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IMPROVING THE EFFICIENCY OF OAT CULTIVATION TECHNOLOGIES IN THE CENTRAL NON-BLACK EARTH REGION OF RUSSIA

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The research aim was to study the peculiarities of the formation of productivity of current varieties of oats of domestic selection (Argamak, Krechet, Yakov) when grown on different backgrounds of mineral nutrition (1-natural fertility (without fertilizers), 2 – $N_{16}P_{16}K_{16}$ when sown +N_{45} in the feeding (tillering phase), 3 – $N_{16}P_{16}K_{16}$ during sowing +N_{90} in feeding) and foliar treatments in the tillering phase with humic preparation Humate+7; give recommendations to the production based on the results obtained. Comprehensive research was conducted in 2018–2020 on the fields of the Educational Scientific and Innovative Production Center "Agrotechnopark" of the Tver State Agricultural Academy. Field and laboratory researches of photosynthetic activity indicators, crop structure, yield accounting, grain quality, mathematical processing of the results were carried out according to well-tested methods in agriculture. It was found that the greatest responsiveness to the applied fertilizers was distinguished by seed oats of the Yakov variety. The crops of this variety were obtained with foliar treatment at the tillering stage with a 1% working solution of Humate+7 against the background of application of $N_{16}P_{16}K_{16}$ at sowing and N90 in feeding grain yield. It is equal to 4.77 t/ha with the greatest grain in the experience – 559 g/l (which corresponds to the grain of the 1st class), and the lowest filminess is 23.4%. These features of the fertilizer system had a positive effect on the crops of all the studied varieties of oats. That allows us to recommend their production as the most promising. At the same time, it is worth noting that non-root feeding with Humate+7 is effective both in conditions of reducing doses of mineral fertilizers and in their complete absence, increasing grain yield by an average of 27.0%–31.5%. The increase in crop productivity is associated with an increase in the photosynthetic activity of plants in crops and an improvement in the main parameters of the crop structure (the density of the productive stem, the weight of grain from the panicle).

Keywords: *seed oats; variety; background of mineral nutrition; foliar treatment; productivity*

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ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ТЕХНОЛОГИЙ ВОЗДЕЛЫВАНИЯ ОВСА В ЦЕНТРАЛЬНОМ НЕЧЕРНОЗЕМЬЕ РОССИИ

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Целью работы было изучить особенности формирования продуктивности современных сортов овса отечественной селекции (Аргамак, Кречет, Яков) при выращивании на разных фонах минерального питания (1 – естественное плодородие (без удобрений), 2 – $N_{16}P_{16}K_{16}$ при посеве + N_{45} в подкормку (фаза кущения), 3 – $N_{16}P_{16}K_{16}$ при посеве + N_{90} в подкормку) и фолиарных обработках в фазу кущения гуминовым препаратом Гумат+7; дать на основании полученных результатов рекомендации производству. Комплексные исследования проводились в 2018-2020 годах на полях Учебного научно-инновационного производственного центра «Агротехнопарк» Тверской ГСХА. Полевые и лабораторные исследования показателей фотосинтетической деятельности, структуры урожая, учет урожайности, качество зерна, математическая обработка результатов выполнялись по хорошо апробированным в земледелии методикам. Установлено, что наибольшей отзывчивостью на применяемые удобрительные средства отличался овес посевной сорта Яков. Посевы данного сорта обеспечили при фолиарной обработке в фазу кущения 1%-ным рабочим раствором Гумата+7 на фоне внесения $N_{16}P_{16}K_{16}$ при посеве и N90 в подкормку урожайность зерна, равную 4,77 т/га с наибольшей в опыте натурой зерна – 559 г/л (что соответствует зерну 1-го класса) и наименьшей пленчатостью – 23,4%. Указанные особенности системы удобрения оказывали положительное воздействие на посевы всех исследуемых сортов овса, что позволяет рекомендовать их производству как наиболее перспективные. Вместе с тем, стоит отметить, что некорневая подкормка препаратом Гумат+7 является эффективной как в условиях уменьшения доз минеральных удобрений, так и при полном их отсутствии, повышая урожайность зерна в среднем на 27,0-31,5%. Рост продуктивности посевов связан с усилением фотосинтетической деятельности растений в посевах и улучшением основ-

ных параметров структуры урожая (густоты продуктивного стеблестоя, масса зерна с метелки).

