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THE STUDY OF THE PHYSICO-CHEMICAL PROPERTIES OF MODIFIED ORGANIC FERTILIZER AND INVESTIGATION OF THEIR INFLUENCE TO THE PROCESSES OF GROWTH AND DEVELOPMENT OF HEDGE SEEDLINGS

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Abstract

The main objective of the study is to develop an environmentally friendly technology and organize the production of biological products, as well as to conduct laboratory and field tests to determine the effectiveness of the effect of chelate complex biological products based on potassium humate, enriched with NPK and Mo. A description of the technology for obtaining potassium humate is shown, as well as physical and chemical characteristics, chemical composition and mass fraction of humic acids in terms of dry matter. The article presents the results of field trials on the effect of growth-stimulating organic fertilizer on hedge seedlings (elm and spirea) on the territory of the Astana Botanical Garden (Astana). Today, landscaping plays an important role in the development of any city. When choosing plants for hedges, it is necessary to take into account a number of indicators, such as unpretentiousness, stress resistance, adaptation to environmental conditions, etc. An important element in maintaining these factors is the use of additional feeding, in the form of biological preparations based on potassium humate. As a result of vegetation experiments, an effective effect of modified organic biopreparations (MOB with NPK, MOB with Mo) was established, in which a stimulating effect on the growth of new shoots and a significant increase in the biomass of elm seedlings was observed. Biological preparations also had a beneficial effect on spirea hedge bushes, which manifested itself in a significant increase in plant height.

Keywords: humate; fertilizer; modified; biopreparation; hedge; soil; humic substances.

Introduction

Humic substances (HS) are a macrocomponent of the organic matter of soil and water ecosystems, as well as solid fossil fuels (coal, peat shale, sapropel). Humic acids (HA) are characterized by a general type of composition and structure. However, depending on the initial composition of the coal, the method of isolation and storage, the indicators of their composition and structure may vary.

The physiological activity of HA is largely due to the content of quinoid groups and phenolic hydroxides [1]. The presence in the macromolecules of oxidized coals and humic acids of an aromatic framework highly substituted with functional groups, such as carboxyl, phenolic, quinoid, carbonyl, and others, determines their ability to enter into an ion exchange reaction and the possibility of using them as active substances [2,3]. Also, humic substances (HS), in addition to being a source of C and N for microorganisms and plants, play an important role in the chemical and physical properties of the soil, mainly due to their high complexing ability with respect to metal ions, which is a consequence of the presence of oxygen-containing functional groups in their structure associated with their high specific surface area [4-6]. It is known that humic acid coals are weakly acidic cation exchangers. When nitrogen atoms are more prone to donor-acceptor bonds with metal ions than oxygen atoms are introduced into these carbons, the latter become more complex and polyampholytic [7].

Organic substances of coal, peat and humic acids included in them largely determine soil fertility, being sources of physiologically active substances. Humates accelerate metabolic and biochemical processes in the soil. They are obtained from brown coal, soil, lignosulfonates and peat [8].

Methods and materials

LLP "Institute of Coal Chemistry and Technology" together with LLP "Research and Production Association "KazTechCoal" developed and introduced into production an innovative technology for the production of organomineral fertilizer "Kazuglegumus" from domestic oxidized brown coal (highly concentrated liquid solution). In the process of preparing humic preparations, a rotary-pulsation apparatus is used, then an ultrasonic reactor is used to bring the size of coal particles (19.2 nm - 3.57 μm) to a nano- and micro-size state. In both cases, air is supplied to oxidize the coal and increase the content of humic substances. In the process of dispersion and ultrasonic exposure, the temperature of the mixture reached no more than 50-55°C, which is acceptable for the oxidation of coal with atmospheric oxygen and the extraction of the formed salts of humic and fulvic acids, as well as amino acids. In the process of oxidation with air, a micellar dispersed system is formed - a solution of humic substances with a particle size of less than a micrometer.

