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4.1.1.- Общее земледелие, растениеводство (сельскохозяйственные науки)

УРОЖАЙНОСТЬ И КАЧЕСТВО ЗЕРНА ОЗИМОЙ ПШЕНИЦЫ В ЗАВИСИМОСТИ ОТ СРОКА ПРИМЕНЕНИЯ РАЗЛИЧНЫХ ФОРМ АЗОТНЫХ УДОБРЕНИЙ

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Изучено влияние аммиачной селитры и серосодержащего азотного удобрения нитрат-сульфат аммония в дозе N_{140} на рост и продуктивность озимой пшеницы при разовом (под основную обработку N_{140}) и дробном (N_{70}- основное+ N_{70} рано весной, а также N_{70} – основное + N_{35} рано весной+ N_{35} в трубкование) внесении на фоне $P_{90}K_{60}$. Удобрения с нормой $N_{140}P_{90}K_{60}$ способствовали увеличению густоты продуктивного стеблестоя с 361 до 673 шт./м²,озернённости колоса с 28,2 до 31,4 шт., в результате чего урожайность озимой пшеницы увеличилась с 4,10 до 7,73 т/га или на 88,5%. При этом форма азотного удобрения не оказывала достоверного влияния на продуктивность культуры. Урожайность зерна при дробном внесении азотных удобрений была существенно (на 0,23-0,35 т/га при $НСР_{05}$-0,16 т/га) выше, чем при разовом. На синтез белков и клейковины сульфат- нитрат аммоний оказывал большее положительное влияние, чем аммиачная селитра. При применении серосодержащего азотного удобрения содержание белка в зерне было на 1,1-

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4.1.1. General farming, crop production (agricultural sciences)

YIELD AND GRAIN QUALITY OF WINTER WHEAT DEPENDING ON DIFFERENT FORMS NITROGENOUS FERTILIZERS TERMS

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The effects of ammonium saltpeter and sulfur-containing nitrogenous fertilizer ammonium nitrate sulfate with rate N_{140} on the growth and productivity of winter wheat with one time use (for basic tillage N_{140}) and fractional application (N_{70} –as a basis + N_{70} during early spring, as well as N_{70}- as a base fertilizer + N_{35} in the period of stem extension) on the background of $P_{90}K_{60}$ has been studied. Fertilizers rate of $N_{140}P_{90}K_{60}$ led to an increase of productive plant stand density from 361 to 673 pcs/m, ear grain content from 28,2 to 31,4 pcs, as a result of which winter wheat yield increased from 4,10 to 7,73 t/ha or 88,5%. At the same time nitrogenous fertilizers form didn’t show reliable impact on crop productivity. Crop yield under fractional application of fertilizers was essentially higher (by 0, 23-0,35 t/ha under LSD05 -0,16 t/ha) than in conditions of the single use. For protein and gluten synthesis sulphate nitrate of ammonium had a greater positive effect than ammonium nitrate. Application of the sulfur-containing nitrogenous fertilizer gave an increase of grain protein up to 1,1 - 1,4 %, the amount of crude gluten was 0,3-0,9%

1,4%, а сырой клейковины на 0,3-0,9% больше, чем на аналогичных вариантах с внесением аммиачной селитры. Качество клейковины на всех варианта опыта соответствовало требованиям первой группы.

above comparable variants with the ammonium nitrate option. The gluten quality in all experimental variants corresponded to the requirements of the first group

Ключевые слова: ОЗИМАЯ ПШЕНИЦА, ФОРМА АЗОТНЫХ УДОБРЕНИЙ, СРОК ПРИМЕНЕНИЯ, ПРОДУКТИВНОСТЬ

Keywords: WINTER WHEAT, NITROGEN FERTILIZER FORM, APPLICATION PERIOD, PRODUCTIVITY

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Introduction

Increasing winter wheat production is inextricably linked with optimizing plant nutrition through the application of mineral fertilizers, including nitrogen. Winter wheat requires nitrogen from seed germination until grain filling is complete, but the consumption of this element varies at different stages of crop ontogenesis. According to long-term research, wheat consumes approximately 20% of its maximum nitrogen requirement during the tillering phase, 50-55% during the tube-to-earing phase, 10-15% during the flowering-early wax ripeness phase, and 5-10% by mid-wax ripeness [3]. Good supply of winter wheat with nitrogen during the early periods of growth and development ensures high yields due to a significant increase in the density of productive stems and the number of spikelets per ear. The use of nitrogen fertilizers during later phases has little effect on yield but significantly improves grain quality [2,4,6]. Along with nitrogen, such a macroelement as sulfur also plays an important role in increasing the yield and grain quality of winter wheat when grown on leached chernozem.

In the leached chernozem of the Western Ciscaucasia, the content of mobile sulfur is below the "critical level," that is, the sulfur content in the soil below which yield declines due to sulfur deficiency. The "critical level" or threshold value of sulfate sulfur concentration in the soil for grain crops is 0.8 mg per 100 g of soil (Smirnov Yu.A., 1983). Leached chernozem belongs to the group of chernozems with a low content of mobile sulfur in the humus-accumulative horizon - less than 0.6 mg per 100 g of soil. That is, such an insufficient supply of this chernozem subtype with mobile sulfur is a limiting factor in increasing the yield of grain crops, including winter wheat [7].

