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Oat yield with organic fertilizer Guminatrin

Currently, the oats are cultivated in almost all regions of Russia. The aim of our research is to study the formation of oat yield according to the application of growth stimulator Guminatrin under the conditions of Priobskaya zone of Altai Krai. The work was conducted on the basis of the training plots of Altai State Agricultural University in 2020-2021. The objects of research were oaks cultivars "Korifej", "Pegas", "Argument", "Vektor", "Rusich". Working solution was prepared at the rate of 2 l of Guminatrin to 8 l of water. The consumption of working solution for treatment: seeds — 10 l per 1 t; plants by vegetation — 1.5-2 l per 1 ha. During the research the following records and observations: the yield structure, the yield of oats, the mass of 1000 seeds. The most responsive cultivarto the growth stimulant Guminatrin was "Rusich". Pre-seeding treatment of seeds and then the plants by vegetating with the Guminatrin contributed to an increase in the yield structure elements of the investigated oats cultivars, and as a consequence resulted in an increase in yield compared to control by 0,38-0.65 t/ha.

Keywords: oats, cultivars, Guminatrin, yield, yield structure elements, yield gain.

Introduction

Oats are one of the most common crops in world agricultural production. Under to various literary sources, the genus *Avena* is up to 70 species. According to the data presented by the "Plantarium. Plants and lichens of Russia and neighboring countries: open online galleries and plant identification guide", 30 species belong to this genus, of which more than half are native to countries on the European continent [1].

The primary centers of origin of cultural oats ancestors were determined by researchers — these are Mongolia and the north-eastern provinces of China. The spread of oats to all continents of the world, thanks to the many positive qualities of the crop, has allowed oats to occupy one of the leading positions in the cereal crop ranking [2].

The quality of grain oats is of great importance. Protein is one of the most important indicators for grain quality in any crop. The protein content in oats grains fluctuates at a level of 12-13 % and is characterized by the presence in its composition of essential amino acids — histidine, arginine, lysine and tryptophan. Scientists Burtseva E.V. and Ternenko I.I. [3] note the presence in oatsgrains up to 60 % offast-breaking starch, vitamin C, fats, sugars, saponins, flavonoids, fitinic acids [4]. The chemical composition of the straw extract showed a high content of silicon acid, iodine, avenin. The analysis of the oats seedlings revealed the presence of large quantities of peptides [5]. The oats grains contain high levels of iron, calcium and phosphorus; the crop has a high content of Al, Fe, As, Sn, Hg salts; the leaves accumulate Cu, Zn, Bi salts; the stems concentrate the Br, Rb, Sr, Cd, Ba salts [2, 6].

According to biological indicators, oatis a crop that develops well under the temperate climates. It is quite resistant to high humidity, low temperature, low soil fertility [2]. It is therefore not surprising that the Russian Federation is the largest producer of oats in the world, with a production volume of 3,775,686 tons per year (Fig. 1). Canada is second in terms of production — 2,808,109 tons/year, followed by Australia — 1,897,989 tons/year, and Poland — 1,625,100 tons/year [7–9].

In 2022/2023, the global production of oats was approximately 25.13 million tons. In the 2023-2024 seasons, Russia ranked second in the world production of grain of this crop (2.6 million tons, which is 17.2 % of all global production of grain of oat).

Despite the fact that Russia is one of the leading places in the world for grain production of oats, recent years have seen a decrease in the size of the areas planted, a reduction in gross harvest, and a decline in the yield in 2023 (Fig. 2).