Ключевые слова: *овес посевной; сорт; фон минерального питания; фолиарная обработка; продуктивность*

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Introduction

Seed oat (*Avena sativa* L.) is the most important food and fodder agricultural crop [21–23; 25–30]. In conditions of low natural fertility of sod-podzolic soils of the Central Non-Black Earth region of Russia, oat crops allow, subject to basic agrotechnical requirements, obtaining stable yields of high-quality grain. This property makes the presence of oat crops the norm for a huge group of agricultural enterprises. Oats are of particular value for the Tver region, which with 2032.7 thousand hectares of agricultural land, is one of the largest agro-industrial regions of the Central part of the Russian Federation, specializing in dairy and beef cattle breeding. More than 40 thousand hectares are occupied by oat crops here. That is more than 55% of all sown areas in the region sown with grain and leguminous crops. Despite such popularity among agricultural commodity producers, the yield of oat grain in recent years has been at a very low level, ranging from 0.99 (2018) to 1.46 (2015) t/ha. With the relative availability of highly productive varieties of intensive types of oats, which allow under certain conditions obtaining 7–8 or more tons of grain from 1 ha, the above-mentioned real level of productivity can be considered critically low. It requires developing integrated scientific approaches to optimize existing agricultural technologies [15–18; 33].

According to most scholars, one of the most effective factors in improving the yield and quality of crop production is a positive transformation of the system of fertilizer. This can improve the supply of plants with mineral nutrients, especially in the most critical stages of their development, and carried out by (1) the optimal ratio of doses and timing of application of traditional forms of mineral fertilizers and (2) the foliar exposure of different groups of current growth-regulating substances [10; 14; 16–19; 21–23; 25–33]. Among the most affordable are preparations based on humic and fulvic acids, obtained from local sources of raw materials (peat, coal, etc.) and having special effectiveness when used in combination with various biophilic macro - and microelements [10; 11; 14; 16–19; 21; 25; 28–31; 33].

Contemporary literature contains a significant number of research results of humic preparations, both when they are used separately, and in combination with other fertilizers [16; 18; 21; 25; 28; 33]. At the same time, the constant appearance of new varieties and fertilizers on the market and the significant variability of soil and climatic conditions require additional research from science to improve the efficiency of growing seed oats in particular and the crop production industry in general.

Materials and methods

The research aimed to study the peculiarities of the formation of productivity of different varieties of oats grown on different backgrounds of mineral nutrition and foliar treatments with Humate+7; to give recommendations to production based on the results obtained.

To achieve this goal, the following tasks were solved:

- To assess the features of the formation of indicators of photosynthetic activity of crops of oats of different varieties in conditions of different supply of their mineral nutrition;
- To identify the specifics of changing the parameters of the crop structure, yield values, and grain quality under the influence of experience factors.

Comprehensive research was conducted in 2018–2020 on the fields of the Educational Scientific and Innovative Production Center "Agrotechnopark" of the Tver State Agricultural Academy.

The soil of the experimental plots is sod-podzolic, well cultivated, sandy loam in granulometric composition, was characterized by the following agrochemical characteristics: humus content – 2.04% [6]; alkaline hydrolyzable nitrogen [12] – 66, P_2O_5 – 301, K_2O – 98 [8] mg/kg of soil; the pH of the salt extraction of the soil is 6.3 [7].

