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Original article

# INCREASE THE YIELD OF INDUSTRIAL CROPS DUE TO BIONUTRIENTS

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***Abstract***

**Background.** The article is devoted to the search for effective ways of a reasonable approach to the chemicalization of agriculture, which will increase crop yields without increasing the doses of applied mineral fertilizers and pesticides. The materials of the analysis and generalization of the results of long-term studies of bionutrients safe for humans and animals synthesized using the triethanolammonium salt of orthocresoxyacetic acid and 1-chloromethylsilatran are presented. The conducted studies have shown that it is possible to achieve high yields of industrial crops that do not depend on the constantly increasing values of mineral fertilizers and pesticides introduced into the soil. An increase in sugar beet yield of up to 20% is recorded when processing seeds and fruiting plants with bionutrients. This is due to an increase in germination energy, and, as a result, seed germination improves. At the same time, the sugar content in plants increases by 0.7 ...1% without the use of additional doses of mineral fertilizers. A similar effect was obtained on sunflower: the yield increase was 18...20%. the weight of seeds from one basket and the weight of 1000 seeds and their oil content increased. Bionutrients restrained the spread of fungal diseases, which makes it possible to reduce or eliminate the use of pesticides. Thus, silatrans and other organosilicon compounds can become important components of agricultural technologies that do not harm the ecosystem, but can improve metabolic processes in plant organisms, increase the efficiency of using nutrients from mineral fertilizers and reducedependence on pesticides used in agriculture.

**Purpose.** Purpose of the present study is to increase the yield of industrial crops using bionutrients.

**Materials and methods.** Let's consider the effectiveness of the use of 1-chloromethylsilatran and triethanolammonium salt of orthocresoxyacetic acid with auxin activity as independent bionutrients and in combination with each other. The research methodology is based on the analysis and generalization of materials from field experiments conducted in different regions of the Russian Federation on industrial crops (sugar beet and sunflower). Bionutrients were used in the form of solutions for the treatment of seeds and vegetative plants, both individually and in combination.

Further, to simplify, we denote the bionutrient 1-chloromethylsilatran with the letter C, the triethanolammonium salt of orthocresoxyacetic acid with the letter T, and their combinations.

**Results.** An economic assessment using the example of wheat has shown that the use of bionutrients to increase yields instead of increasing the applied doses of mineral fertilizers can reduce the cost of production and increase business profitability. And this is already an effective incentive for the revision of traditional crop production technologies and the transition to the reasonable use of agrochemistry, reducing the cost of fertilizers that are not involved in the formation of an economically useful part of the crop.

**Conclusion.** The results of the assessment of the possibility of a reasonable approach to the chemicalization of agriculture while increasing crop yields due to bionutrients safe for humans and animals based on organosilicon compounds 1-chloromethylsilatran and a substance with auxin activity – triethanolammonium salt of orthocresoxyacetic acid, showed a real prospect of minimizing doses of mineral fertilizers and pesticides. In particular, it was found that beet yields increased by 14...18%, and sugar content – by 0.7... 1% without the use of additional doses of mineral fertilizers.

A similar effect was obtained on sunflower: the yield increase was 18...20%. the weight of seeds from one basket and the weight of 1000 seeds and their oil content increased. Bionutrients restrained the spread of fungal diseases.

Thus, silatrans and other organosilicon compounds can become important components of agricultural technologies that do not harm the ecosystem, but can improve metabolic processes in plant organisms, increase the efficiency of using nutrients from mineral fertilizers and reduce dependence on pesticides used in agriculture.

