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INCREASING THE OATS (*AVENA SATIVA*) PRODUCTIVITY WHEN CO-USE OF FERTILIZERS AND GROWTH REGULATOR IN CONDITIONS OF THE NONCHERNOZEM ZONE OF RUSSIA

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ABSTRACT

Recently, growth regulators have been used in agricultural practice as effective, economical and environmentally friendly products that increase the efficiency of growing crops. This article contains research materials for 2016-2018 on the study of the effect of the co-use of mineral fertilizers and the stimulator of growth (Emistim, R) on the growth, development and productive indices of spring oats (Avena sativa), recognized variety Skakun, on the gray forest, heavy loamy soil of Ryazan Oblast, the Russian Federation. As it has been established over the years of research, the yield of oats increases with respect to the control: on average by 31.8%, when introducing a reasonable amount of mineral fertilizers, on average by 17.1% when oats pretreatment with Emistim, R at a dose of 1 ml/ha (without fertilizers) and on average by 37.8 % when combining the application of mineral fertilizers and pretreatment of oats grain with elicitor agent, Emistim, R at a dose of 1 ml/ha.

Disciplinary: Agricultural Sciences (Soil and Plant Sciences).

1. INTRODUCTION

Since the 80s of the last century, oats in world agriculture are increasingly becoming a food crop. According to the Food and Agriculture Organization of the United Nations (FAO), in 2016 Russia occupied the leading place in the world for the production of oats (4,761.365 thousand tons), being ahead of such largest producers like Canada, Poland, Australia and Finland [1].

Oats in the Russian Federation occupy 10-12% in the general structure of acreage, which is less than spring barley. And yet oats in Russia should be considered an important grain-fodder crop, as it grows where other crops grow poorly. The main areas of oats are concentrated in the more humid and

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cold regions of the country. Due to a more powerful root system, oats are less demanding for soils than other grain crops. It can be cultivated on sandy loamy soils and areas with high acidity [2, 3, 4, 23]. The crop can grow on all types of soil, although the most productive ones are black earth and well-fertilized gray forest soils [14, 17]. At present, the genetic potential of grain crops, including oats, has not been completely realized yet, as modern varieties have a sufficiently high potential for productivity [8,10,15,18,19].

The system of agrotechnical methods is one of the main factors leading to the high yield of cereals. In the practice of recent Russian agriculture, the protection of plants from unfavorable weather factors, their growth stimulation and, as a result, an increase in the yield and resistance to diseases happen when modern growth regulators are used in crops growing technology [5, 6].

The action of bio-fertilizers and plant growth regulators is currently a promising direction, both in terms of increasing crop yields and taking into account the production of ecologically safe crop products [9, 16, 20, 22, 24].

2. METHOD

This research assesses the impact of the use of mineral fertilizer combinations and growth stimulator Emistim, R on the growth, development and productive indices of spring oats (*Avena sativa*), recognized variety Skakun, grown on the gray forest, heavy loamy soil of Ryazan Oblast, the Russian Federation.

As an object of research was taken Spring oats (*Avena sativa*), variety Skakun, recognized in Ryazan oblast was taken as an object of the research. To compare the effect of growth regulators used during the pretreatment on stimulating the process of oat seeds germination, we had a laboratory experiment on the most popular preparations in Russia in three replications. Seeds of spring oats (*Avena sativa*), variety Skakun was used as an object of the laboratory experiment. The greatest stimulating effect in lab experiments was achieved, when soaking oat seeds in a solution of elicitor growth regulator Emistim, R. This is an original preparation with an economical dose of 0.01 g / l containing a balanced complex of phytohormones, amino acids, carbohydrates, fatty acids, and micro-elements. It is a natural product of the metabolism of symbiotic fungus *Acremonium lichenicolous*, isolated from ginseng roots and containing growth substances of cytokinin and gibberellin nature, beta-lactam antibiotics, cyclosporine C, alkaloids with phytoalexin activity and hydroxylated isoprenoids.