The research was carried out according to the following scheme:

- Factor A – seed oat variety: A_1 – Argamak (Originator of the Federal Agrarian Research Center of the North-East named after N. V. Rudnitsky," Russia), A_2 – Krechet (Federal Agrarian Scientific Center of the North-East named after N. V. Rudnitsky), A_3 – Yakov (Federal Research Center "Nemchinovka," Russia);
- Factor B – the background of mineral nutrition: B_1 – natural fertility (without fertilizers), B_2 – $N_{16}P_{16}K_{16}$ when sowing $+N_{45}$ in feeding, B_3 - $N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in feeding;
- Factor C – foliar treatment: C_1 – without treatment, C_2 – treatment with the preparation Humate+7 with the rate of consumption of the drug 1 l/ha.

Foliar treatment was performed with a manual sprayer of the Marolex brand in the oat tillering phase corresponding to 21–23 microphases according to the BBCH-code, with a working fluid flow rate of 100 l/ha.

The area under the experiment was 0.2 ha, the accounting area of the plot of the third order was 25 m^2, the repetition was fourfold, and the placement of options was by the split plot method [9].

The preparation Humate+7 used in the experiment is a liquid concentrated water-soluble fertilizer containing 10% of natural humic and fulvic acids with the addition of a group of trace elements (B, Mn, Cu, Mo, Zn, Mg, Fe, etc.) in a chelated form. It is produced by Agrotech Humate LLC, the city of Angarsk, Irkutsk region of the Russian Federation, as well as by regional branches of the Federal State Budgetary Institution "Rosselkhoznadzor".

Azofoska (nitroamofoska, NPK) with content of nitrogen, phosphorus, potassium of 16%:16%:16% was used as mineral fertilizers during sowing, ammonium nitrate with a nitrogen content of 34.4% was used in the crop care system (it was applied manually).

The technology of oat cultivation was generally accepted for the region. The predecessor is spring wheat. The main tillage included disc peeling of stubble and deep winter plowing, pre-sowing two cultivations with harrowing (the second was carried out perpendicular to the direction of sowing to a depth of 5-6 cm). Sowing was carried out with seeds of the elite category using a grain-fertilizing seeder SZ-5.4 Astra with a seeding rate of 5 million germinable seeds per hectare. The care system included the measures provided for by the experiment scheme, as well as the treatment of crops in the tillering phase of oats with the herbicide Granstar, water-dispersible granules (Tribenuron-methyl (500 g/kg) + Typhensulfuron-methyl (250 g/kg)). The harvesting of crops was carried out jointly with the continuous method with the help of the Terrion-Sampo SR2010 seed-breeding combined in the phase of full ripeness of oat grain.

According to the data of the Tver weather station, the agro-climatic conditions were heterogeneous, especially in terms of moisture content, thereby contributing to an increase in the efficiency of evaluating the studied experience factors. So, for the period of sowing and harvesting oats in 2018. $\Sigma t > 10°C$ was 2089.1° or 110.0% of the average long-term norm ,WW - 247 mm or 85.1% of the average long-term norm, the State Customs Committee for Selyaninov was 1.18, respectively, in 2019 - 1944.3° (102.4%), 270 mm (93.4%), 1.39, and in 2020 - 1945° (102.2%), 434 mm (151.2%), 2.23.

Field and laboratory researches of photosynthetic activity indicators [15; 18], crop structures [15], grain quality [1–5] and mathematical processing of the results [9] were performed according to well-tested methods in agriculture.