**Keywords:** bionutrients; chloromethylsilatran; mineral fertilizers; minimization; sugar beet; sunflower

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Научная статья

# ПОВЫШЕНИЕ УРОЖАЙНОСТИ ТЕХНИЧЕСКИХ КУЛЬТУР ЗА СЧЕТ БИОНУТРИЕНТОВ

***Ю.А. Широков, М.В. Абрамов, Д.Н. Денисов***

***Аннотация***

**Обоснование.** Статья посвящена поиску эффективных путей разумного подхода к химизации сельского хозяйства, позволяющих повысить урожайность сельскохозяйственных культур без увеличения доз вносимых минеральных удобрений и пестицидов. Представлены материалы анализа и обобщения результатов многолетних исследований безопасных для человека и животных бионутриентов, синтезированных с использованием триэтаноламмониевой соли ортокрезоксиуксусной кислоты и 1-хлорметилсилатрана. Проведенные исследования показали возможность получения высоких урожаев технических культур, не зависящих от постоянно возрастающих значений вносимых в почву минеральных удобрений и пестицидов. При обработке семян и плодовых растений бионутриентами отмечается увеличение урожайности сахарной свеклы до 20 %. Это связано с увеличением энергии прорастания и, как следствие, улучшением всхожести семян. При этом содержание сахара в растениях увеличивается на 0,7...1 % без применения дополнительных доз минеральных удобрений. Аналогичный эффект получен на подсолнечнике: прибавка урожая составила 18...20 %, увеличились масса семян из одной корзинки и масса 1000 семян, содержание масла в них. Бионутриенты сдерживают распространение грибковых заболеваний, что дает возможность сократить или вовсе отказаться от применения пестицидов. Таким образом, силатраны и другие кремнийорганические соединения могут стать важными компонентами сельскохозяйственных технологий, которые не наносят вреда экосистеме, но способны улучшить обменные процессы в растительных организмах, повысить эффективность использования питательных веществ из минеральных удобрений и снизить зависимость от пестицидов, применяемых в сельском хозяйстве.

**Цель.** Цель исследования – повысить урожайность технических культур с помощью бионутриентов.

**Материалы и методы.** Рассмотрим эффективность применения 1-хлорметилсилатрана и триэтаноламмониевой соли ортокрезоксиуксусной кислоты с ауксиновой активностью в качестве самостоятельных биоудобрений и в сочетании друг с другом. Методология исследований основана на анализе и обобщении материалов полевых опытов, проведенных в различных регионах Российской Федерации на технических культурах (сахарной свекле и подсолнечнике). Биоудобрения применялись в виде растворов для обработки семян и вегетирующих растений, как по отдельности, так и в сочетании друг с другом.

Далее для упрощения обозначим биоэлемент 1-хлорметилсилатран буквой С, триэтаноламмониевую соль ортокрезоксиуксусной кислоты – буквой Т, а их сочетания – буквами.

**Результаты.** Экономическая оценка на примере пшеницы показала, что использование бионутриентов для повышения урожайности вместо увеличения вносимых доз минеральных удобрений позволяет снизить себестоимость продукции и повысить рентабельность бизнеса. А это уже эффективный стимул для пересмотра традиционных технологий растениеводства и перехода к разумному использованию агрохимии, снижению затрат на удобрения, которые не участвуют в формировании экономически полезной части урожая.

**Заключение.** Результаты оценки возможности разумного подхода к химизации сельского хозяйства при повышении урожайности за счет безопасных для человека и животных бионутриентов на основе кремнийорганических соединений 1-хлорметилсилатрана и вещества с ауксиновой активностью – триэтаноламмониевой соли ортокрезоксиуксусной кислоты, показали реальную перспективу минимизации доз минеральных удобрений и пестицидов. В частности, было установлено, что урожайность свеклы увеличилась на 14...18 %, а сахаристость – на 0,7... 1% без применения дополнительных доз минеральных удобрений.

Аналогичный эффект получен на подсолнечнике: прибавка урожая составила 18...20 %, увеличились масса семян с одной корзинки и масса 1000 семян, содержание масла в них. Бионаполнители сдерживали распространение грибковых заболеваний.

Таким образом, силатраны и другие кремнийорганические соединения могут стать важными компонентами агротехнологий, которые не наносят вреда экосистеме, но способны улучшить обменные процессы в растительных организмах, повысить эффективность использования питательных веществ из минеральных удобрений и снизить зависимость от пестицидов, применяемых в сельском хозяйстве.