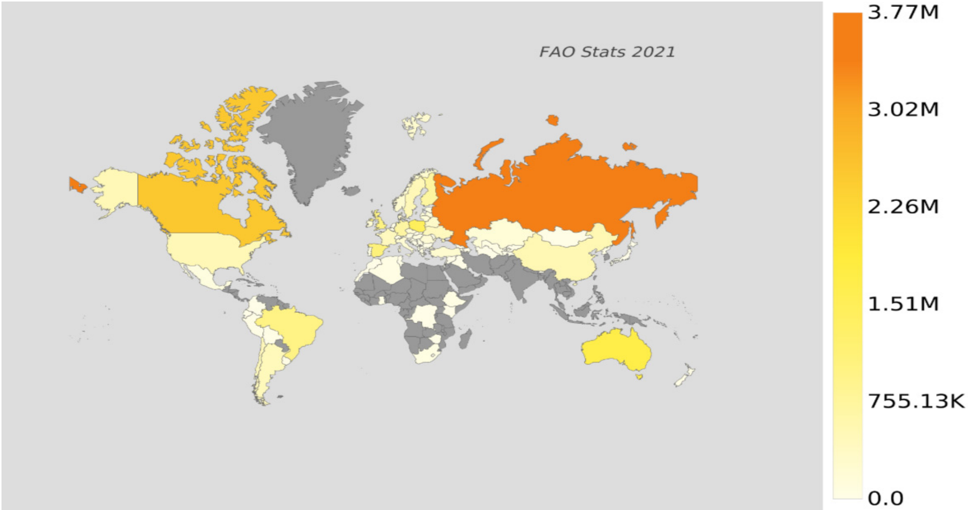

Figure 1. World oat production by country, 2021 (source: Rosstat)

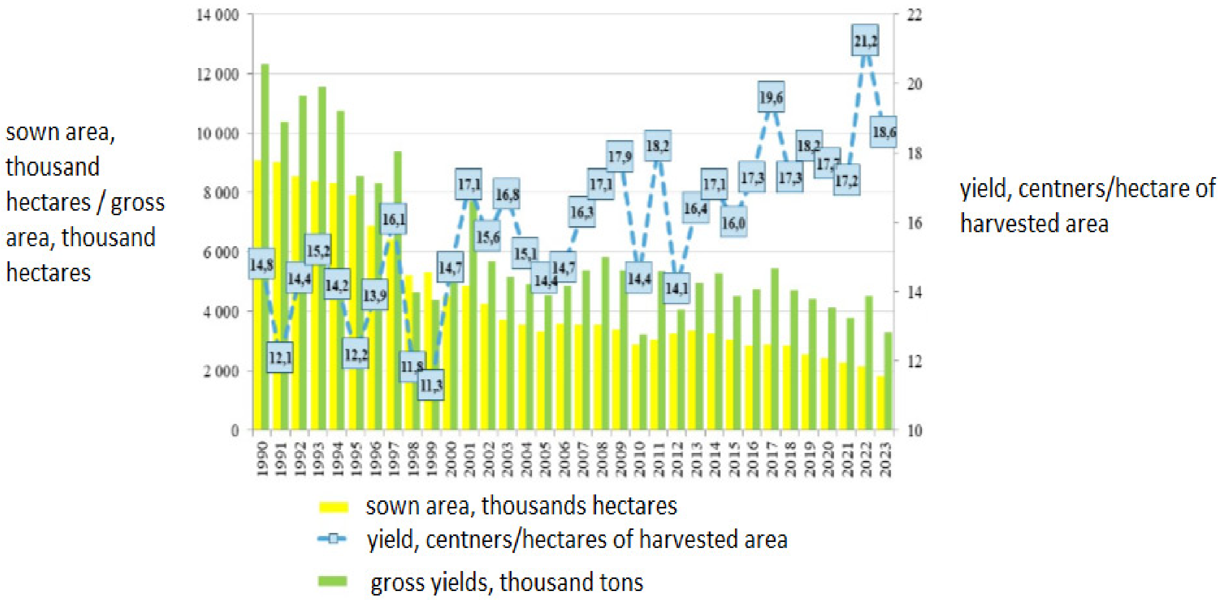

Figure 2.The area planted, gross yield and yield of oats in Russia in 1990–2023 (source: Rosstat)

In 2023, the oat area decreased by 79.9 % over the period under analysis and reached the target. Gross revenues in 2023 were 3,300 thousand tons, which is 27.1 % lower than in 2022. Such a sharp drop in the figure was observed in Russia and in 2010, when due to drought 3,225.2 thousand tons were obtained. The oat yield has increased by 7.5 % in the past five years, 13.4 % in 10 years, 8.8 % to 2001 and 25.7 % to 1990 [10].