Results

The production process of plants is a complex biological phenomenon that allows the transformation of sunlight energy, hydrothermal resources, and nutrients into economically valuable products. Effective management of this process is the most important task of agronomic science at the entire stage of its development [17]. In our research, we adhered to the well-known concept of a stable correlation between the photosynthetic activity of plants in crops and their final productivity. For this reason, the main indicators of the photosynthetic activity of oat crops were taken into account (Table 1). The most important of them is the leaf area, which determines the ability to create the number of assimilates, necessary for the normal functioning of plants. At the same time, the photosynthetic surface of oat plants, as a rule, reaches its maximum development in the sweeping phase. It is established that the highest value as the average (22.2 thousand m^2/ha) and maximum (32.7 thousand m^2/ha) leaf area was characterized by crops of oats varieties of Yakov. For all the years of field experiments, that was allocated more powerful habitus, primarily due to the high biological productivity potential inherent in most current varieties. It is noteworthy that the highest values of the leaf surface (28.1 (average) and 32.7 (maximum) thousand m^2 / ha) were formed in the conditions of the best provision of crops with mineral nutrition, created by adding $N_{16}P_{16}K_{16}$ during sowing and N_{90} to the feeding, as well as a foliar treatment with Humate+7. The increase in the leaf area relative to the option without fertilizers was 93.8% on average during the vegetation and 105.8% on maximum. The increase directly from non-root fertilization was equal to 13.1% and 18.3%, respectively.

Slightly lower values of the leaf surface were characterized by oat crops of the Krechet varieties (average – 19.5 and maximum - 28.5 thousand m^2/ha) and Argamak (18.3 and 25.3 thousand m^2/ha). The growth of the leaf area from foliar treatment in these varieties was 18.7%–26.4% and 12.8%–19.9%, with its maximum efficiency achieved with the addition of $N_{16}P_{16}K_{16}$ and nitrogen fertilization (N_{90}).

The revealed regularities of the formation of the leaf apparatus of oat plants in crops were reflected in the power of the photosynthetic potential of crops. The maximum values of which were 1822.1 and 1951.5 thousand m^2×day/ha were achieved by Yakov and Krechet varieties under the conditions of the best provision of their mineral nutrition within the experiments. The parameters of the photosynthetic potential of sowing obtained in our experiments are close to the optimal values for grain crops (2.0–2.5 million m^2×day/ha) established by earlier studies [17; 18]. At the same time, when creating highly productive crops, it is important to strive not only for optimizing the maximization of overall indicators but also to take into account the dynamics of their formation with reference to the most critical phases of plant growth and development, as well as the course of formation of agroclimatic security for each specific growing season in general and the interphase period in particular.

The efficiency of the photosynthetic system is determined, first of all, by its ability to form assimilates and the intensity of their subsequent transformation into an economically valuable part of the crop. Thus, the greatest amount of grain per 1 thousand units of photosynthetic potential was formed by crops of oats varieties Krechet (2.48 kg) and Argamak (2.43 kg) at foliar treatment Humate+7 against the background of application of $N_{16}P_{16}K_{16}$ at sowing and of N_{90} in fertilizer, and in the variety Yakov (2.47 kg) when feeding Humate+7 in complex with a pre-sowing application of azofoska and fertilizer nitrogen (N_{45}). The identified productivity indicators of the photosynthetic potential of oat crops were achieved, in particular, due to improved net assimilation.

The increased photosynthetic activity of plants in oat crops directly affected the formation of elements of the crop structure (Table 2). The results of our early researches revealed that for the best realization of the productive potential, at least 300 plants with several productive stems of the order of 450-500 and grain weight of at least 1 gram per 1 panicle should be located on 1 m^2 [17; 18]. Crops with similar characteristics within the framework of the analyzed experimental data were obtained only in oats of the Krechet and Yakov varieties with non-root fertilization with Humate +7 in combination with the addition of $N_{16}P_{16}K_{16}$ and nitrogen fertilization (N_{90}). The number of plants to be harvested in these variants was 337-340 pcs./m^2, productive stems 457–461 pcs./m^2, grain weight from 1 panicle 1.013-1.020 g with the graininess of one inflorescence equal to 29.2%–30.0%. Foliar treatment of crops with Humate+7 increased the number of grains in the panicle on average for varieties from 19.1% to 22.1%, the weight of grain from the inflorescence from 22.3% to 25.3%. The improvement of the panicle parameters, both from leaf fertilization and from root fertilization with nitrogen fertilizers, is primarily explained by the timing of their use, coinciding with the III and IV stages of organogenesis, when the number of segments and spikelet tubercles in the inflorescence is formed.