As a feedstock for the production of humate, oxidized brown coal from the Sarykol deposit was used, which was previously crushed to a particle size of less than 0.5 mm and had the following characteristics (wt.%): A^d 66.09; W^r 5.73; V^d 17.78; S_t^d 0.71; C_t^d 21,01; H_t^d 1,68; N_t^d 2.09; Na 0.61; Al 0.89; K 0.58; Ca 0.31; Ti 0.22; Fe 1.11; Zr 0.08. The particle size of the coal was: 2.95 microns - 10%, 63.8 microns - 50%, 452 microns - 90%. X-ray phase composition of the sample contains: halloysite ($Al_2Si_2O_5(O\ H)_4$), silicon oxide (SiO_2), albite $Na(AlSi_3O_8)$. The output of humic substances from brown coal was 56%. Next, the physicochemical properties of the resulting fraction were studied [9].

Humidity, ash content and volatility of the samples were determined on a thermogravimetric analyzer "Thermoster Eltra" (according to ASTM D7582-12). The mass fraction of humic acids (in terms of dry matter) - 56%, was determined according to the state standard 9517-94 [10-13]. To determine the quality of raw materials and the content of humic substances, the following instruments were used: IR-Fourier spectrometer (NicoletiS 10) (USA), elemental analyzer CHNS / O (Perkin Elmer) (Germany), particle size analyzer (Mastersizer 3000) (Great Britain).

The main indicators according to international standards are the content of substances such as carbon, hydrogen, nitrogen, sulfur and oxygen in the humate. The saturation of the fraction with these components determines the quality and value of humic substances. The main elements are always present, regardless of their origin, country or continent [14].

Table 1 presents data on the elemental composition of isolated humic substances from oxidized brown coal according to the method described above using a 3% KOH solution.

Table 1 – Average content of carbon (C), hydrogen (H), nitrogen (N), sulfur (S) and oxygen (O)

Content, %					Atomic ratio				Chemical formula
C	H	N	S	O	C/H	C/O	C/N	C/S	
22.205 ±0,1	1.9065±0,3	3.5±0,3	0.6775±0,1	20.4435±0,1	0.979	0.447	7.411	87.49	$C_{95}H_{95}O_{65}N_{15}S_1$
Atomic fraction					Percentage				
1.85	1.89	0.25	0.02	1.28	C/H	C/O	C/N	C/S	

The resulting humic substance was a dark brown liquid with a density of 1,0416 г/см^3, the dynamic viscosity of the resulting sample was 1,84*10^{-3} Pa*s. The humic fraction is non-toxic, combustible, belongs to the 4th hazard class.

The particle size of HS after the rotational cavitation and ultrasonic apparatus ranged from 19.2 nm to 3.57 μm (Fig. 1).

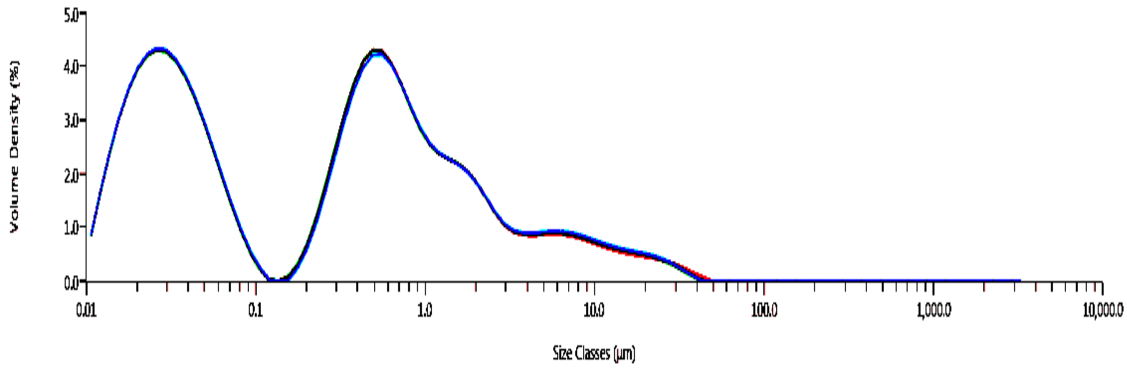


Figure 1 – Size distribution of HS particles

The IR spectrum (Figure 2) of the purified humate sample shows wide peaks in the region of 3262 cm^{-1}, which were attributed to the stretching vibrations of the −OH, −COOH bonds.