Currently, the oats are cultivated in almost all regions of Russia. In 2023, 29.2 % of all oat harvest from regions included in the TOP-5, to share of the TOP-10 was 45.3 %. The maximum volume of oat production from regions included in the TOP-10 are noted from such municipalities as Altai Krai, Krasnoyarsk Krai, Tyumen Oblast, Republic of Bashkortostan, Novosibirsk, Irkutsk, Nizhnygorodskaya, Omsk, Kirov and Kemerovo regions (Fig. 3) [10].

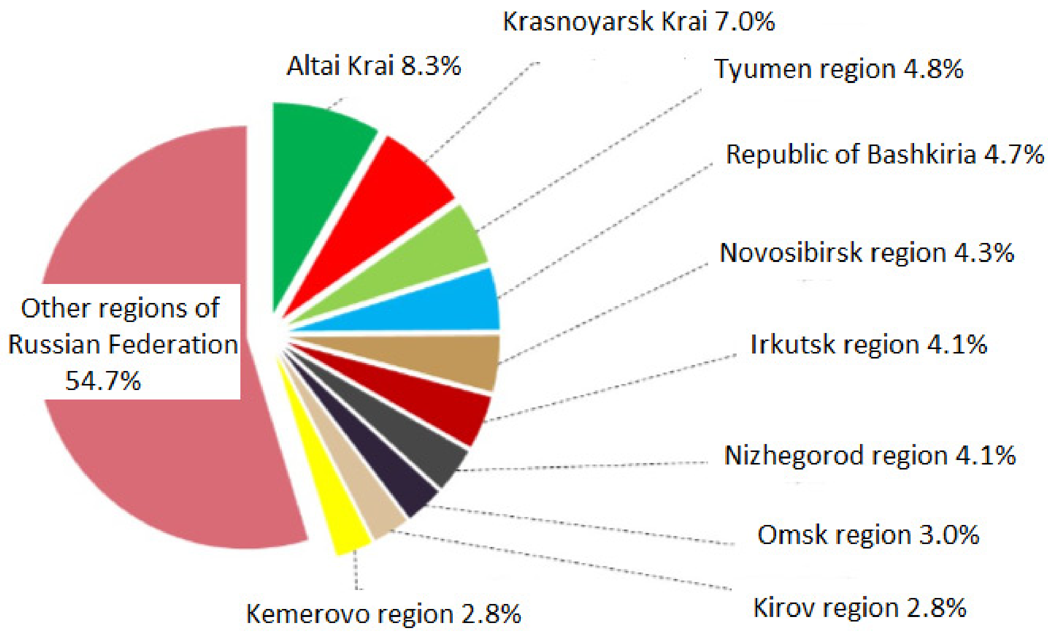

Figure 3. Share of regions in total production of oats in Russia in 2023, in % (source: Rosstat)

The importance of growing oats in modern agricultural production is undeniable. Oats occupies an honorable place among cereal crops. Oats contain a high protein, starch and fat content. This makes the oat a very important food and feed. The crop is used to make cereals, cookies, biscuits, coffee. It is also used as animal feed.

Oat is the good forecrop for other crops, because it is weakly damaged by lodging infections. Due to the short harvesting time, blotchy ripening and high propensity for falling grain, oats are difficult to harvest and require additional measures to obtain simultaneously ripening crops [11].

The application of growth regulators allows obtaining changes in plant metabolism and development identical to those that occur under certain environmental conditions [12]. Plant growth regulators are now an excellent way to solve many problems in crop farming practice. They are improving the agricultural techniques of growing selected crops. The application of growth regulators is becoming more and more relevant and demanded for agricultural producers every year. The use of physiologically active substances in the production of oats allows controlling the individual stages of growth and development of plants in order to improve their yield and grain quality [13, 14].