The improvement of the elements of the crop structure under the conditions of optimization of mineral nutrition conditions naturally affected the final productivity of oat crops (Table 3). Thus, the highest yield of grain (4.77 t/ha) and straw (6.46 t/ha) in the experiment was obtained in the Yakov variety with foliar treatment with Humate+7 against the background of the introduction of

$N_{16}P_{16}K_{16}$ during sowing and N_{90} in feeding. The highest grain nature (559 g/l) and its lowest filminess (23.4%) were also noted in this variant. These conditions for the formation of the fertilizer system contributed to strengthening the orientation of the production process in other studied oat varieties, contributing to an additional increase in the mass of 1000 grains and an increase in their laboratory germination.

The treatment of crops directly with the preparation Humate+7 contributed to an increase in grain yield by 27.0%–31.5%, straw by 24.3%–31.1%, and was accompanied by a significant improvement in the technological qualities of grain.

Table 1.

Indicators of photosynthetic activity of oat crops, on average for three years

Variety (A)	Background of mineral nutrition (B)	Foliar treatment (C)	The area of the sowing leaves, thousand m² / ha		Photosynthetic potential of sowing (FPP), thousand m ²×day/ha	Productivity of 1 thousand units of FPP, kg	Net productivity of sowing (on average during the growing season), g/m ²×day
			average for the growing season	maximum			
Argamak	Natural fertility	Without treatment	12.1	16.1	868.2	1.92	5.28
		Humate+7	15.3	19.3	1081.4	2.00	5.52
	N_{16} $P_{16}K_{16}$ when sowing $+N_{45}$ in the feeding	Without treatment	17.7	24.8	1222.6	2.13	5.51
		Humate+7	19.9	28.5	1418.2	2.23	5.74
	$N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in the feeding	Without treatment	21.8	30.1	1560.3	2.20	5.79
		Humate+7	23.0	32.7	1625.1	2.43	5.93
	On average		18.3	25.3	1296.0	2.15	5.63
Krechet	Natural fertility	Without treatment	12.3	18.8	907.8	2.08	5.44
		Humate+7	14.6	21.2	1070.6	2.24	5.63
	$N_{16}P_{16}K_{16}$ when sowing $+N_{45}$ in the feeding	Without treatment	18.9	26.7	1374.8	2.20	5.85
		Humate+7	22.2	31.1	1563.7	2.32	6.01
	$N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in the feeding	Without treatment	23.7	34.1	1718.3	2.32	5.98
		Humate+7	25.3	39.1	1822.1	2.48	6.14
	On average		19.5	28.5	1409.6	2.27	5.84

End of Table 1.

Yakov	Natural fertility	Without treatment	14.5	20.7	1070.2	1.90	5.60
		Humate+7	16.4	24.5	1258.3	2.12	5.77
	$N_{16}P_{16}K_{16}$ when sowing $+N_{45}$ in the feeding	Without treatment	23.0	31.4	1555.7	2.12	5.93
		Humate+7	24.5	36.8	1680.8	2.47	6.05
	$N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in the feeding	Without treatment	26.4	39.9	1796.9	2.34	6.07
		Humate+7	28.1	42.6	1951.5	2.44	6.24
	On average		22.2	32.7	1552.2	2.23	5.94

Table 2.