Studies took place in 2016-2018 on the field of the experimental agrotechnological station of Ryazan State Agrotechnological University Named after P.A. Kostychev.

The fertilizer system was calculated based on agrochemical analysis when digging a hole in gray forest heavy loamy soils using the elementary balance method [7]. Fertilizers were applied to the plots in accordance with the following calculation norms in a dose $N_{135}P_{135}K_{75}$.

Placing options in plots is systematic. Agrotechnics is common for the Nonchernozem zone of Russia. Sowing of oats was carried out in the third decade of April, the seeding rate was 5 million pieces of germinating seeds/ha. Mineral fertilizers and lime (background) were introduced when pre-sowing cultivation. Pretreatment of oat seeds with growth regulator Emistim, R was carried out in three variants of doses and the dose of 1 ml/ha is recommended by the manufacturer.

The scheme of the field experience included the following options:

1. Control - without applying fertilizers and pretreatment with the stimulator.
2. Mineral fertilizers.
3. Mineral fertilizers+ lime.
4. Pretreatment with Emistim, R in a dose of 1ml/ha (without fertilizers).
5. Pretreatment with Emistim, R in a dose of 0.75ml/ha (without fertilizers).
6. Pretreatment with Emistim, R in a dose of 0.5ml/ha (without fertilizers).
7. Mineral fertilizers + pretreatment with Emistim, R in a dose of 1ml/ha.
8. Mineral fertilizers + lime + pretreatment with Emistim, R in a dose of 1ml/ha.

3. RESULTS AND DISCUSSION

It is well known that the formation of the oat crop after sowing begins with the provision of high field germination of seeds, the preservation and survival of plants, and the optimal crop density, that is, the developing conditions for growth and development, depending on the agricultural methods.

In general, for three years, the field germination of oats was lower in all varieties in 2016, and the highest in 2018. The maximum field germination in three years, equal to 91.6 %, was noted in the seventh variant with the introduction of mineral fertilizers and pretreatment with Emistim, R at a dose of 1 ml/ha. In this variant, the decisive role in increasing the field germination was exerted by optimal mineral nutrition of plants in combination with the effect of the growth regulator Emistim, R on the rate of plant growth and development. The use of only mineral fertilizers (variant 2) had the lowest result in field germination (88. 4 %), which is greater than the control variant only by 0.3 %.

Table 1: Structural elements of oats depending on the effect of mineral fertilizers, lime and Emistim, R, the average for 2016-2018

#	Variant	Stems per $1m^2$, pcs	Productive tilling capacity	Grains in panicle, pcs	Mass of 1000 grains, g	Length of panicle, cm	Height of plants, cm
1.	Control	364.8	1.16	35.6	28.2	12.9	85.3
2.	Mineral fertilizers	391.4	1.38	42.8	34.1	15.1	93.9
3.	Mineral fertilizers + lime	394.7	1.35	41.9	32.2	15.4	94.1
4.	Emistim, R, 1 ml/ha	411.2	1.22	46.0	31.3	14.5	86.6
5.	Emistim, R, 0.75 ml/ha	405.5	1.22	42.9	30.6	14.5	86.4
6.	Emistim, R, 0.5 ml/ha	400.7	1.17	42.0	30.0	14.0	86.4
7.	Mineral fertilizers + Emistim, R, 1 ml/ha	413.8	1.34	41.0	33.7	15.6	93.3
8.	Mineral fertilizers + lime + Emistim, R, 1 ml/ha	407.5	1.32	42.1	33.3	15.5	93.1

Plants safety for three years in all variants was lower in 2016, and the highest one in 2017. In general, the safety of oat plants in all variants was higher than that of the control. The seventh variant with mineral fertilizers and pretreatment with Emistim, R at a dose of 1 ml/ha had the best plant safety (90.2 %), which was on average 7.6 % higher than the control. Plants safety in the second variant (only with mineral fertilizers) was slightly lower (by 0.2 and 1.4%) than in variants 4 and 5 (only with pretreatment with Emistim, R, respectively in doses of 0.75 and 0.5 ml/ha). When comparing the obtained results of variants 2 and 3, and variants 7 and 8, one can note that the addition of lime as a whole adversely affected the safety of oat plants, although the difference between those variants was

