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ВЕСТНИК

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН

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I.A. Dobrosmyslova[1], A.A. Sazanova[1], V.G. Semenov[2], Zh.Tuleubayev[3], Z.T. Yesimbekova[4], G. Ziyaeva[3]

[1]Chuvash State University named after I.N. Ulyanov, Cheboksary, Chuvash Republic, Russia;
[2]Chuvash State Agricultural Academy, Cheboksary, Chuvash Republic, Russia;
[3]M.Kh. Dulati Taraz State University, Taraz, Republic of Kazakhstan;
[4]Kazakh Scientific Research Institute of Animal Breeding and Fodder Production, Almaty, Republic of Kazakhstan.
E-mail: weda9@mail.ru, cheiz96@rambler.ru, semenov_v.g@list.ru, tuleubayev51@mail.ru, zina_jk@mail.ru, gulnarzia-71@mail.ru

PLANT GROWTH AND BIOLOGICAL PRODUCTIVITY AFTER PROCESSING WITH MICROELEMENTS

Abstract. In laboratory conditions, the effect of sodium selenite and a mixture of sodium selenite and zeolite on the growth and biological productivity of peas was investigated. The soil was examined after harvesting. It was shown that the addition of both sodium selenite and the mixture of sodium selenite with zeolite to the soil with irrigation affects the development of the root system - the length of the main root in the first case increased by 16.5%, the height of the stems 30 days after planting was 29% more in comparison with the control variant, and in the second case, the length of the main root increased by 18.5%, the height of the length of the stems increased by 24% than that of the control. Processing of peas with microelements also caused a stimulation of the reproduction system: an increase in the number of inflorescences by 3 times and the number of beans in 3.4 times compared with the control. A 160-fold decrease in the selenium content and the introduction of zeolite did not cause a large difference in the obtained results (except for the number of beans - with the addition of zeolite, the number of beans increased by 8%). Biochemical indicators of pea biomass showed an increase in dry matter, in sugar content by 28.8%, but a decrease in crude protein by 17.7%, a decrease in carotene by 17.5%, nitrogen by 18% (when irrigated with sodium selenite). When treated pea with sodium selenite and zeolite, the sugar content increased by 85.5%, but it was observed a decrease in crude protein by 9.5%, in crude fat - by 16.5%, a decrease in carotene by 31.2%, a decrease in nitrogen by 9.4%. Analysis of the soil after harvesting showed in the option with the addition of sodium selenite a decrease in the amount of humus by 6.5%, mobile potassium by 18.5%, but an increase in mobile phosphorus by 6.6%, mobile calcium by 2.7%. In the option with the introduction of the mixture of sodium selenite and zeolite, no decrease in humus was observed, the content of mobile potassium decreased by 10.8%, the content of mobile phosphorus increased by 9.8%, mobile calcium by 3.5%. The acidity of the soil has not changed.

Keywords: peas, watering, sodium selenite, zeolite, development, productivity, biochemical parameters, soil.

Introduction. The issue of studying the influence of microelements on plants has always been relevant for plant physiology. Of great interest is the role of microelement of selenium in plants. This is caused by the current environmental problem - a deficiency of selenium in animal feed and human food, which causes many serious diseases [1-3].

There is little data on the effect of selenium compounds on plant growth and development and they are contradictory. Selenium in low concentrations is essential for plants. However, the need for it is determined by the species and varietal characteristics of plants, since in some cases even low concentrations of selenium do not have a positive effect on the growth, development, and productivity of some crops [4,5].

For example, the use of presowing treatment of spring wheat seeds with selenium contributed to an increase in grain yield. A significant effect of seed treatment with selenium on photosynthetic indicators and the nature of donor-acceptor relations of plants under different conditions of water supply was noted [6,7]. Under the action of selenium (2.5 mg/kg of soil), seed germination and grain yield increased. Signs of toxicosis occurred at doses greater than 8 mg/kg.