Indicators of the structure of the oat crop, on average for 3 years

Variety (factor A)	Background of mineral nutrition (factor B)	Foliar treatment (C)	Number of plants to be harvested, pcs/m²	Number of shoots with a panicle, pcs./m²	Productive bushiness, units.	The number of grains in the inflorescence, pcs.	Grain weight per inflorescence, g	Plant height, cm
Argamak	Natural fertility	Without treatment	302	356	1.18	15.2	0.501	82.2
		Humate+7	307	367	1.20	18.1	0.613	84.8
	$N_{16}P_{16}K_{16}$ when sowing $+N_{45}$ in the feeding	Without treatment	314	389	1.24	21.4	0.704	91.9
		Humate+7	320	401	1.25	23.3	0.798	94.0
	$N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in the feeding	Without treatment	316	414	1.31	25.2	0.869	93.1
		Humate+7	322	424	1.32	27.0	0.962	97.6
	On average		314	392	1.25	21.7	0.741	90.6
Krechet	Natural fertility	Without treatment	313	368	1.18	16.1	0.534	88.2
		Humate+7	325	382	1.18	19.4	0.656	91.3
	$N_{16}P_{16}K_{16}$ when sowing $+N_{45}$ in the feeding	Without treatment	327	400	1.22	23.2	0.804	96.9
		Humate+7	330	416	1.26	24.9	0.887	100.4
	$N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in the feeding	Without treatment	332	433	1.30	26.8	0.941	101.3
		Humate+7	337	457	1.36	29.2	1.013	105.0
	On average		327	409	1.25	23.3	0.806	97.2

End of Table 2.

Yakov	Natural fertility	Without treatment	322	414	1.29	14.9	0.521	90.2
		Humate+7	326	427	1.31	18.2	0.653	94.1
	$N_{16}P_{16}K_{16}$ when sowing +N_{45} in the feeding	Without treatment	331	438	1.32	22.6	0.772	103.6
		Humate+7	336	454	1.35	25.8	0.938	106.2
	$N_{16}P_{16}K_{16}$ when sowing +N_{90} in the feeding	Without treatment	340	461	1.36	27.1	0.922	105.5
		Humate+7	344	476	1.38	30.0	1.020	109.1
	On average		333	445	1.34	23.1	0.804	101.5

Table 3.

The yield and quality of oat grain, on average for 3 years

Variety (factor A)	Background of mineral nutrition (factor B)	Foliar treatment (C)	Yield, t / ha		Grain nature, g / l	Filminess, %	Weight of 1000 grains, g	Laboratory germination, %
			grain	straw				
Argamak	Natural fertility	Without treatment	1.67	2.22	484	26.1	33.64	90.1
		Humate+7	2.16	2.91	492	25.6	34.17	91.1
	$N_{16}P_{16}K_{16}$ when sowing + N_{45} in the feeding	Without treatment	2.61	3.60	501	25.2	33.89	92.2
		Humate+7	3.16	4.23	509	24.6	34.91	92.9
	$N_{16}P_{16}K_{16}$ when sowing +N_{90} in the feeding	Without treatment	3.44	4.70	510	25.0	35.01	92.5
		Humate+7	3.95	5.08	517	24.5	35.87	93.3
Krechet	Natural fertility	Without treatment	1.89	2.60	533	24.7	33.98	93.8
		Humate+7	2.40	3.34	538	24.3	34.77	94.4
	$N_{16}P_{16}K_{16}$ when sowing +N_{45} in the feeding	Without treatment	3.03	4.25	544	24.0	35.30	95.0
		Humate+7	3.62	4.82	550	23.6	35.93	95.7
	$N_{16}P_{16}K_{16}$ when sowing +N_{90} in the feeding	Without treatment	3.98	5.34	549	23.9	35.13	95.1
		Humate+7	4.51	5.80	553	23.6	35.22	96.3

End of Table 3.

Yakov	Natural fertility	Without treatment	2.03	3.12	539	24.8	35.02	92.4
		Humate+7	2.67	3.88	545	24.4	36.54	93.6
	$N_{16}P_{16}K_{16}$ when sowing $+N_{45}$ in the feeding	Without treatment	3.30	4.79	550	23.7	35.46	93.0
		Humate+7	4.15	5.68	554	23.5	36.44	94.1
	$N_{16}P_{16}K_{16}$ when sowing $+N_{90}$ in the feeding	Without treatment	4.21	6.01	553	23.6	34.53	93.2
		Humate+7	4.77	6.46	559	23.4	34.60	94.5
NDS_{05} (least significant difference at 5% significance level), the grain yield: for a factor A – 0.17; for factor B – 0.22; for factor C – 0.20; to interaction AB – 0.23; to interaction AC – 0.23; to interaction BC – 0.24; to interaction ABC – 0.25; yield straw: for A – 0.25; for B – 0.32; for C – 0.24; for AB – 0.27; for AC – 0.28; for ABC – 0.32; for ABC is 0.34 t/ha.								