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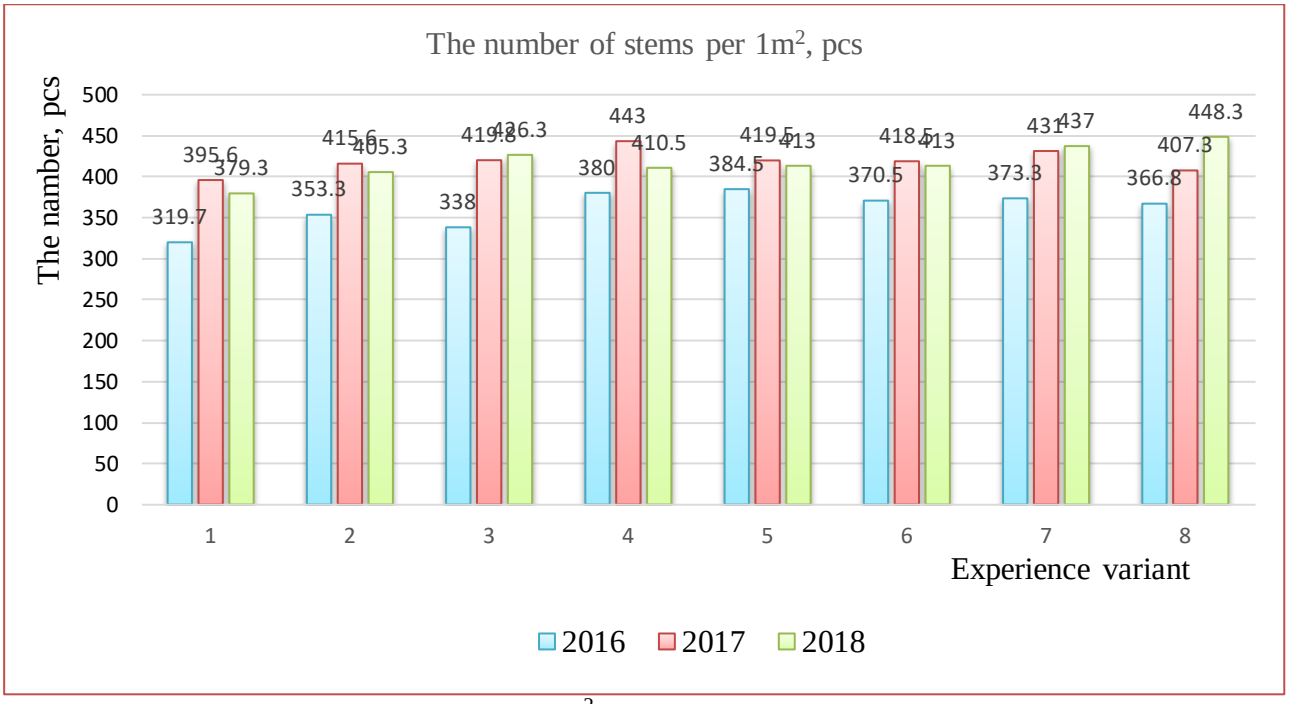
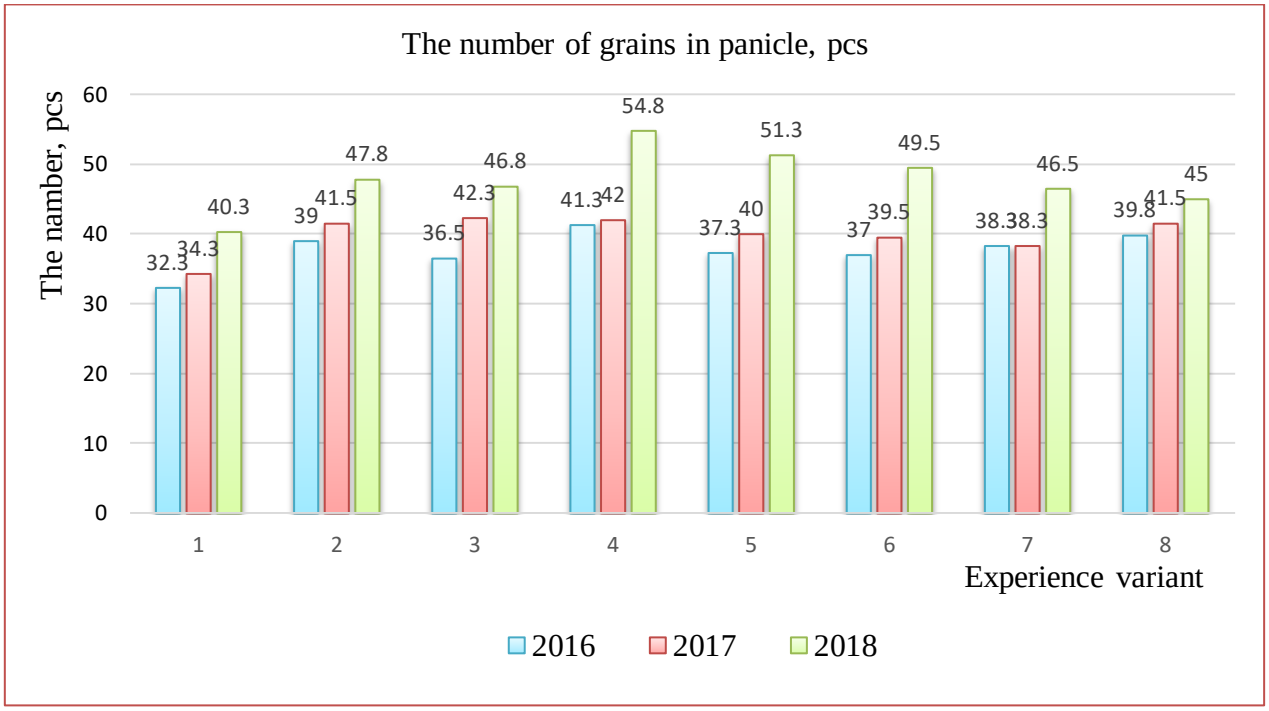
negligible (up to 1.2 %).