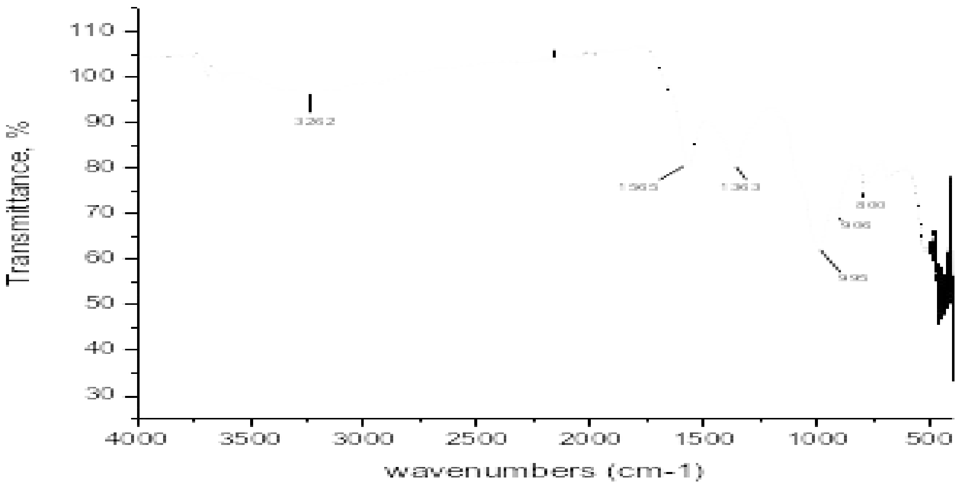


Figure 2 – IR spectrum of potassium humate

Bending vibrations of the methyl and methylene groups at 1363 cm^{-1} and stretching vibrations of the C-O bond in alcohols, phenols, and others also confirm the presence of these functional groups.

Peaks in the range 1000-800 cm^{-1} are responsible for the strong stretching of the C-O group. The peaks at 1565, 1363, and 995 cm^{-1} were assigned to the stretching vibrations of the −COO and −CH, −OH, etc. groups. Accordingly, this indicates rich oxygen-containing functional groups on the potassium humate surface, which promotes the complexation or adsorption reaction.

An increase in the intensity of the peak with a frequency of 1565 cm^{-1} makes it possible to attribute this peak to vibrations of the carboxylate ion. A pronounced maximum with a frequency of 1363 cm^{-1}, apparently, shows C-O vibrations associated with the potassium ion by ion-ion interaction. In the region of 995 cm^{-1} in the spectrum of potassium humate, a band is clearly manifested, which is also present in the last spectrum and is related to the bending vibrations of alcohol hydroxyls.

For comparison, the reference sample of humic acid isolated from coal has the highest absorption capacity at 3400 cm^{-1}. Weaker absorption at 2000 cm^{-1} indicates the presence of C–H stretching. A loop with a sharp edge in the 1577 cm^{-1} band indicates the contribution of C =. Stretching C (aromatic ring) and 1375 cm^{-1} shows a characteristic band of COO groups. The sharp-edged loop observed at 1571 cm^{-1} indicates the presence of N-H (multiple transamide dimers). The weakest peak at 1123 cm^{-1}, 1000 cm^{-1} and 747 cm^{-1} indicates amines (RHN_2) of a different order. At 1123 cm^{-1}, C–C–O stretching indicates the presence of ester functional groups. The peak at 1000 cm^{-1} shows the stretching of esters (C O-C) [4]. Compared to the reference sample, the isolated sample is less enriched in oxygen and hydrogen, and the presence of a large number of groups contributes to greater reactivity.