Many different biological preparations are currently being developed and used in agricultural production. One of these is Guminatrin. The humic acid salts in it are a complex mixture of high molecular natural organic compounds. It is natural growth stimulator, which improves the penetration of mineral nutrients through plant roots, actively participate in oxidative-restorative processes of plant cells, mobilize the phosphorus content into bioavailable forms. Humic acids are able to bind and safely transfer radionuclides, heavy metals, pesticide residues, accelerate the intensity of photosynthesis and chlorophyll synthesis. Boron, manganese, copper, zinc, molybdenum, iron, cobalt, which are included in “Guminatrin”, stimulate the growth and development of plants. Under their action, plants are increasingly resistant to bacterial and fungal diseases, to adverse environmental factors [14].

The aim of our research is to study the formation of oat yield according to the application of growth stimulator Guminatrinunder the conditions of Priobskaya zone of Altai Krai.

Experimental

The research was conducted on the basis of the training plots of Altai State Agricultural University in 2020-2021. Test plots soil — leached medium-thicksemi-loammedium-humic chernozem. The objects of research were oaks cultivars “Korifej”, “Pegas”, “Argument”, “Vektor”, “Rusich”. The fore crop was a spring wheat, sowing made by hand. The seed rate was 500 pcs. germinating seeds per 1 m^2. The plot area was 2 m^2, repetition was 3-times (Fig. 4).

The Guminatrin is a liquid fertilizer consisting of humic and fulvic acids, it also contains live agrobacteriums (Agrika, Rizotorfin B, Rizoagrin B) and amino acid complex. The product has a stimulating effect, increasing the resistance of plants to diseases, extreme climatic factors: drought, excess moisture, soil salinity. Enhances the ability of plants extract macro- and micro-nutrients from soil. Increases seed germination and gives plants favorable starting conditions due to the rich complex of micronutrients, together with soil bacteria [15].

Experiment options:

- pre-seeding treatment of seeds, and then of plants in the stage of tillering with Guminatrin;
- non-treated control.

Working solution was prepared at the rate of 2 l of Guminatr into 8 l of water. The consumption of working solution for treatment: seeds — 10 l per 1 t; plants by vegetation — 1.5-2 l per 1 ha.

Figure 4. Experimental plots, 2020

During the research conducted the following records and observations: counted the yield structure, recorded yield of oats, counted the mass of 1000 seeds. The experiments and studies were conducted in accordance with the guidelines [16]. Mathematical processing of data was carried out according to the methodology of Dospekhov B.A. [17].

Results and Discussion

Positive reaction of plants to the treatment with growth stimulator on seed germination was noted for all cultivars. However, responsiveness was mixed. The highest increase in field germination (and excess of control) was obtained by the cultivars “Korifej” (16,7 %), “Argument” (12,2 %), “Pegas” (14,3 %), “Rusich” (11,8 %), “Vektor” (7,6 %).

The study of yield structure elements of crops allows highlighting those of them that are paramount in determining its valueunder specific soil-climatic conditions (Tables 1, 2).

Table 1

Yield structure elements, 2020

No.	Cultivar	Experiment option	Plant height, cm	Number of stems on one plant, pcs	Panicle			Mass of 1000 grains, g
					Length, cm	Number of grains, pcs	Mass of grain from one plant, g	
1	Pegas	Control	80	1.3	11	25	1.59	26.2
		Guminatrin	82	1.4	10	26	1.64	27.4

Continuation of Table 1

No.	Cultivar	Experiment option	Plant height, cm	Number of stems on one plant, pcs	Panicle			Mass of 1000 grains, g
					Length, cm	Number of grains, pcs	Mass of grain from one plant, g	
2	Korifej	Control	81	1.2	13	24	1.51	26.7
		Guminatrin	83	1.2	11	28	1.64	29.4
3	Argument	Control	86	1.3	14	24	1.87	24.6
		Guminatrin	87	1.4	11	26	1.93	26.9
4	Vektor	Control	86	1.3	14	22	1.56	23.2
		Guminatrin	87	1.3	13	26	1.64	25.7
5	Rusich	Control	80	1.1	14	22	1.55	29.1
		Guminatrin	83	1.1	13	25	1.59	30.6
Statistics								
Mean			83.5	1.3	12.4	24.8	1.65	27.0
σ			2.7	0.1	1.4	1.8	0.13	2.1
Cv, %			3.2	8.1	11.5	7.2	7.94	7.9
SEM			0.9	0.03	0.5	0.6	0.04	0.7