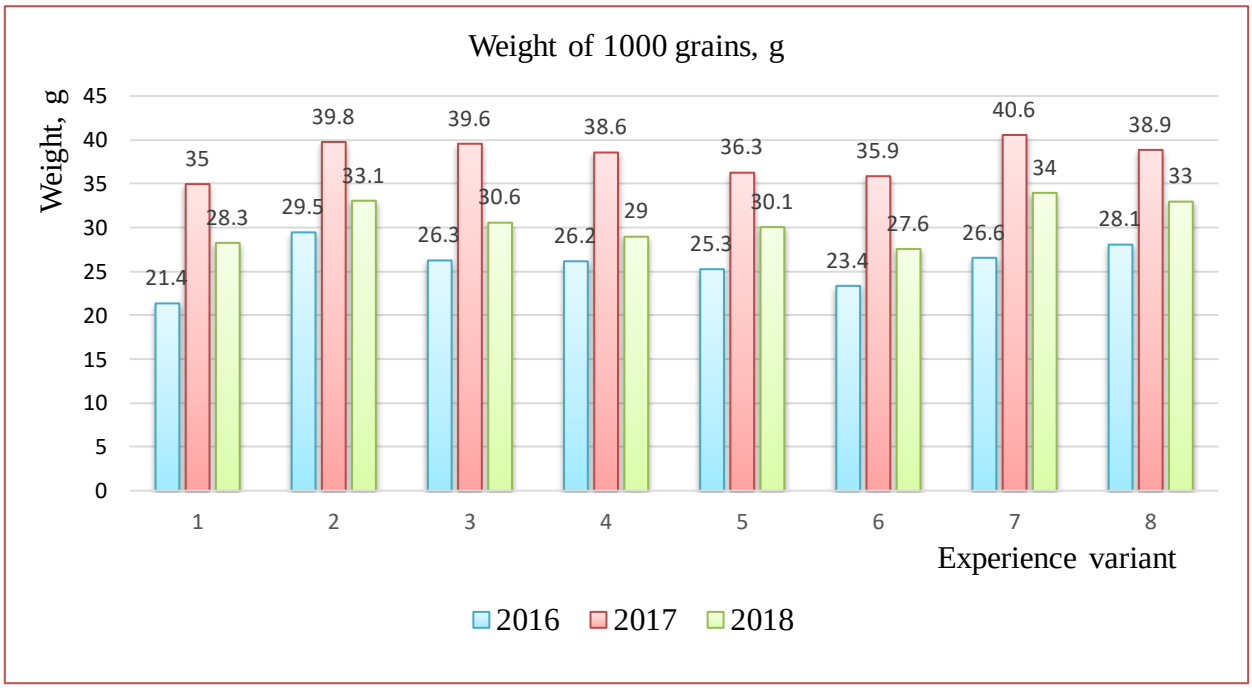
Table 1 and Figure 1 show the average data for three years of investigations on the effect of fertilizers and the growth regulator on the structural elements of oats, depending on the variants studied.



