaceae). *Botanical Journal*, 72(2), 260-267.
6. Dobrovolskiy, V. G. (Ed.). (2002). *Degradation and protection of soils*. Moscow, Russian Federation: Publishing house of Moscow State University.
7. Efimov, V. N. (1986). *Peat soils and their fertility*. Leningrad, Russian Federation: Agropromizdat.
8. Gaoa, Y., Heb, J., and Hea, Z. (2017). Effects of fulvic acid on growth performance and intestinal health of juvenile loach *Paramisgurnus dabryanus* (Sauvage). *Fish & Shellfish Immunology*, 62, 47-56.
9. Gladkowskaia, W., and Kielbowicza, G. (2011). Fatty acid composition of egg yolk phospholipid fractions following feed supplementation of Lohmann Brown hens with humic-fat preparations. *Food Chemistry*, 126(3), 1013-1018.
10. Golovkov, V. F., Koshelev, A. V., Afanasyev, V. V., Kozlov, G. V., and Eleev, Yu. A. (2017). Application of salts of humic acids in the reclamation of contaminated areas. *Chemistry and Technology of Organic Substances*, 2, 64-69.
11. Gondek, K. (2009). Zinc in Maize (*Zea mays* L.) and soils fertilized with sewage sludge and sewage sludge mixed with peat. *Polish Journal of Environmental Studies*, 18(3), 359-368.
12. GOST 1721-85. (1986). Fresh food garden carrot for supply and delivery. Specifications. Retrieved from: <http://docs.cntd.ru/document/gost-1721-85>.
13. Hoffmann, K., and Hoffmann, J. (2007). The utilization of peat, lignite and industrial wastes in the production of mineral-organic fertilizers. *American Journal of Agrocultural and Biological Sciences*, 2, 254-259.
14. Inisheva, L. I. (2006). Peat soils: their genesis and classification. *Soil Science*, 6, 781-786.
15. Klein, O. I., Stepanova, E. V., Kulikova, N. A., Landesman, E. O., Suprenok, V. V., and Koroleva, O. V. (2007). New approaches to the processing of industrial slimes using basidiomycetes: obtaining physiologically active humic-like substances. In: *Proceedings of the 4th All-Russian Conference – Humic substances in the biosphere*. Moscow, Russian Federation: Russian Academy of Sciences.
16. Lavrukov, M. Yu. (2012). *Influence of the organic-mineral fertilizer "Stimulife" and sodium humate on the growth and development of specimens of the snakehead (Dracocephalum L.) in the conditions of the Leningrad region*. St. Petersburg, Russian Federation: St. Petersburg State Agrarian University.
17. Naumova, G. V., Zhmakova, N. A., Ovchinnikova, T. F., and Makarova, N. L. (2007). New humic preparations of fungicidal and bactericidal action based on peat. In: *Proceedings of the 4th All-Russian Conference – Humic Substances in the Biosphere*. Moscow, Russian Federation: Russian Academy of Sciences.
18. Oil industries: Results of 2017 and short-term prospects (2018). Retrieved from: <https://nangs.org/analytics/analiticheskij-tsentr-pri-pravitelstve-rf-neftyanaya-otrasl-itogi-2017-goda-i-kratkosrochnye-perspektivy-yanvar-2018-pdf>.
19. Orlov, D. S. (1990). *Humus acids of soils and general theory of humification*. Moscow, Russian Federation: Publishing house of Moscow State University.
20. Orlov, D. S. (1997). Humic substances in the biosphere. *Soros Educational Journal*, 2, 56-63.
21. Panov, A. N., Lycheva, T. V., and Belousov, N. M. (2010). Absorption capacity of high-moor peat for water, mineral and organic components of effluents. *Bulletin of the Samara Scientific Center of the Russian Academy of Sciences*, 12(1(4)), 1020-1022.
22. Pirogovskaya, G. V., Bogomaz, I. A., Shagieva, E. I., Kovalenok, M. F., Kuleshova, S. I., Naumova, G. V., and Raitsina, G. I. (1993). The use of humic preparations in the production of mineral fertilizers. In: *Collection of works "Humic substances in the biosphere" (pp. 166-174)*. Moscow, Russian Federation: Nauka.
23. Popov, A. I. (2004). *Humic substances*:

- properties, structure, education. St. Petersburg, Russian Federation: Publishing house of St. Petersburg. University.
24. Prikhodko, L. A., Gorovaya, A. I., Globa, M. P., and Kulik, A. F. (1980). The effectiveness of humic and mineral fertilizers in the cultivation of crops against the background of increased doses of atrazine. In: *Humic fertilizers. Theory and practice of their application* (pp. 243-253). Dnepropetrovsk, Ukraine: Publishing House of the Agricultural Institute.
 25. Proydakov, A. G., Polubentsev, A. V., and Kuznetsova, L. A. (2005). Humic acids from brown coal, mechanically processed in the presence of air. *Chemistry for Sustainable Development*, 13, 641-647.
 26. Radchevsky, P. P., Moroz, N. B., and Troshin, L. P. (2010). Innovations of viticulture in Russia. Application of biologically active substances of humate in the cultivation of grape planting material. *Scientific Journal of KubSAU*, 60, 1-17.
 27. Rashid, M. (1985). *Geochemistry of marine humic compounds*. Oxford, UK: Springer-Verlag.
 28. Review of the market for humic fertilizers in Russia and the world. (2018). Retrieved from: <https://www.infomine.ru>.
 29. Romanchuk, N. I. (2008). *Influence of organomineral fertilisation based on hydrolytic ligin on the fertility of sod-podzolic soils and the productivity of the main agrocenochs of the Middle taiga*. Barnaul, Russian Federation: Syktyvkar State University.
 30. Savicheva, O. G., and Inisheva, L. I. (2003). Biochemical activity of peats of different botanical composition. *Chemistry of Vegetable Raw Materials*, 3, 41-50.
 31. Semenov, V. M., and Kogut, B. M. (2013). I. V. Tyurin and current trends in the development of the theory of soil organic matter in the 21st century. In: *Materials of the International Scientific Conference* (pp. 9-15). Kazan, Russian Federation: Publishing house "Otechestvo".
 32. Shchadov, V. M. (2007). *Complex processing of coals and increasing the efficiency of their use*. Moscow, Russian Federation: NTK "Track".
 33. Shchetkin, B. N. (2004). *Methodology of ecological safe processing of poultry manure into organic fertilizers and creation of devices for assessing the quality of their introduction into the soil during the cultivation of agricultural crops*. St. Petersburg, Russian Federation: St. Petersburg State Agrarian University.
 34. Solovev, M. A. (2013). *Influence of organomineral fertilizers and growth regulators on the productivity of spring barley varieties in the zone of insufficient moisturization of the Rostov region*. Stavropol, Russian Federation: Azov-Black Sea State Agroengineering Academy.
 35. Sorkina, T. A., Kulikova, N. A., Filippova, O. I., Lebedeva, G. F., and Perminova, I. V. (2007). Biological activity of iron humate in relation to wheat seedlings. In: *Proceedings of the 4th All-Russian Conference – Humic Substances in the Biosphere*. Moscow, Russian Federation: Russian Academy of Sciences.
 36. Sorokin, I. B., Titov, E. V., and Glagoliev, V. P. (2007). Long aftereffect of lowland peat. *Bulletin of the Tomsk State University*, 3, 235-236.
 37. Sorokin, N. T. (2015). On the development of scientific and practical cooperation at the international level in the field of agriculture. *Section I Materials of the 9th International Scientific Conference of Central and Eastern Europe (CEEAgEng): Collection of Scientific Papers*, 87, 11-17.
 38. Sorokina, T., Kulikova, N., Necvetay, A., Fillipova, O., Lebedeva, G., and Perminova, I. (2008). Synthesis and use of iron humates for correction of iron deficiency chlorosis in higher plants. In: *From Molecular Understanding to Innovative Applications of Humic Substances; Proceedings of the 14th International Meeting of the International Humic Substances Society*. Moscow, Russian Federation: Nauka.
 39. Stevenson, F. J. (1994). *Humus chemistry: genesis, composition, reactions*. New York, USA: John Wiley & Sons.
 40. Timoshina, N. A. (2003). *Influence of new organomineral fertilizers on the growth and development, productivity and quality of potatoes in sod-podzolic sandy loam soil*. Moscow, Russian Federation: All-Russian Scientific Research Institute of Potato Economy named after A. G. Lorkh.
 41. Yakimenko, O. S. (2004). Industrial humic preparations: prospects and limitations of use. In: *Materials of the 2nd International Scientific and Practical Conference "Earthworms and*

Soil Fertility” (pp. 249-252). Vladimir, Russian Federation: Russian Academy of Agricultural Sciences.

42. Yarkova, T. A. (2007). *Chemical modification of the structure of peat humic acids with the purpose of increasing their biological and sorption activity*. Moscow, Russian Federation: Novomoskovsk Institute of the Russian University of Chemical Technology

named after D.I. Mendeleev.

43. Zharebtsov, S. I. (1998). Non-fuel use of Itatsky brown coal. In: *Experience and prospects of science-intensive technologies in the coal industry of Kuzbass: Materials of a scientific and technical conference* (pp. 258-262). Kemerovo, Russian Federation: Institute of Coal and Coal Chemistry SB RAS.