Our data are consistent with similar studies. For comparison, humic acid isolated from the soil shows a wide absorption centered in the regions of 3360, 1406, 1233, and 1060 cm^{-1} [15].

Fertilizer "Kazuglegumus" is intended for all types of crops, processing can be carried out on any type of soil and is recommended for use at all stages of plant growth and development - from pre-sowing treatment of seeds and planting material, root and foliar top dressing during the growing season before and after harvest.

The active use of humic substances in agronomy is due to their positive effect on the condition of the soil, as well as on the growth and development of plants. This is explained by the fact that humic acid is a source of macro- and microelements entering the soil, which are necessary for the growth and development of plants. It was experimentally shown that in the presence of humic substances, the permeability of cell membranes is higher, which contributes to an increase in the supply of nitrogen, phosphorus, potassium, iron, and plant resistance to a wide range of adverse factors (pesticides, frosts, droughts, high salt content in the soil) [16]. It has also been proven that humic substances increase the intensity of photosynthesis and respiration, enhance protein and phosphorus metabolism in plants. In this regard, the scientists of LLP “Institute of Coal Chemistry and Technology” obtained modified organic biopreparations (MOB) based on the Kazuglegumus organic fertilizer with the addition of NPK components (nitrogen, phosphorus, potassium) and molybdenum. A study was also conducted on the growth-stimulating effect of humic fertilizer on elm and spirea hedge seedlings on the territory of the Astana Botanical Garden. Modified fertilizer with NPK stimulate the growth and development of organs in plants, enhance the absorption of nutrients, increase metabolism, reduce stress in plants under adverse environmental conditions. Fertilizers for foliar and root top dressing are used prophylactically in all phases of the development of the plant organism (the exclusion of flowering) and, first of all, it is necessary to use drugs under stress. Phosphorus contributes to the proper formation of roots, and also increases resistance to various diseases. With a lack of nitrogen, the plant may stop growing, and the number of inflorescences will decrease. Plants with potassium deficiency are less resistant to drought, waterlogging, high and low temperatures.

Modified fertilizer with Mo is involved in the metabolism of higher plants and microorganisms. Molybdenum is involved in the process of converting mineral phosphorus into organic, prevents the occurrence of diseases, strengthens the health of plants, promoting development. The element is part of the chloroplast and is considered a fundamental factor in the process of photosynthesis. This element is included in their composition and activates enzymes such as nitratereductase, with the participation of which the process of reduction of nitrates to ammonia takes place, and also catalyzes the processes of reduction of molecular nitrogen by nitrogen-fixing free-living and nodule bacteria.

In this regard, we conducted tests on the open ground of the Astana Botanical Garden to determine the effect of chelate fertilizer complexes based on potassium humate enriched with NPK and Mo components on hedge bioobjects (elm and spirea).

Irrigation of the soil with preparations of Potassium Humate + NPK, Potassium Humate + Mo (2 ml of the preparation per 10 l of water) was carried out on a hedge: *Ulmus parvifolia* (Figure 3) and *Spiraea japonica* (Figure 4).

Figure 3 –Elm (*Ulmus parvifolia*)

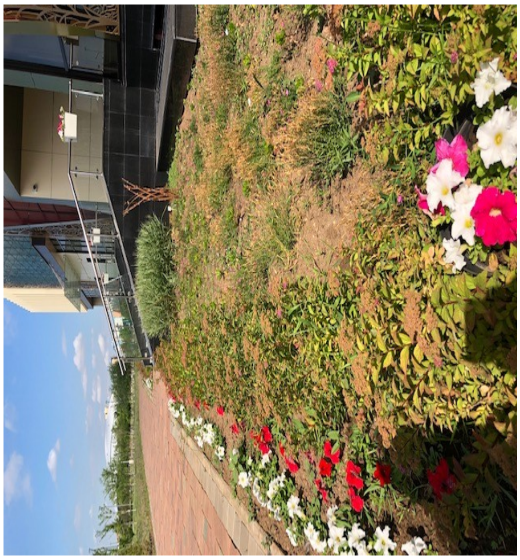


Figure 4 – Spirea (*Spiraea japonica*)