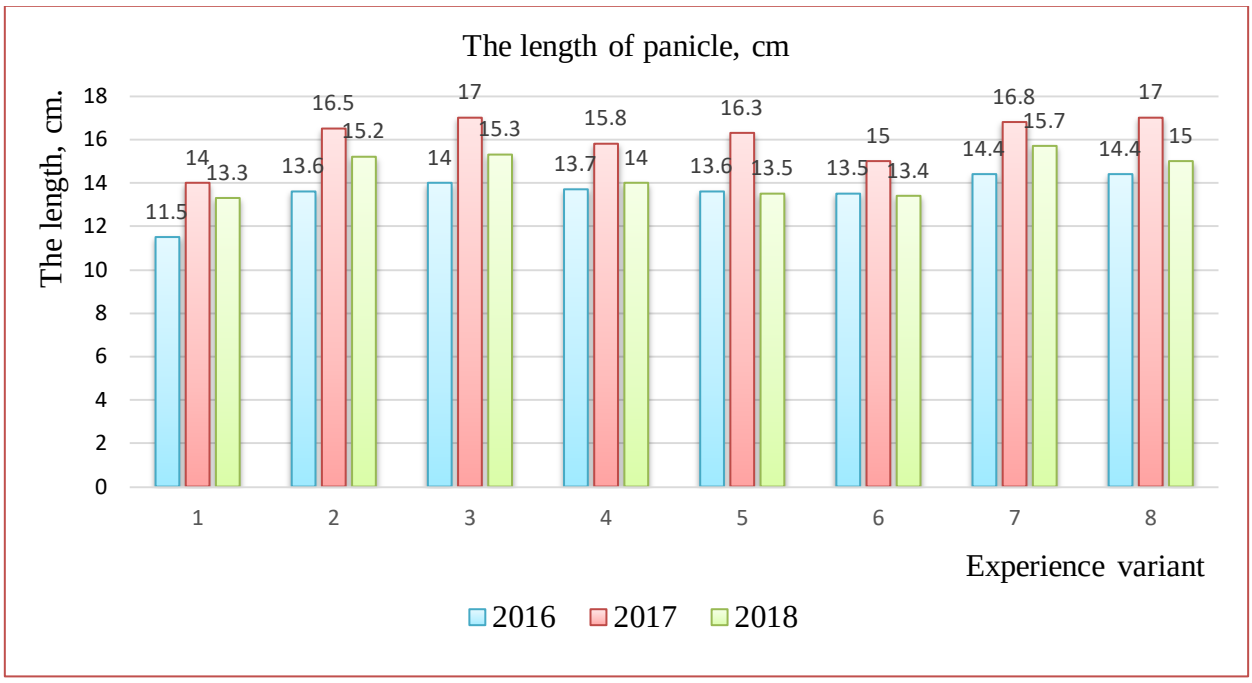
A) The number of stems before harvest, pcs / m^2 (1-control; 2- mineral fertilizer; 3- mineral fertilizer + lime; 4- Emistim, R 1 ml/ha; 5- Emistim, R 0.75 ml/ha; 6- Emistim, R 0.5 ml/ha; 7- mineral fertilizer + Emistim, R 1 ml/ha; 8 - mineral fertilizer + lime + Emistim, R 1 ml/ha).