An increase in the resistance of plants to stress factors under the selenium action is confirmed by experiments on treating eastern galega with sodium selenate of different concentrations against heat and salt stresses, as well as by determining the resistance of nodule bacteria to prolonged hypothermia when selenium is introduced into the soil [8 -11].

The study of new starting material is always relevant in view of the fact that the quality of the starting material always determines the effectiveness of selection [12].

The lack of selenium in plants is compensated by fertilizers in the form of selenites and selenates introduced into the soil. It has been shown that sodium selenite was the most active form of fertilizer. In cereals and fodder crops, selenium is converted primarily to selenomethionine. It is incorporated into proteins instead of methionine [13].

Some scientific experiments have resulted that the use of sodium selenite promotes an increase in not only nitrogen, but also potassium in barley plants and their accumulation in grain [14 - 16]. It was found that selenium enhances the synthesis of free amino acids in cereals, which confirms the physiological significance of this element for plants.

Currently, to increase productivity, along with selenium, the zeolites are used both as an independent fertilizer and as the mixture with mineral fertilizers. Zeolites as active natural sorbents absorb, retain for a long time and gradually release absorbed nutrient ions into the environment. Part of the nitrogen in the soil is fixed by zeolite grains and is kept from leaching. The nitrogen bonded with zeolite is used by plants gradually, throughout the growing season. Also, natural zeolites absorb elements poisonous to plants from the soil, such as mercury, lead, cobalt, etc. and improve the ion-exchange and adsorption properties of soils. [17-21].

The aim of this work is to show in laboratory conditions the effect of sodium selenite and the mixture of sodium selenite and zeolite on the morphogenesis and biochemical parameters of peas and soil conditions after harvesting.

To achieve the aim, the following objectives were set:

1. to show the impact of sodium selenite and the mixture of sodium selenite and zeolite on the development of pea shoots;
2. to determine the biochemical parameters of the green mass of peas;
3. to investigate the composition of the soil after harvesting peas.

Materials and methods of the research. To set up the experiments, there were used pea of the Triumph variety; 30 peas were placed in wooden containers with 8 kg of universal soil (GOST R 53381-2009). Sodium selenite (TS 6-09-17-209-88) was added to the soil in the form of 800 ml of an aqueous solution with a concentration of 0.056%, with which plantings were watered 5 times throughout the season at intervals of 15 days (experiment 1). In experiment 2, watering was carried out with an aqueous solution (480) ml of sodium selenite and zeolite (TS 2163-077-05766575-99) with 0.025% concentration. The experiments were carried out at a temperature of 20-25 °C in four series, threefold repetition. The height of pea shoots was measured 30 days after planting, the number of inflorescences was determined 60 days after planting, the number of beans and the length of the main root was determined after 76 days, the content of biochemical substances was defined in slices of greenery and fruits 76 days after planting. The results of the experiments are summarized in tables 1,2,3, figures 1,2,3. To obtain agrochemical parameters, the methods described in [22] were used.

Carotene was determined with the photometric method by extraction with petroleum naphtha and photometry of colored solutions [22].

Nitrogen and crude protein were determined by mineralizing the sample with boiling sulfuric acid in the presence of a catalyst to form ammonium sulfate, adding excess sodium hydroxide to the cooled mineralizate to disengage ammonia, distilling and titrating the disengaged ammonia, calculating the mass fraction of nitrogen in the test sample and recalculating the mass fraction of crude protein.

Crude fat was determined by continuous extraction with sulphuric ether (according to Soxhlet).

Sugar was defined by the photometric method, based on the interaction of carbonyl groups of sugars in alkaline medium with potassium ferricyanide and measuring the optical density of the resulting solution with a photoelectric colorimeter.

Humus in the soil was specified by oxidation of organic matter with a solution of potassium bichromate in sulfuric acid and the subsequent determination of trivalent chromium, equivalent to the content of organic matter, on a photoelectric colorimeter.

Exchange calcium was determined by the chelatometry by titration with Trilon B at pH of 12.5–13.0 using acid dark blue as an indicator of chromium.