As shown in Figures 3, 4, the studied plants needed additional feeding in the form of fertilizers. Bioobjects lacked splendor and leaf surface, and the stems were marked by brittleness and dryness. In this regard, preparations based on potassium humate enriched with NPK and Mo elements were selected.

Results

The study of the effect of MOB with NPK, MOB with Mo was carried out by irrigation method, carried out every 15 days. The total period of the experiment was 45 days.

Prior to testing, the seedlings had bare branches and a low number of shoots. Spirea bushes had a dim pigment of the leaves, and their slow growth was also observed. According to the results of the experiment, we noted a favorable effect of MOB on the growth and development of biological objects.

Discussion

According to the data presented in Figure 5, as well as in tables 2,3, one can observe the favorable effect of humic fertilizer on the growth of new shoots of elm (*Ulmus parvifolia*) seedlings, expressed as a percentage. High rates were noted in the experimental groups of MOB with NPK (23.8%) and MOB with Mo 1 (31.8%).

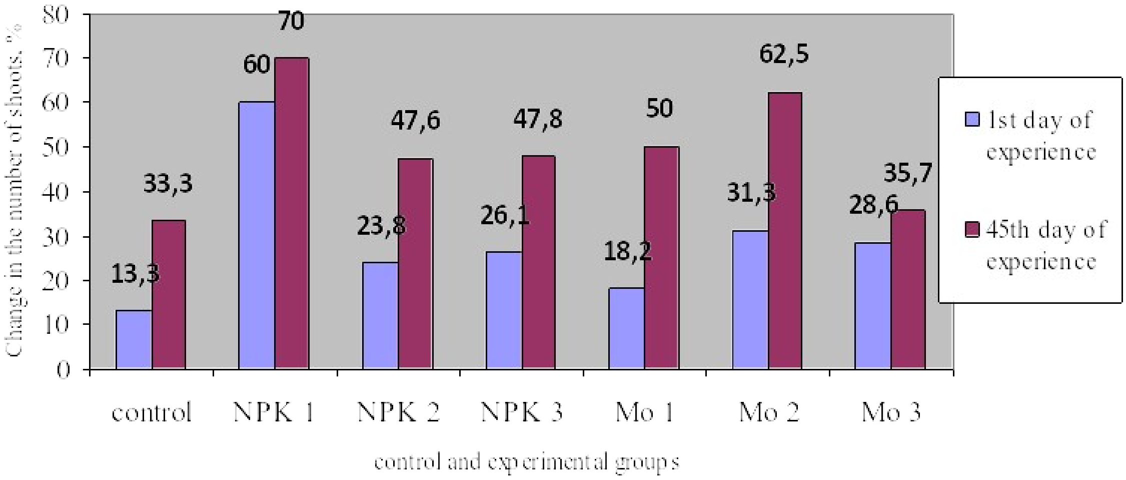


Figure 5 – Comparative characteristics of the effectiveness of MOB with NPK and MOB with Mo on the growth of new shoots (*Ulmus parvifolia*) as a percentage for the entire period of the experiment (45 days)

Table 2 – Data on the use of preparation MOB with NPK, MOB with Mo on the hedge on the first experimental day (*Spiraea japonica*)

Group	Number of bushes	Maximum height, cm	Minimum height, cm
MOB with NPK			
Control 1	15	50	19
NPK 1	13	59	30
Control 2	15	50	19
NPK 2	15	45	15
Control 3	10	40	28
NPK 3	12	49	36
MOB with Mo			
Control 1	15	47	29
Mo 1	11	42	30
Control 2	10	55	30
Mo 2	13	35	58
Control 3	10	40	40
Mo 3	10	35	20