B) The number of grains in panicle, pcs (1-control; 2- mineral fertilizer; 3- mineral fertilizer + lime; 4- Emistim, R 1 ml/ha; 5- Emistim, R 0.75 ml/ha; 6- Emistim, R 0.5 ml/ha; 7- mineral fertilizer + Emistim, R 1 ml/ha; 8 - mineral fertilizer + lime + Emistim, R 1 ml/ha)



C) Mass of 1000 grains, g (1-control; 2- mineral fertilizer; 3- mineral fertilizer + lime; 4- Emistim, R 1 ml/ha; 5- Emistim, R 0.75 ml/ha; 6- Emistim, R 0.5 ml/ha; 7- mineral fertilizer + Emistim, R 1 ml/ha; 8 - mineral fertilizer + lime + Emistim, R 1 ml/ha)



D) The length of panicle, cm (1 - control; 2 – mineral fertilizer; 3 – mineral fertilizer + lime; 4 - Emistim, R 1 ml/ha; 5 - Emistim, R 0.75 ml/ha; 6 - Emistim, R 0.5 ml/ha; 7 – mineral fertilizer + Emistim, R 1 ml/ha; 8 – mineral fertilizer + lime + Emistim, R 1 ml/ha)

Figure 1: Structural elements of oats by years, depending on the effects of mineral fertilizers, lime and Emistim, R

Analysis of the structural elements of oats yield shows that the decisive role in obtaining the yield is given to the crop density, which is determined by the variants used. The variant with mineral

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fertilizers + Emistim, R, at a dose of 1 ml/ha had the highest crop density (413.8 heads per 1 m^2), which is on average 13.4 % higher than the control (364.8 heads per 1 m^2).

The pretreatment with the preparation of Emistim, R in lower doses (variants 5 and 6) has better results in crop density parameter, than variants only with mineral fertilizers (variants 2 and 3). As it follows from the results obtained, oats pretreatment with growth regulator Emistim, R has the greatest influence on increasing the number of stems per 1 m^2 for 3 years.

Mineral fertilizers increased tilling capacity. The maximum values (1.38) were noted on the variant with the effect of mineral fertilizers without lime and pretreatment with Emistim, R, which was 18.9 % higher than the control one. In general, low indices of tilling capacity were found in variants 4, 5 and 6 with different doses of Emistim, R but without fertilizers.

In general, for all the variants of the 3 years' experiment, the fourth variant (without mineral fertilizers but with pretreatment with Emistim, R at a dose of 1 ml/ha) had the largest number of grains in the panicle (46.0 pcs.), which is 29.2 % more than that of the control. The role of mineral fertilizers in this indicator was ambiguous (variants 2 and 3), and its values were even worse than in variants with lower doses of Emistim, R without fertilizers (5 and 6). Moreover, there is a relative decrease in the number of grains in the panicle (up to 12 %) in variants 7 and 8 having the combination of mineral fertilizers and Emistim, R in comparison with variants 4, 5 and 6 without fertilizers.