Discussion

Optimization of the production process of current varieties of oats, characterized by a high biological potential, is determined primarily by the rationalization of mineral nutrition of crops, achieved by harmonizing the combination of traditional and innovative forms of fertilizers [10; 14; 16–19; 21–23; 25–33]. In long-term field experiments, we have proved the feasibility of using foliar treatments of oat crops with various types of fertilizers. It is also confirmed by the results of other authors [17; 18]. Humic fertilizers are the most promising from an ecological and economic point of view. Most authors point to a significant expansion of the positive impact of humic preparations (including those containing trace elements) when using them with traditional forms of mineral fertilizers [10; 11; 14; 16–19; 21; 25; 28; 29; 31; 33].

Numerous studies have established the positive effect of humic substances on the course of organ formation of plants, with both vegetative (leaves, stems, roots) and generative (inflorescences of cereals, potato tubers, etc.) [21; 14; 17; 33]. At the same time, it is necessary to take into account the need to approach the terms of use of fertilizers to the most critical stages of plant growth and development, coinciding with the formation of the main elements of productivity [11; 30]. For oats, such a period is the tillering phase, when the main parameters of the future inflorescence are being formed. Strengthening of mineral nutrition during this period allows one to directly influence the length of the inflorescence and the number of spikelets in it [16; 17]. In addition, there is an intensive increase in the leaf surface at this stage, between the size of which and the yield, there is a close correlation [13; 19; 32]. Improving the conditions of fertilization of crops at the initial stages of plant development creates prerequisites for a general strengthening of the course of the production process. It persists throughout the growing season and contributes to an increase in both the yield and quality of the products obtained.

Further improvement of technologies for the use of humic fertilizers should include combining foliar treatment with the chemical weeding of crops. Thus, it will allow correcting, as a rule, the stress effect of herbicides on the growth processes of cultivated plants, as well as to reduce the financial costs for the multiplicity of sprays. This property is of particular value when using tank mixtures of herbicides.

Conclusion

Thus, as a result of complex researches performed on sod-podzolic soils of the Central Non-Black Earth Region of Russia, the peculiarities of the formation of photosynthetic activity indicators, crop structure, yield, and crop quality of three current" highly productive varieties (Argamak, Krechet, Yakov) were revealed. It was found that the greatest responsiveness to the applied fertilizers was distinguished by seed oats of the Yakov variety. The crops of this variety were obtained with foliar treatment at the tillering stage with 1% working solution of Humate+7 against the background of application of $N_{16}P_{16}K_{16}$ at sowing and of N_{90} in feeding grain yield equal to 4.77 t/ha with the greatest grain in the experience – 559 g/l (which corresponds to the grain of the 1st class), and the lowest filminess is 23.4%. These features of the fertilizer system had a positive effect on the crops of all the studied varieties of oats, which allows us to recommend their production as the most promising. At the same time, it is worth noting that non-root feeding with Humat+7 is effective both in conditions of reducing doses of mineral fertilizers and in their complete absence, increasing grain yield by an average of 27.0%–31.5%. The increase in crop productivity is associated with an increase in the photosynthetic activity of plants in crops and an improvement in the main parameters of the crop structure (the density of the productive stem, the weight of grain from the panicle).

At further stages of research, it is planned to expand the number of studied humic preparations and the conditions for their use to study the feasibility of their use as part of various tank mixtures of herbicides.

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