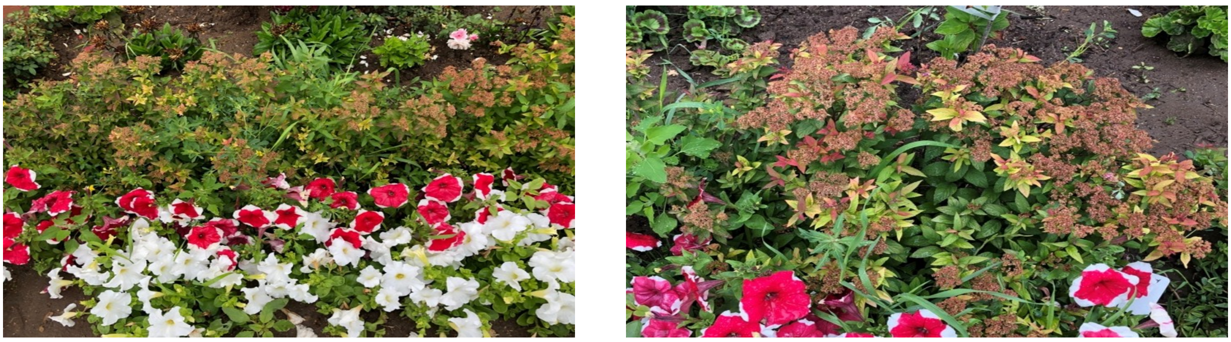
Table 3 – Data on the use of drugs MOB with NPK, MOB with Mo on hedge (*Spiraea japonica*) 45 experimental day

Group	Number of bushes	Maximum height, cm	Minimum height, cm
MOB with NPK			
Control 1	15	50	19

NPK 1	13	59	30
Control 2	15	50	19
NPK 2	15	47	15
Control 3	10	44	30
NPK 3	12	49	36
MOB with Mo			
Control 1	15	47	29
Mo1	11	48	30
Control 2	10	58	30
Mo 2	13	58	37
Control 3	10	45	45
Mo 3	10	40	25

a b

Figure 6 – The results of the application of fertilizers on hedges (*Ulmus parvifolia*): a) before the experiment; b) after the experiment



a b

Figure 7 –The results of the use of fertilizers on hedges (*Spiraea japonica*): (a) before the experiment (b) after the experiment

During the period of the experiment before and after the experiment (Figure 6.7), changes were noted that manifested themselves as a positive result. Thus, the data obtained indicate the effectiveness and prospects of using modified organic fertilizers based on potassium humate.

Conclusion

As a result of the studies, the effect of the effectiveness of preparations of MOB with NPK and MOB with Mo on the increase in the number of new shoots and the color intensity of the leaves of elm seedlings was shown. We noted the active growth of spirea bushes, as well as the foliage of plants acquired a bright color, the number of flowers increased and the stems were wiry.

According to the results of the application of MOB with NPK and MOB with Mo on spirea bushes, their effective effect was also noted, which was expressed in an increase in plant height growth. The best result was found in the second experimental group of MRD with Mo, where the maximum growth height increased by 23 cm.

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МОДИФИКАЦИЯЛАНҒАН ОРГАНИКАЛЫҚ ТЫҢАЙТҚЫШТАРДЫҢ ФИЗИКА-ХИМИЯЛЫҚ ҚАСИЕТТЕРІН ЗЕРТТЕУ ЖӘНЕ ОЛАРДЫҢ БҰТАДАН ЖАСАЛҒАН ҚОРШАУ КӨШЕТТЕРІНІҢ ӨСУ ЖӘНЕ ДАМУ ПРОЦЕСТЕРІНЕ ӘСЕРІН ЗЕРТТЕУ