Mobile phosphorus and potassium were determined by extracting phosphorus and potassium from a sample weight with hydrochloric acid of 0.2 mol/dm^3 concentration and then determining the mobile compounds of phosphorus using photoelectric colorimeter and potassium - using a flame photometer.

Total nitrogen was determined by the photometric method by mineralization of the sample by heating with concentrated sulfuric acid in the presence of hydrogen peroxide, followed by measuring the optical density of the colored indophenol compound formed in the alkaline medium during the interaction of ammonia with hypochlorite and sodium salicylate.

Humic acids were specified by treatment of the sample with an alkaline solution of sodium pyrophosphate, subsequent extraction of the sample with a sodium hydroxide solution, precipitation of humic acids with an excess of mineral acid, and determination of the mass of the obtained precipitate.

Research results. The analysis of the obtained data (table 1, figure 1) indicates that the addition of both sodium selenite and the mixture of sodium selenite with zeolite to the soil with irrigation affected the development of the root system, which, having a higher absorption capacity, probably contributed to more intensive consumption of nitrogen and this could have a positive effect on the formation of pea productivity. So watering with sodium selenite (ex. 1) caused an increase in the length of the main root by 16.5%, and watering with the mixture of selenite and zeolite (ex. 2) - by 18.5%. Besides, stimulation of the growth and development of pea was observed in comparison with the control: the length of the stems (ex.1) 30 days after planting was 29%, and in ex. 2 – 24% higher than that of the control. Apparently, this can be explained by the intensity of photosynthesis and a strong increase in the overall biological activity of the soil.

Control Experiment 1 Experiment 2

Figure 1 - The height of the pea stems after planting after 30 days

Table 1 - Average phytotesting data for various concentrations of mineral additives

No of ex.	Watering	Added to 1 kg of soil per season, mg		Germination after 15 days, %	Height of the shoots after 30 days, cm	Number of inflorescences after 60 days, pcs.	Number of beans after 76 days, pcs.	Length of the main root after 76 days, cm
		Sodium Selenite	Zeolite					
Control	Water	-	-	89.2	26.05	13.3	10.3	9.14
1	Sodium selenite + water	7.5	-	80.8	33.65	39.75	33.75	10.65
2	Sodium selenite + zeolite + water	0.047	4.653	91.7	32.2	39.5	36.5	10.83

The treatment of pea with sodium selenite and the mixture of selenite and zeolite also stimulated the reproduction system: an increase in the number of inflorescences by 3 times and the number of beans by 3.4 times compared to the control (figure 2). It should be noted that a 160-fold decrease in the selenium content in experiment 2 compared to experiment 1 and the introduction of zeolite did not cause a big difference in the experimental results (except for the number of beans increased by 8% compared to experiment 1).

The biochemical indicators of pea biomass are given in table 2 and figures 3, 4. The results showed a gain in dry matter in experiments 1 and 2 compared with the control (figure 3), an increase in sugar content: in ex.1 by 28.75%, in ex.2 by 85.54% (figure 4) - apparently, this is connected with the activation of photosynthesis or increased sugar transport under the action of selenite and zeolite, but a decrease in crude protein was noted: in experiment 1 - by 17.7%, in experiment 2 - by 9.5%. It was noted in the work [15] that selenium can stimulate or inhibit protein biosynthesis in a plant depending on conditions, a form of the compound, and its concentration. Evidently, in our conditions, protein synthesis was inhibited. There was also a decrease in crude fat - by 16.5% in ex.2, a decrease in carotene in ex.1 by 17.5% and in ex.2 - by 31.2% compared with the control. The nitrogen content declined in ex. 1 by 18%, in ex. 2 - by 9.4%. This is possibly due to the influence of selenium and zeolite on the development of the root system, which, having a greater absorption capacity, consumed nitrogen more intensively, and used it more efficiently.

Figure 2 - Inflorescences and beans of Triumph pea cultivar (Experiment 2).