Table 2

Yield structure elements, 2021

No.	Cultivar	Experiment option	Plant height, cm	Number of stems on one plant, pcs	Panicle			Mass of 1000 grains, g
					Length, cm	Number of grains, pcs	Mass of grain from one plant, g	
1	Pegas	Control	84	1.2	11	31	1.78	27.6
		Guminatrin	85	1.2	12	32	1.81	29.6
2	Korifej	Control	76	1.1	12	29	1.72	25.2
		Guminatrin	86	1.1	13	27	1.83	26.2
3	Argument	Control	84	1.1	9	24	1.35	21.9
		Guminatrin	92	1.1	10	29	1.54	22.6
4	Vektor	Control	76	1.1	13	29	1.27	23.3
		Guminatrin	85	1.1	13	33	1.41	24.7
5	Rusich	Control	83	1.1	11	26	1.14	26.8
		Guminatrin	92	1.1	14	31	1.28	29.2
Statistics								
Mean			84.3	1.1	11.8	29.1	1.51	25.7
σ			5.1	0.0	1.5	2.7	0.24	2.5
Cv, %			6.1	1.9	12.5	9.2	16.10	9.8
SEM			1.7	0.01	0.5	0.9	0.08	0.8

Under the 2020 conditions, all the yield structure elements studied except for the panicle length were higher on the Guminatrin option. So, the height of plants was on average 1.8 cm higher, the maximum obtained in the “Argument” and “Vector” cultivars — 87 cm. “Rusich” surpassed the control more than others, by 3 cm, with its average height of 83 cm. Average height was 83.5 cm.

The number of stems on one plantin the processed option exceeded the control only in cultivars “Argument” and “Pegas”, and that by only 0.1 pcs. Average number of stems on one plant was 1.3 pcs.

The panicle length was maximum at the control, exceeding the experimental option by an average of 1.6 cm. The shortest — 10 cm — was obtained from the “Pegas”. Average panicle length was 12.4 cm.

The number of grains from one panicle led by the “Korifej” cultivar — 28 pcs. on the Guminatrin variant, the lowest number obtained from “Vector” and “Rusich” cultivars was 22 pcs. The average excess over control was 2.8 pcs. Average number of grains from one panicle was 24.8 pcs.

The mass of grain from one plant in the processed option exceeded the control on average by 0.07 g. Maximum was obtained from the “Argument” — 1.93 g with Guminatrin and 1.87 g by control. Average mass of grain from one plant was 1.65 g.

The mass of 1000 grains were also higher on the Guminatrin option. “Rusich” cultivar showed the best result with 30.6 g, and the second place had “Korifej” cultivar with 29.4 g. The average excess over control was 2.04 g. Average mass of 1000 grains was 27.0 g.

The “Korifej” cultivar showed the great receptivity to treatment — the mass of 1000 grains after it increased by 2.7 g. The “Pegas” cultivar showed the lowest dependence, the increase was only 1.2 g. The “Vector” cultivar showed a 2.5 g increase, the “Argument” cultivar showed an increase of 2.3 g, the “Rusich” showed a 1.5 g increase.

Under the 2021 conditions, all the yield structure elements studied except for the number of grains from one panicle were higher on the Guminatrin option.

The “Pegas” cultivar showed the lowest responsiveness too. Plant height and panicle length has hardly changed, the increase was only 1 cm. The number of grains per plant has increased by 1 pcs., but “Pegas” showed a slight increase in the mass of grains from one plant, and as a consequence — an increase in the mass of 1000 grains by 2.0 g.