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Түйін

Зерттеудің негізгі мақсаты экологиялық таза технологияны әзірлеу және биопрепараттар өндіруді ұйымдастыру, сонымен қатар NPK-мен және Mo байытылған калий гуматы негізіндегі хелаттық кешенді биопрепараттардың әсерінің тиімділігін анықтау үшін зертханалық және далалық сынақтар жүргізу. Калий гуматын алу технологиясының сипаттамасы, сондай-ақ физикалық-химиялық сипаттамалары, химиялық құрамы және құрғақ зат бойынша гумин қышқылдарының массалық үлесі көрсетілген. Мақалада Астана ботаникалық бағы (Астана қ.) аумағындағы өсуді ынталандыратын органикалық тыңайтқыштың қоршау көшеттеріне (қарағаш және спирея) әсері бойынша далалық сынақтардың нәтижелері келтірілген. Бүгінде кез келген қаланың дамуында көгалдандыру маңызды рөл атқарады. Қоршау көшеттеріне арналған өсімдіктерді таңдағанда, қарапайымдылық, күйзеліске төзімділік, қоршаған орта жағдайларына бейімделу және т.б. сияқты бірқатар көрсеткіштерді ескеру қажет. Аталған факторларды сақтаудың маңызды элементі ретінде калий гуматы негізіндегі биопрепараттарды қосымша азықтандыруда пайдалану болып табылады. Вегетациялық тәжірибелер жүргізу нәтижесінде

модификацияланған биопрепараттардың (NPK-мен МОБ, Мо-мен МОБ) тиімді әсері анықталды, онда жаңа өскіндердің өсуіне ынталандырушы әсері және қарағаш көшеттерінің биомассасының айтарлықтай өсуі байқалды. Биопрепараттар сонымен қатар өсімдік биіктігінің айтарлықтай өсуімен көрінетін спиреа бұталарына пайдалы әсер етті.

Кілт сөздер: гумат; тыңайтқыш; модификациялау; қоршау көшеттері; топырақ; гуминдік заттар.

ИЗУЧЕНИЕ ФИЗИКО-ХИМИЧЕСКИХ СВОЙСТВ МОДИФИЦИРОВАННОГО ОРГАНИЧЕСКОГО УДОБРЕНИЯ И ИССЛЕДОВАНИЯ ИХ ВЛИЯНИЯ НА ПРОЦЕССЫ РОСТА И РАЗВИТИЯ САЖЕНЦЕВ ЖИВОЙ ИЗГОРОДИ

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Аннотация

Основной задачей исследования является разработка экологически чистой технологии и организация получения биопрепаратов, а также проведение лабораторных и полевых испытаний по определению эффективности влияния хелатных комплексных биопрепаратов на основе гумата калия, обогащенных NPK и Mo. Показано описание технологии получения гумата калия, а также приведены физико-химические характеристики, химический состав и массовая доля гуминовых кислот в перерасчете на сухое вещество. В статье приведены результаты, проведенных полевых испытаний, по влиянию ростостимулирующего органического удобрения на саженцы живой изгороди (вяз и спирея) на территории Астанинского ботанического сада (г. Астана). На сегодняшний день озеленение играет немаловажную роль в развитии любого города. При выборе растений для живой изгороди необходимо учитывать ряд показателей, таких как неприхотливость, стрессоустойчивость, адаптация к условиям окружающей среды и пр. Важным элементом в поддержании данных факторов является применение дополнительной подкормки, в виде биопрепаратов на основе гумата калия. В результате проведения вегетационных опытов установлено эффективное влияние модифицированных биопрепаратов (МОБ с NPK, МОБ с Mo), при котором наблюдалось стимулирующее действие на рост новых побегов и значительное увеличение биомассы саженцев вязи. Благоприятное воздействие биопрепараты также оказали на кусты живой изгороди спиреи, проявившиеся в значительном увеличении высоты растений.

Ключевые слова: гумат; удобрение; модифицирование; биопрепарат; живая изгородь; почвогрунт; гуминовые вещества.