**Ключевые слова:** биоудобрения; хлорметилсилатран; минеральные удобрения; минимизация; сахарная свекла; подсолнечник

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## Introduction

In recent years, we have seen significant progress in the development of agriculture, which not only successfully solves the problem of food security in our country, but also makes a significant contribution to providing food to many countries around the world. At the same time, the potential of Russian agriculture is far from being exhausted [1].

The genetic potential of the varieties, photosynthetically active radiation and soil moisture supply are mainly used by 30-60%. For example, grain yields in the last record year amounted to just over 3.0 t/ha, and the genetic potential of varieties significantly exceeds 12.0 t/ha. The same applies to other cultures. However, it is known that with the traditional approach to increasing yields, an increasing dose of mineral fertilizers and pesticides is required for each subsequent hundredweight achieved [2-5].

Using well-known yield forecasting formulas, it is not difficult to calculate how much NPK needs to be applied to increase wheat yields from 10 to 60 c/ha. For example, to increase wheat yield from 30 to 10 c/ha, you need: 25...35 kg of nitrogen, 11... 13 kg of phosphorus, 20... 27 kg of potassium. And this can produce a total of more than 45 million tons of grain, increasing the export potential by more than 100%. A similar situation is observed with other cultures (Fig.1).

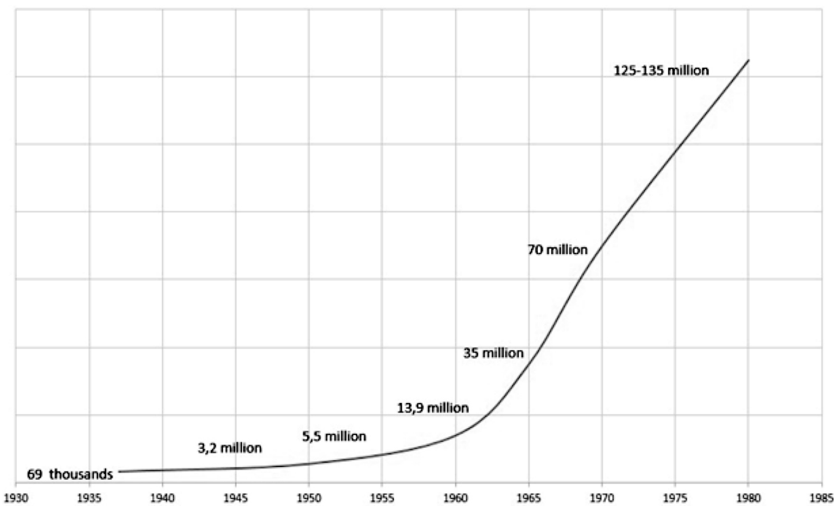


**Fig. 1.** The growth of the use of mineral fertilizers
(formulated by the authors on the basis of statistical data)

The increase in the use of mineral fertilizers (formulated by the authors on the basis of statistical data) As a result, Russia can become the absolute breadwinner of the world (if we also take care of logistics and storage of such an increase in grain reserves in advance). However, traditional chemicalization of crop production leads to chemicalization of food products, disruption of the ecological balance and, as a result, to a serious deterioration in public health, which will not contribute to the preservation of national nature or the solution of demographic problems [6-11].

At the same time, intensive chemicalization of agriculture does not have the expected effect. With an increase in the volume of fertilizers applied in the USSR from 1960 to 1980 by almost 10 times (from 13.9 million tons to 135 million tons) (Fig. 1), grain yields increased by no more than 2 times (from 1.3 t/ha to 1.8 t/ha). The increase in the use of mineral fertilizers (formulated by the authors on the basis of statistical data) is no secret that the chemicalization of crop production leads to the chemicalization of food products, disruption of the ecological balance and, as a result, to a serious deterioration in public health, destruction of ecological imbalance, decreased reproductive functions and the birth of children with various developmental disorders [12-14]. (Fig. 2).