The “Korifej” cultivar showed the rise in plant height by 10 cm on the Guminatrin option — the first place among all studied cultivars. Its mass of grains from one plant increased by 0.11 g, the mass of 1000 grains — by only 1.0 g.

The “Argument” cultivar showed a rise in plant height by 8 cm, panicle length by 1 cm, number of grains from one panicle 5 pcs., the mass of grains from one plant in 0.19 g, the mass of 1000 grains has increased by only 0.7 g.

The “Vector” cultivar showed a rise in the plant height by 9 cm, in the number of grains from one panicle by 4 pcs., in the mass of grains from one plant by 0.14 g, and the mass of 1000 grains increased by only 1.4 g.

The “Rusich” cultivar showed a rise in the plant height by 9 cm, in the panicle length by 3 cm, in the number of grains from one panicle by 3 pcs., in the mass of grains from one plant 0.14 g per plant, and the mass of 1000 grains increased by 2.4 g.

Crop yield is a very important indicator, it shows how much production was obtained from one unit of the area. To increase the yield, it is necessary that optimal conditions for the growth and development of the plant are created. When the optimum is deviated, the yield decreases, so the use of growth stimulators allows not only to reduce the impact of adverse factors on the plant, but also to increase the yield at the expense of increasing resistance to external factors. Table 3 shows the yield of oats for 2020-2021.

Table 3

Yield of oats, t/ha

No.	Cultivar	Experiment option	Yield, t/ha			Yield gain	
			2020	2021	Mean	t/ha	%
1	Pegas	Control	1.56	1.85	1.71	-	-
		Guminatrin	1.75	2.42	2.09	0.38	22.2
2	Korifej	Control	1.60	1.77	1.69	-	-
		Guminatrin	2.20	2.08	2.14	0.46	27.0
3	Argument	Control	1.35	1.33	1.34	-	-
		Guminatrin	1.84	1.83	1.84	0.50	36.9
4	Vektor	Control	1.51	1.62	1.57	-	-
		Guminatrin	1.99	2.15	2.07	0.51	32.3
5	Rusich	Control	1.56	1.64	1.60	-	-
		Guminatrin	2.01	2.49	2.25	0.65	40.6
Statistics							
Mean			1.74	1.92	1.83	0.50	31.8
σ			0.25	0.35	0.28	0.09	6.6
Cv, %			14.64	18.10	15.38	17.57	20.8
SEM			0.08	0.12	0.09	0.04	3.3

Yield growth was between 22 and 40 percent. Based on the harvest data, it can be concluded that in 2021 the average yield was higher both on control and on the experiment, the exception being only the “Korifej” cultivar.

The yield of “Pegas” cultivar in 2021 was significantly higher than in 2020. At the control, the difference was 0.29 t/ha, at the experiment — 0.67 t/ha. Despite the significant change in crop yields in 2021, the trend of increased the yields with Guminatrin was maintained and stands at 12.2 % in 2020 and 23 % in 2021.

The “Korifej” cultivar also had an increase in the yield by control in 2021 compared to 2020, this increase was 0.17 t/ ha, the option with Guminatrin had a negative growth dynamic and it was 0.12 t/ ha. The average increase in control over two years was 0.46 t/ha or 27.0 %.

The average of the “Argument” cultivar over two years was almost identical and the difference was only 0.02 t/ha. But if we compare the options of the experiment, it turns out that the application of Guminatrin increased yield by 0.5 t/ha or 36.9 %.

The “Vector” cultivar had the same positive dynamics of yield growth in 2021 compared to 2020, it was 0.11-0.16 t/ha. The experiment with fertilizer gave an increase in yield of 0.51 t/ ha, which was an increase in yield by 32.27 %.

The “Rusich” cultivar showed the highest response to the use of Guminatrin, an increase of yield was 0.65 t/ha, which corresponds to a record increase in yields of 40.63 %.