Table 2 - Biochemical indicators of pea

No.	Crude protein,%	Crude fat,%	Nitrogen,%	Carotene, mg/kg
Control	26.70	4.11	4.27	77.11
Experiment 1	21.88	4.16	3.50	63.65
Experiment 2	24.17	3.43	3.87	53.04

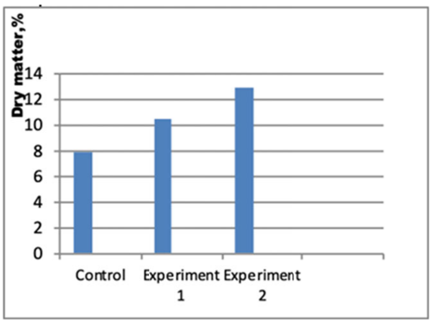

Figure 3 - Dry matter content in peas

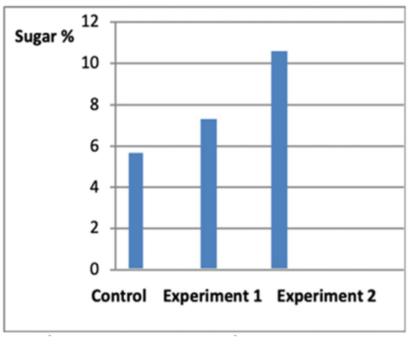

Figure 4 - Sugar content in peas.

After harvesting, the soil was analyzed. The data in table 3 indicate that the content of humus in the soil decreased by 6.5% after the application of selenite (ex. 1) and did not change after the introduction of selenite with zeolite (ex. 2). Options for laboratory experiments with the introduction of sodium selenite and the mixture of zeolite and sodium selenite are characterized by the enhanced content of mobile phosphorus by 6.6% (ex. 1), by 9.8% (ex. 2), mobile calcium by 2.7% (ex. 1), by 3.5% (ex. 2) compared to the option without additives. Apparently, selenium and zeolite introduced into the soil affect the mobility of chemical elements, increasing or decreasing their level, availability for plants. It should be noted that the level of mobile potassium decreased by 18.5% in experiment 1 and by 10.8% in experiment 2 compared with the control. The soil acidity after the introduction of additives has not changed. The positive impact of selenite and zeolite on soil properties is also expressed in the increased content of total nitrogen by 7.4% (ex.1), by 31% in ex.2, the humic acids by 12.6% (ex.1), by 7 % in ex. 2 compared with the control.

Table 3 - Physico-chemical parameters of the soil after harvesting

No.	Humus,%	Mobile phosphorus, mg/kg of soil	Mobile potassium, mg/kg of soil	Total nitrogen, mg/kg	Humic acids, mg/kg	Exchange calcium, mmol/kg	pH
Control	16.93	266.8	135.5	6.8	218.3	222.5	6.68
Experiment 1	15.83	284.5	110.5	7.3	245.8	228.5	6.53
Experiment 2	17.1	292.8	120.8	8.9	223.5	230.5	6.50

Conclusion. In such a way, it was found that 5-fold watering of pea seedlings during the season under laboratory conditions with aqueous solutions of sodium selenite and the mixture of zeolite and selenite stimulates the growth and development of the plant, stimulates the pea reproduction system, increasing the number of inflorescences by 3 times and the number of beans in 3,4 times compared with the control. The introduction of microelements sodium selenite and zeolite ambiguously affects the biochemistry of pea: the sugar content sharply increases, but crude protein, crude fat, and carotene decrease compared to the control. Analysis of the soil after harvesting showed an increase in mobile elements - phosphorus and calcium, an increase in the content of total nitrogen, humic acids, but a decrease in the level of mobile potassium compared with the control experiment.