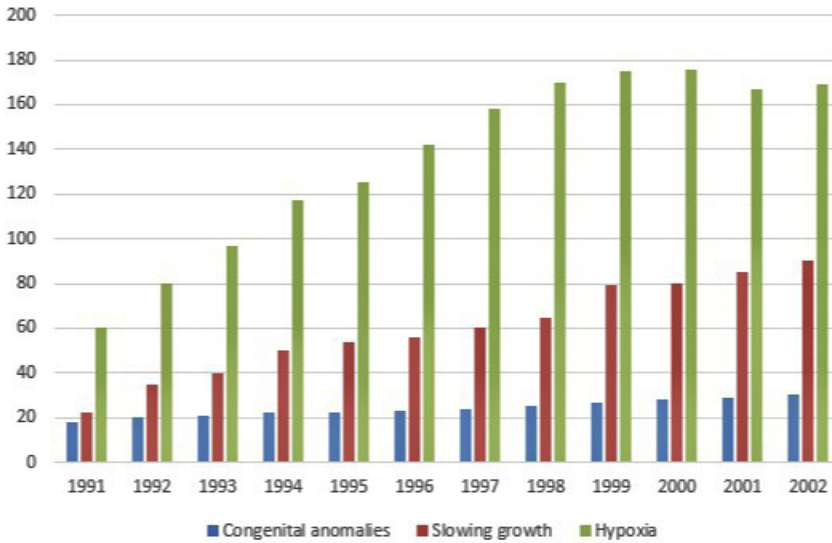


**Fig. 2.** The dynamics of the increase in the birth of children with abnormalities

Agrotechnologies should be considered not only from the point of view of increasing yields and profitability, but also ensuring the safety of agriculture for the population of our country with a full understanding of food security in the interpretation of the FAO. The search for effective ways of a reasonable approach to the chemicalization of agriculture has been going on for many decades [15-19].

The greatest attention is paid to the issues of accurate transfer of nutrients in various forms to the root system of plants of the desired species during a given growing season and increasing the efficiency of their assimilation [13; 17-19]. Much attention is paid to the introduction of drugs into plant cultivation technology that promote the better use of nutrients from mineral fertilizers, which allows either reducing fertilizer doses without compromising yields, or increasing yields without increasing fertilizer doses [1; 13; 20]. For example, these can be well-known chemical compounds such as Ce-Ce, Epin, etc. Of great interest are natural products such as humates of various origins or silatrans and other variants of organoelement compounds or bionutrients - products that do not create a burden on the ecosystem, but can improve metabolic processes in plant organisms, increase the efficiency of the use of nutrients from mineral fertilizers and reduce the need for pesticides [1].

To confirm the possibility of intensifying crop production with the reasonable use of agrochemicals, we will additionally consider the effectiveness of the introduction of silatrans into agricultural technology. It was found that the biological activity of silatrans is due to their unique molecular structure, the presence of a silicon atom and a specific electronic configuration. A wide range of their biological effects as a new type of biostimulants of metabolic processes allows them to be successfully used in the cultivation of industrial crops [1]. It is important to understand the practical applicability of silatrans to improve metabolic processes and increase the yield of industrial crops without increasing the doses of mineral fertilizers.

The purpose of the study is to summarize and analyze experiments conducted to assess the possibility of increasing the yield of industrial crops without increasing the doses of mineral fertilizers due to bionutrients based on organosilicon compounds that are safe for humans and animals.

**Purpose**

The main objective of the present study is to increase the yield of industrial crops using bionutrients.

**Materials and methods**

Let's consider the effectiveness of the use of 1-chloromethylsilatran and triethanolammonium salt of orthocresoxyacetic acid with auxin activity as independent bionutrients and in combination with each other. The research methodology is based on the analysis and generalization of materials from field experiments conducted in different regions of the Russian Federation on industrial crops (sugar beet and sunflower). Bionutrients were used in the form of solutions for the treatment of seeds and vegetative plants, both individually and in combination.

Further, to simplify, we denote the bionutrient 1-chloromethylsilatran with the letter C, the triethanolammonium salt of orthocresoxyacetic acid with the letter T, and their combinations with.

**Results**

Vegetative and field studies of the bionutrient CT and its components – C and T were carried out at the Russian State Agricultural Academy named after K.A. Timiryazev, NPO Sugar Beet, agro-industrial Complex Kuban for many years. The results of studies with soaking sugar beet seeds before sowing are shown in Table 1.