In comparison with the control, the relative weight of 1000 grains in other variants of the field experiment in different years was higher: in 2016 from 9.3 to 31.3 %, in 2017 from 2.3 to 16 % and in 2018 from 2.5 to 20.1 %. Fertilizers as a whole had some positive effect on the mass of grains. The greatest weight, for three years of the research (34.1 g), was noted in the second variant (only with mineral fertilizers without pretreatment with Emistim, R), which was 20.9 % more than in the control variant. In general, in three years, the worst effect on the mass of grains was caused by pretreatment with Emistim, R in different doses (variants 4, 5 and 6) without mineral fertilizers.

On average, the combination of mineral fertilizers and pretreatment with Emistim, R had some positive effect on the length of the oats panicle. Thus, the maximum length of the panicle (15.6 cm) was noted in the variant with fertilizers and pretreatment with Emistim, R at a dose of 1 ml/ha, which was 20.9 % higher than the control variant.

Table 2 shows the data on the effect of fertilizers and the growth regulator on the yield of oats, depending on the variants studied.

Table 2: Oats yield, depending on variants.

#	Variant	Yield, t/ha				Average increase	
		2016	2017	2018	Average over 3 years	t/ha	%
1.	Control	2.31	3.51	2.75	2.86	-	-
2.	Mineral fertilizers	3.34	4.76	3.20	3.77	0.91	31.8
3.	Mineral fertilizers + lime	3.16	4.58	3.19	3.64	0.78	27.3
4.	Emistim, R, 1 ml/ha	2.97	4.12	2.96	3.35	0.49	17.1
5.	Emistim, R, 0.75 ml/ha	2.68	3.91	2.80	3.13	0.27	9.4
6.	Emistim, R, 0.5 ml/ha	2.51	3.69	2.74	2.98	0.12	4.2
7.	Mineral fertilizers + Emistim, R, 1 ml/ha	3.59	4.95	3.28	3.94	1.08	37.8
8.	Mineral fertilizers + lime + Emistim, R, 1 ml/ha	3.41	4.50	3.21	3.71	0.85	29.7
HCP_{05}		0.68	0.37	2.52			

Analysis of the data in Table 2 shows that all variants of the experiment had rather high and stable yields, higher than the average one for the region. In general, the differences between the variants of the experiment were small and were within the experimental error. 2017 turned out to be favorable especially on the moisture regime. At the same time, rainfalls at the end of vegetation caused crop lodging and yield decrease.

4. CONCLUSION

Our obtained data are well correlated and even exceed the results of studies on the co-use of nitrogen fertilizers and spraying of oats of Skakun variety in the tillering phase with a tank mixture of a herbicide and plant growth regulator (Reasil Universal) conducted by specialists of the Russian State Research Institute of Agriculture of the South-East [12, 13]. As a result, it was found that oats demonstrated the highest responsiveness when combined use of fertilizers, herbicides and a plant growth regulator (yield increase as compared to the control by 0.6-0.77 t/ha).

The maximum yield of oats (3.94 t/ha) in our investigations was noted on the variant with fertilizers and pretreatment with Emistim, R at a dose of 1 ml/ha, which is 37.8 % (1.08 t/ha) higher, than the control variant. The variant only with pretreatment with Emistim, R at a dose of 0.5 ml/ha without any fertilizers had the low yield (2.98 t/ha), which is insignificantly (4.2 %) different from the control variant. Thus, preparation Emistim, R increased the viability and field germination of seeds in investigations, revealed the potential of the variety, contributed to accelerated cell division, the development of a more powerful root system, an increase in leaf surface area and chlorophyll content. According to the results of the investigation, we recommend using the variant of the joint action of mineral fertilizers and the growth regulator in agricultural production, taking into account the soil and climatic features of the region.

5. AVAILABILITY OF DATA AND MATERIAL

Information can be made available by contacting the corresponding author.

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