The highest yield was generated by the use of Guminatrin in 2020 by the cultivars “Rusich” (2.01 t/ ha) and “Korifej” (2.20 t/ ha), in 2021 — by the cultivars “Pegas” (2.42 t/ ha) and also “Rusich” (2.49 t/ ha). On average for 2 years of the research, the yield of more than 2.0 t/ ha was formed at the background of Guminatrin by the “Pegas”, “Korifej”, “Vector” and “Rusich”.

Pre-seeding treatment of seeds and then the plants in the growing phase with Guminatrin fertilizer with a stimulating effect contributed to increased yields compared to control in both years of studies for all test options. In 2021, the increase of oats yields at the background of the treatment was higher than in 2020 by 0.01-0.47 t/ha. The average yield gain by 2 years was from 22.2 % to 40.6 %. The most responsive cultivar to the growth stimulant Guminatrin was “Rusich”.

Conclusions

Pre-seeding treatment of seeds and then the plants by vegetating with the stimulant Guminatrin contributed to an increase in the yield structure elements of the investigated oats cultivars, and as a consequence resulted in an increase in yield compared to control by 0,38-0.65 tons/ha.

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Органикалық гуминатрин тыңайтқышы бар сұлы өнімділігі

Қазіргі уақытта сұлы Ресейдің барлық дерлік аймақтарында өсіріледі. Зерттеудің мақсаты — Алтай өлкесінің Приобская аймағы жағдайында гуминатрин өсу стимуляторын қолдануға байланысты сұлы өнімділігінің қалыптасуын зерттеу. Жұмыс Алтай мемлекеттік аграрлық университетінің оқу учаскелері базасында 2020-2021 жылдары жүргізілді. Зерттеу объектілері «Корифей», «Пегас», «Аргумент», «Вектор», «Русич» сорттарының емен ағаштары болды. Жұмыс ерітіндісі 8 л суға 2 л гуминатрин мөлшерінде дайындалды. Өңдеу үшін жұмыс ерітіндісінің шығыны: тұқымдар — 1 тоннаға 10 л; өсімдіктер вегетациялық кезеңге сәйкес — 1 га-ға 1,5-2 л. Зерттеу барысында келесі жазбалар мен бақылаулар жүргізілді: өнімнің құрылымы, сұлы өнімділігі, 1000 тұқымның салмағы. Гуминатриннің өсу стимуляторына ең сезімтал сорт «Русич» болды. Тұқымдарды, содан кейін өсімдіктерді вегетациялық кезеңде гуминатринмен егу алдында өңдеу зерттелетін сұлы сорттарының өнімділік құрылымының элементтерінің жоғарылауына ықпал етті және нәтижесінде бақылаумен салыстырғанда өнімділіктің 0,38-0,65 т/га өсуіне әкелді.

Кілт сөздер: сұлы, сорттар, гуминатрин, өнімділік, дақыл құрылымының элементтері, өнімділіктің өсуі.

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Урожайность овса с органическим удобрением Гуминатрин

В настоящее время овес возделывается практически во всех регионах России. Цель наших исследований — изучить формирование урожайности овса в зависимости от применения стимулятора роста — Гуминатрина в условиях Приобской зоны Алтайского края. Работа проводилась на базе учебных участков Алтайского государственного аграрного университета в 2020–2021 гг. Объектами исследований служили дубравы сортов «Корифей», «Пегас», «Аргумент», «Вектор», «Русич». Рабочий раствор готовили из расчета 2 л Гуминатрина на 8 л воды. Расход рабочего раствора на обработку: семян — 10 л на 1 т; растений по вегетации — 1,5–2 л на 1 га. В ходе исследований проводились следующие учеты и наблюдения: структура урожая, урожайность овса, масса 1000 семян. Наиболее «отзывчивым» на стимулятор роста Гуминатрин оказался сорт «Русич». Предпосевная обработка семян, а затем растений по вегетации Гуминатрином способствовала увеличению элементов структуры урожая исследуемых сортов овса и, как следствие, привела к увеличению урожайности по сравнению с контролем на 0,38–0,65 т/га.

Ключевые слова: овес, сорта, Гуминатрин, урожайность, элементы структуры урожая, прирост урожайности.

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