In all cases, it was noted that in addition to increasing the yield of sugar beet, an increase in the sugar content by 0.3...0.7% is observed during seed treatment with the bionutrient CT, which is most important for this crop.

Vegetative experiments with sugar beet of the Yaltushkovskaya single-seeded variety were carried out on dark gray forest sandy-loamy soil with the following agrochemical indicators: humus content of 1.3%, pH value – 5.1 NG – 4.2 mg-eq./ 100 g of soil.

*Table 1.*

**The effect of processing sugar beet seeds with bionutrients on the productivity and quality of root crops**

| Option (soaking the seeds for 40... 60 min.) | Dose, mg/l | Yield of root crops, kg/ha | Sugar collection, t/ha | | Sugar content, % |
|---|---|---|---|---|---|
| | | | common | the increase | |
| Control, water | - | 67700 | 9,07 | - | 13,4 |
| *T*, 0,02…0,05% | 5,0 | 69000 | 9,82 | 0,75 | 13,7 |
| *C*, 0,02…0,05% | 50,0 | 71000 | 9,88 | 0,81 | 13,5 |
| *CT*, 0,02…0,05% | 50,0 | 72500 | 10,15 | 1,08 | 14,1 |

The seeds were soaked in 0.02 ...0.05% solution of CT and C. The effect of growth regulators was studied on two backgrounds – a control one (pure, without herbicides) and an experimental one (with the addition of the herbicide Eptam). Data on seed germination are given in Table 2.

*Table 2.*

**Effect of sugar beet seed treatment on germination**

| Option | Germination, % | |
|---|---|---|
| | Control, without herbicide | Eptam, 12 mg/vessel |
| Control, water | 80,4 ± 3,5 | 67,8 ±1,3 |
| *C*, 0,02% | 39,0 ± 1,7 | 37,6 ± 3,1 |
| *C*, 0,05% | 72,0 ± 5,9 | 71,4 ± 2,2 |
| *CT*, 0,02% | 82,0 ± 2,6 | 80,8 ± 2,1 |
| *CT*, 0,05% | 79,6 ± 3,6 | 80,6 ± 2,3 |

In continuation of the research on the same soil and with the same variety, field experiments were conducted on the basis of an experimental farm of the IGF. Agrotechnics in field experiments are generally accepted for this soil and climatic zone. The research objectives included studying the effect of pre-sowing treatment of sugar beet seeds with silicon-containing bionutrients on seed germination, yield and accumulation of sugars in sugar beet root crops (Table 3).

*Table 3.*

**The effect of bionutrients CT and C on the yield of sugar beet Yaltushkovskaya (seed soaking)**

| Option | Control, without herbicide | | Eptam,3 kg/ha | | Eptam,5 kg/ha | |
|---|---|---|---|---|---|---|
| | t/ha | sugar, % | t/ha | sugar, % | t/ha | sugar, % |
| Control, water | 47,9 | 16,8 | 47,5 | 16,5 | 41,0 | 16,7 |
| *C*, 0,02% | 43,0 | 16,5 | 46,0 | 16,5 | 39,8 | 16,6 |
| *C* 0,05% | 47,8 | 16,9 | 49,0 | 16,7 | 48,5 | 16,8 |
| *CT*, 0,02% | 48,9 | 16,9 | 50,5 | 16,7 | 49,0 | 16,5 |
| *CT*, 0,05% | 50,0 | 16,9 | 51,0 | 16,9 | 49,2 | 16,8 |

The results of the experiment show that CT and C neutralize the phytotoxic effect of the herbicide eptam, which is often used in the cultivation of sugar beet using standard technologies. CT neutralizes the phytotoxic effect of the herbicide on sugar beet. The increase in yield, depending on the dose of eptam, ranges from 7 to 20% compared with the control.

In production tests of modern technologies (2003-2021, Orel region) with the variety of sugar beet Barres (joint French-Russian breeding), the research results were confirmed.

Field tests of the CT preparation on sugar beet of the North Caucasian 42 variety (SKO-42) were carried out on slightly leached Western pre-Caucasian chernozem, pH - 7...8, the content in 100 g of soil P2O5 is average, K2O is high. The predecessor is winter wheat. The results of the research are shown in Table 4.