И.А. Добросмыслова[1], А.А. Сазанова[1] ,
В.Г. Семенов[2], Ж. Тулеубаев[3], З.Т. Есимбекова[4], Г.К. Зияева[3]

[1]И.Н. Ульянов атындағы Чуваш мемлекеттік университеті, Чебоксары қаласы, Ресей;
[2]Чуваш ауылшаруашылығы мемлекеттік академиясы, Чебоксары қаласы, Ресей;
[3]М.Х. Дулати атындағы Тараз мемлекеттік университеті, Тараз, Қазақстан;
[4] «Қазақ малшаруашылығы және жемшөп өндірісі ғылыми-зерттеу институты» ЖШС, Алматы, Қазақстан

МИКРОЭЛЕМЕНТТІ ҚОСПАЛАРМЕН ӨҢДЕУДЕН КЕЙІНГІ ӨСІМДІКТЕРДІҢ ӨСУІ МЕН БИОЛОГИЯЛЫҚ ӨНІМДІЛІГІ

Аннотация. Зертханалық жағдайда натрий селенитінің және натрий селениті мен цеолит қоспасының бұршақтың өсуіне және биологиялық өнімділігіне әсері зерттелді. Егін жиналғаннан кейін топырақ тексерілді. Суару кезінде натрий селенитінің де, натрий селенитінің де цеолит қоспасының топыраққа қосылуы тамыр жүйесінің дамуына әсер ететіні көрсетілген - бірінші жағдайда негізгі тамырдың ұзындығы 16,5%-ға өсті, отырғызудан 30 күн өткен соң сабақтарының биіктігі бақылау нұсқасымен салыстырғанда 29%-ға көп болды, ал екінші жағдайда негізгі тамырдың ұзындығы 18,5%-ға өсті, сабақтың ұзындығы бақылаумен салыстырғанда 24%-ға өсті. Бұршақты микроэлементтермен емдеу репродуктивті жүйені ынталандырды: бақылаумен салыстырғанда соцветия санының 3 есе және бұршақ санының 3,4 есе артуы. Селен мөлшерінің 160 есе төмендеуі және цеолитті енгізу нәтижелерде үлкен айырмашылықты тудырмады (бұршақ санын қоспағанда - цеолит қосылған кезде бұршақ саны 8%-ға өсті). Бұршақ биомассасының биохимиялық көрсеткіштері құрғақ заттың, қант құрамының 28,8%-ға артуын ғана емес, шикі протеиннің 17,7% - ға төмендеуін, каротиннің 17,5%-ға, азоттың 18%-ға төмендеуін (натрий селенитімен суару кезінде) көрсетті. Бұршақты натрий селенитімен және цеолитпен өңдеу кезінде қант мөлшері 85,5%-ға ұлғайды, бірақ шикі ақуыздың 9,5% - ға, шикі майдың 16,5%-ға төмендеуі, каротиннің 31,2%-ға төмендеуі, азоттың 9,4% - ға төмендеуі байқалды. Жинаудан кейінгі топырақ талдауы натрий селениті қосылған нұсқада қарашірік мөлшерінің 6.5%-ға, жылжымалы калийдің 18,5%-ға төмендегенін, сондай-ақ жылжымалы фосфордың

6,6%-ға, жылжымалы кальцийдің 2,7%-ға өскенін көрсетті. Натрий селениті мен цеолит қоспасы енгізілген нұсқада қарашіріктің төмендеуі байқалмады, жылжымалы калий 10,8%-ға төмендеді, жылжымалы фосфор 9,8%-ға, жылжымалы кальций 3,5%-ға өсті. Топырақтың қышқылдығы өзгерген жоқ.

Түйін сөздер: бұршақ, суару, натрий селениті, цеолит, даму, өнімділік, биохимиялық көрсеткіштер, топырақ.

И.А. Добросмыслова[1], А.А. Сазанова[1] ,
В.Г. Семенов[2], Ж. Тулеубаев[3], З.Т. Есимбекова[4], Г. К. Зияева[3]

[1]Чувашский государственный университет им. И.Н.Ульянова, Чебоксары, Россия;
[2]Чувашская государственная сельскохозяйственная академия, Чебоксары, Россия;
[3]Таразский государственный университет им. М.Х. Дулати, Тараз, Казахстан;
[4]Товарищество с ограниченной ответственностью «Казахский научно-исследовательский институт животноводства и кормопроизводства», Алматы, Казахстан