Table 1. Dry residues of liquid samples of components and final NOF compound

No.	Liquid fertilizer and its components	Dry residue, %
1	Coal sodium humate	35.1
2	Vermicompost extract	1.1
3	Organomineral fertilizer	8.65

Table 2. Analysis of the content of the main nutrients in the NOF and in its components

No.	Specimens	Nitrogen, mg/l	Phosphorus, mg/l	Potassium, mg/l
1	Brown coal	0.616	0.040	-
2	Coal sodium humate	5.628	850	500
3	Vermicompost extract	1.960	1000	1500
4	Organomineral fertilizer	2.156	300	400

Table 3. Results of chem. analysis (elemental analysis) of the initial brown coal powder and after the processes of their separation on the device “Scanning electron microscope JSM-6490LV” with the systems of energy-dispersive microanalysis INCA Energy and structural analysis HKL-Basic

Code	% by weight									
	1D	2A-ini.	2A-R	2A-F	3B-ini.	3B-R	3B-F	4S-ini.	4C-R	4C-F
C	53.30	49.52	48.5	49.3	32.95	40.76	27.05	47.82	52.10	28.60
O	33.22	35.23	35.6	36.2	38.83	42.46	35.67	35.66	33.83	42.13
Mg	0.06	2.44	2.79	5.96	1.81	0.43	4.15	3.72	1.31	17.79
Al	2.86	0.05	0.04	1.59	1.05	1.14	0.66	0.08	0.12	0.08
Si	9.76	2.75	2.90	5.37	1.08	1.59	0.39	2.25	2.99	1.47
S	0.14	9.20	9.29	0.04	4.62	5.79	0.22	8.92	8.70	3.82
Cl	0.06	0.15	0.16	0.22	1.07	1.18	2.50	0.25	0.10	0.34
K	0.12	0.03	0.05	0.29	1.46	0.34	6.02	0.15	0.30	0.97
Ca	0.13	0.09	0.12	0.10	1.90	1.48	22.29	0.47	0.16	1.27
Ti	0.29	0.12	0.14	0.50	10.83	3.73	-	0.34	0.29	1.63
Fe	0.06	0.29	0.30	0.16	3.53	0.06	-	0.22	0.09	1.57

Note: 1D – initial brown coal powder; 2A-ini. – initial coal sodium humate (100-105 °C); 2A-R – coal sodium humate residue; 2A-F – coal sodium humate filtrate; 3B-ini. – initial extract of vermicompost (100-105 °C); 3B-R – vermicompost extract residue; 3B-F – vermicompost extract filtrate; 4C-ini. – initial organomineral fertilizer (100-105 °C); 4C-R – organomineral fertilizer residue; 4C-F – organomineral fertilizer filtrate.

Table 4. Influence of NOF foliar dressing on grain yield

Variants	Yield, dt/ha	Gain, dt/ha
1. Control without fertilization	32.0	-
2. New organomineral fertilizer (NOF)	36.2	4.2

Table 5. Influence of NOF foliar dressing on grain yield

Variants	Yield, dt/ha	Gain, dt/ha
1. Control without fertilizati	29.4	-
2. New ganomineral fertilizer (NOF)	34.1	4.7

Table 6. The efficiency of NOF on spruce seedlings

Variant	Method of application	Consumption rate of the compound, l/ha; kg/ha	Multiplicity of processing	Replication	Height gain	Increase in height gain relative to control, %
NOF	watering		3	1	4.7	151.6
				2	4.6	148.4
				3	4.7	151.6

Brown coal

Concentrated coal sodium humate solution

Figure 1. Component A

Vermicompost

Vermicompost extract

Figure 2. Component B

Figure 3. General view of the nursery garden

Figure 4. Methodology of processes and results of chemical analysis

Figure 5. Overlay of IR spectra of coal sodium humate samples (2A - ini., residue, filtrate)

Figure 6. Overlay of IR spectra of vermicompost extract samples (3B - ini., residue, filtrate)

Figure 7. Overlay of IR spectra of organomineral fertilizer samples (4C - ini., residue, filtrate)

Figure 8. Overlay of IR spectra of samples (2A, 3B, 4C - initial)

Figure 9. Overlay of IR spectra of samples (2A, 3B, 4C - filtrate)

Figure 10. Overlay of IR spectra of samples (2A, 3B, 4C - residue)

NOF Control

NOF Control

Figure 11. NOF testing on conifers of FE "Green Helper & Carg "

NOF Control

NOF Control

Figure 12. NOF testing on conifers of FE “Green Helper & Cargo”

Figure 13. Sowing saxaul in the fields of MPI “Bakanasskoe Forestry”

Figure 14. Laying of LEU-treated saxaul (*Haloxylon aphyllum*) seeds