*Table 4.*

**The effect of bionutrients on the productivity of sugar beet of the SKO-42 variety**

| Option | Yield, t/ha | Sugar content, % | Sugar is obtained | |
|---|---|---|---|---|
| | | | Average yield, t/ha | +/- to control, t/ha |
| Processing in the phase of 3-4 pairs of real leaves | | | | |
| Control | 677,0 | 13,4 | 9,07 | - |
| T, 40 mg / l | 725,0 | 14,3 | 10,15 | 1,08 |
| (15 g / ha) | 736,0 | 13,4 | 9,86 | 0,79 |
| C, 40 mg/l | 756,0 | 14,5 | 10,46 | 1,39 |
| Processing in the closing phase of the leaves | | | | |
| Control | 685,0 | 13,5 | 92,5 | - |
| T, 40 mg / l | 740,0 | 13,4 | 104,3 | 1,18 |
| (15 g / ha) | 756,0 | 14,0 | 105,8 | 1,33 |
| C, 40 mg/l | 764,0 | 14,2 | 107,4 | 1,49 |

The treatment of plants with solutions of bionutrients was carried out during the initial growth period in the phase 3...4 pairs of real leaves and during the mass formation of the root crop before the row spacing closed. The working solution was prepared at the rate of 40 mg of the drug per 1 liter, the consumption of the tank mixture was 400 l / ha, the consumption rate of the drug was 20 g / ha.

The treatment of plants with bionutrients contributed to an increase in yield by 12%, which, with such a high yield level at the control (677...685 c/ha), in absolute terms amounts to 79 c/ha. It is important to note that an increase in the sugar content in root crops to 1% was found, which made it possible to increase the sugar harvest from 1 ha by 13.9 ... 14.9 c/ha in the variant with bionutrient CT treatment, at a consumption of 10... 15 g/ha.

Production tests in the southern beet-growing regions (Belgorod and Voronezh regions) confirm the results of field experiments.

The most uniform shoots and the formation of a powerful root system are noted during the germination of seeds treated with CT. The control group for these indicators has the lowest values. Control measurements in the first decade of August, i.e. the season of the most intensive growth showed an increase in the weight of root crops from 200 to 1000 g (in the control group it did not exceed 200 g), the formation of elastic leaves with thickened petioles in plants in the amount of 18 to 24 pieces (in control samples – no more than 19 pieces), and the defeat of shoots as a result of the disease was noted up to 1 point (control group – up to 3 points).

The sugar content in the root crops under control was 13.2%, in the experiment with CT – 15.2%. The use of CT increased yields by an average of 30...40 c/ha with an average yield of 200 c/ha, which is 15...20%.

Research on sunflower. Field studies were conducted to study the effect of the bio nutrient CT on the yield and quality of sunflower oil seeds, the srednerанniy – Saratovsky 87 variety (super elite seeds). The soil of the experimental site is light chestnut, slightly loamy, slightly saline. The thickness of the humus horizon is 27 cm. The water regime is not of the flushing type, the maximum soaking is 100...130 cm.

The scheme of the experience:

- control, without processing;
- seed treatment with a Ta solution – consumption of 15 ...20 g/t per 10 liters of water;
- seed treatment with Agate solution-25 To 10 ml/t;
- seed treatment with CT solution – consumption of 20 g / t per 10 liters of water.

The experiment was conducted in the conditions of crop rotation, the predecessor of sunflower is oats. Pre-sowing treatment of CT seeds improved germination and germination energy, the number of seedlings 63.5...66.5 thousand units/ha is significantly higher than in the control (60.4...63.2 thousand plants per 1 ha). The results of the experiment are shown in Tables 5 and 6.