РОСТ И БИОЛОГИЧЕСКАЯ ПРДУКТИВНОСТЬ РАСТЕНИЙ ПОСЛЕ ОБРАБОТКИ МИКРОЭЛЕМЕНТНЫМ СОСТАВОМ

Аннотация. В лабораторных условиях исследовано влияние селенита натрия и смеси селенита натрия и цеолита на рост и биологическую продуктивность гороха. Почву осматривали после уборки урожая. Показано, что добавление как селенита натрия, так и смеси селенита натрия с цеолитом в почву при орошении влияет на развитие корневой системы - длина основного корня в первом случае увеличилась на 16,5%, высота стеблей через 30 дней после посадки была на 29% больше по сравнению с контрольным вариантом, а во втором случае длина основного корня увеличилась на 18,5%, высота длины стеблей увеличилась на 24% по сравнению с контролем. Обработка гороха микроэлементами также вызывала стимуляцию репродуктивной системы: увеличение количества соцветий в 3 раза и количества бобов в 3,4 раза по сравнению с контролем. 160-кратное снижение содержания селена и введение цеолита не вызвало большой разницы в полученных результатах (за исключением количества бобов - при добавлении цеолита количество бобов увеличилось на 8%). Биохимические показатели биомассы гороха показали увеличение не только сухого вещества, содержания сахара на 28,8%, но и снижение сырого протеина на 17,7%, снижение каротина на 17,5%, азота на 18% (при орошении селенитом натрия). При обработке гороха селенитом натрия и цеолитом содержание сахара увеличивалось на 85,5%, но наблюдалось снижение сырого белка на 9,5%, сырого жира - на 16,5%, снижение каротина на 31,2%, снижение азота на 9,4%. Анализ почвы после уборки показал в варианте с добавлением селенита натрия снижение количества гумуса на 6.5%, подвижного калия на 18,5%, а также увеличение подвижного фосфора на 6,6%, подвижного кальция на 2,7%. В варианте с внесением смеси селенита натрия и цеолита снижения гумуса не наблюдалось, содержание подвижного калия снизилось на 10,8%, содержание подвижного фосфора увеличилось на 9,8%, подвижного кальция-на 3,5%. Кислотность почвы не изменилась.

Ключевые слова: горох, полив, селенит натрия, цеолит, развитие, продуктивность, биохимические показатели, почва.

Information about the authors:

Dobrosmyslova Irina Anatolievna, Candidate of Science in Biology, Associate Professor of Chuvash State University named after I.N. Ulyanov, Cheboksary, Chuvash Republic, Russia, e- mail: weda9@mail.ru, https://orcid.org/0000-0001-8662-1075;

Sazanova Alevtina Anatolyevna, Candidate of Science in Chemistry, Associate Professor of Chuvash State University named after I.N. Ulyanov, Cheboksary, Chuvash Republic, Russia, e- mail: cheiz96@rambler.ru, https://orcid.org/0000-0001-8357-4154;

Semenov Vladimir Grigoryevich, Doctor of Biological Sciences, professor, Honored Worker of Science of the Chuvash Republic, professor of the Department of Morphology, Obstetrics and Therapy, Chuvash State Agricultural Academy, 29, Karl Marx str., Cheboksary, 428003, Chuvash Republic, Russia, E-mail: semenov_v.g@list.ru, https://orcid.org/0000-0002-0349-5825;

Tuleubayev Zhaxybay - doctor of agricultural Sciences, Professor, Taraz Regional University named after M.Kh.Dulati, E: tuleubayev51@mail.ru, https://orcid.org/0000-0002-1563-1361;

Yesembekova Zinagul Tursynkaliyevna, Researcher, Kazakh Scientific Research Institute of Animal Breeding and Fodder Production, Almaty, Republic of Kazakhstan, E mail: zina_jk@mail.ru, https://orcid.org 0000-0003-1745-9611;

Ziyaeva Gulnar, Candidate of Biological Sciences, associate Professor Taraz Regional University named after M.Kh.Dulati, E-mail: gulnarzia-71@mail.ru, https://orcid.org/0000-0001-7260-2164.

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