*Table 5.*

**Analysis of the pathogen infestation of sunflower plants**

| Option | The spread of a harmful object, % | | |
|---|---|---|---|
| | gray rot | dry rot | verticillosis |
| Control | 5,5 | 1,5 | 1,7 |
| *T* | 1,5 | 1,0 | 1,0 |
| Agat 25K | 1,5 | 1,0 | 1,0 |
| *CT* | 0,5 | 0,0 | 0,0 |

The determination of the infestation of plants with a complex of diseases was carried out before harvesting. Pre-sowing treatment of seeds with CT significantly reduced the incidence to the complete exclusion of fungal diseases.

Growth regulators helped to increase plant productivity and increased the fat content in seeds.

*Table 6.*

**Sunflower yield and fat content in oilseeds**

| Option | Diameter of the sunflower basket, cm | Weight 1000 seeds, g | Seed weight from 1 root, g | Yield, t/ha | Fat content, %, (on a completely dry substance) |
|---|---|---|---|---|---|
| Control | 10,6 | 42,1 | 17,2 | 1,04 | 42,5 |
| *T* | 11,1 | 43,7 | 19,7 | 1,20 | 43,5 |
| Agat 25 K | 10,8 | 42,7 | 19,0 | 1,12 | 43,5 |
| *CT* | 11,7 | 43,3 | 20,1 | 1,23 | 43,3 |

Tests of the CT preparation on sunflower culture, which showed a noticeable increase in the main indicators of sunflower yield. There is an increase in seed germination, vegetative plants have a thick, durable stem. The forming sunflower leaves are larger and more intensely colored with green pigment, their number is also increasing. The size of the baskets exceeds the control figures, and the seed content increases. Secondary roots appear 8 days earlier, which leads to the formation of a more powerful root system. Flowering accelerates, and as a result, maturation, on average for 10-15 days. There is an increase in the drought tolerance of a group of treated plants. The effect of CT stimulated an increase in sunflower yield by 20%, to 24.1 c/ha, in the control group – 20 (Table 7).

*Table 7.*

**Assessment of the effect of bionutrients on sunflower yield**

| Option | Weight of seeds from 1 basket, g | Basket diameter, cm | Yield,t/ha | The increase | |
|---|---|---|---|---|---|
| | | | | t/ha | % |
| Control | 31,4 | 17,6 | 2,00 | - | - |
| *C* | 32,7 | 17,9 | 2,18 | 0,18 | 9,0 |
| *CT* | 35,7 | 19,1 | 2,41 | 0,41 | 20,5 |

The complex bionutrient (preparation CT), when used in the processing of sunflower seeds, gives an increase in yield to 19 c /ha, which in its effect is comparable to the efficiency of processing C and T. At the same time, the control group of plants shows a yield at the border of 10.4 c / ha, i.e. there is an increase in sunflower yield by 18.2%. The tendency to increase is clearly expressed the fat content in oilseeds when using CT. The fat content in the seeds increases by 0.8...1.0% (from 43.7 to 44.6% for absolutely dry matter).

An economic assessment using the example of wheat has shown that the use of bionutrients to increase yields instead of increasing the applied doses of mineral fertilizers can reduce the cost of production and increase business profitability. And this is already an effective incentive for the revision of traditional crop production technologies and the transition to the reasonable use of agrochemistry, reducing the cost of fertilizers that are not involved in the formation of an economically useful part of the crop [4; 11].

**Conclusion**

The results of the assessment of the possibility of a reasonable approach to the chemicalization of agriculture while increasing crop yields due to bionutrients safe for humans and animals based on organosilicon compounds 1-chloromethylsilatran and a substance with auxin activity – triethanolammonium salt of orthocresoxyacetic acid, showed a real prospect of minimizing doses of mineral fertilizers and pesticides. In particular, it was found that beet yields increased by 14...18%, and sugar content - by 0.7... 1% without the use of additional doses of mineral fertilizers.

A similar effect was obtained on sunflower: the yield increase was 18...20%. the weight of seeds from one basket and the weight of 1000 seeds and their oil content increased. Bionutrients restrained the spread of fungal diseases.

Thus, silatrans and other organosilicon compounds can become important components of agricultural technologies that do not harm the ecosystem, but can improve metabolic processes in plant organisms, increase the efficiency of using nutrients from mineral fertilizers and reduce dependence on pesticides used in agriculture.

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