Despite the large number of studies examining the effectiveness of fertilizer application to winter wheat crops, they do not address many issues, particularly factors such as the form of nitrogen fertilizer and the timing of its application. Therefore, the aim of our study was to investigate the impact of the timing of application of ammonium nitrate and the sulfur-containing nitrogen fertilizer ammonium sulfate nitrate on the yield and grain quality of winter wheat.

Materials and methods of research. The research was conducted in the 2024-2025 agricultural year at the first department of the educational and experimental farm "Kuban" of the Kuban State Agrarian University.

The effect of the timing of application of ammonium nitrate and the sulfur-containing nitrogen fertilizer ammonium sulfate nitrate on the yield and grain quality of winter wheat was studied. The experimental design is presented in Table 1.

Table 1 - Experimental design

A form of nitrogen fertilizer	Fertilizer application period
Ammonium nitrate NH4NO3- Contains N34	Without fertilizer (k)
	Main-N140
	Main-N70 Early spring - N70
	Main - N70 Early spring-N35 In tubing - N35
Ammonium sulfate nitrate (NH4)2SO4 *NH4NO3 Contains N26S13	Without fertilizer (k)
	Main-N140
	Main - N70 Early spring - N70
	Main - N70 Early spring - N35 In tubing - N35

Note: The effectiveness of various nitrogen fertilizers was studied against the background of application under primary tillage $P_{90}K_{60}$.

The total plot area is 540 m² (30 m * 18 m), the accounting area is 104 m² (26 m * 4 m). The experiment was repeated three times.

The soil of the experimental plot is represented by extremely deep, low-humus leached chernozem. The humus content in the arable horizon is 3.1-3.4%, total nitrogen 0.18%, phosphorus 0.16-0.18%, and potassium 1.5-2.0%, with an aqueous pH of 6.8-7.0. The soil texture is heavy: physical clay content ranges from 61-64%, and silt fraction 37-44%.

The central zone of the Krasnodar Krai is characterized by unstable moisture conditions. According to long-term data, annual precipitation is 643 mm. Weather conditions for the 2024-2025 agricultural year can generally be described as satisfactory for winter wheat harvesting.

The mid-late, semi-dwarf, highly lodging-resistant winter wheat variety "Gomer" was sown in the experiment, following sunflower as a predecessor. The agronomic practices used in the winter wheat cultivation in the experiment were those recommended for the central zone of Krasnodar Krai when grown after row-crop sunflower, with the exception of the agronomic practices studied in the experiment.

Observations, records, and analyses in the experiment were conducted in accordance with the current plant growing methodology of the "State Variety Testing of Agricultural Crops" (1989). Statistical processing of winter wheat yield data was performed using the variance analysis method according to B.A. Dospekhov [1] on a personal computer of the Plant Growing Department using the "Data Analysis" package of Microsoft Excel 2013.

Discussion.

Tillering and rooting processes are crucial for the productivity of winter crops. Properly tillered in the fall, winter crops grow back better in the spring, producing numerous spike-bearing stems. They are more resistant to pest damage and disease, and also create a dense cover of shoots and leaves on the soil surface, allowing for more effective weed control. The formation of new above-ground organs is accompanied by the simultaneous development of nodal roots. A robust root system allows plants to better utilize soil moisture and nutrients.

Bushiness is determined by the number of stems per plant. This indicator, a genetic characteristic of the variety, varies depending on the growing area, as well as the availability of moisture and nutrients.

Analysis of the data on tillering of winter wheat plants obtained in our experiment showed that the highest number of shoots in all variants were found in plants at the end of the spring tillering phase - 3.6-7.4 pcs./plant (Table 2).

During subsequent vegetation, shoot dieback was observed, and by the milk stage of grain maturity, the total tillering rate in the variants using ammonium nitrate was 2.5-2.9 shoots per plant, while in the variants using ammonium sulfate-nitrate, it was 2.2-3.0 shoots per plant. This was higher than the control, based on the applied forms of nitrogen fertilizer, by 0.4-0.8 and 0.1-0.8 shoots per plant. The use of ammonium nitrate and ammonium sulfate-nitrate increased shoot formation during autumn and spring tillering and reduced the rate of tillering during the boot-earing phase. At the end of the tillering phase in spring, as well as during the milk stage of grain maturity, plants with a one-time application of nitrogen fertilizers during primary tillage had the highest tillering rate.

Table 2 - Effect of the period of application of various forms of nitrogen fertilizers on the tillering coefficient of winter wheat plants, pcs/plant (2025)

<table>
<tr><th rowspan="2">A form of nitrogen fertilizer</th><th rowspan="2">Fertilizer application period</th><th colspan="4">Vegetation phase</th></tr>
<tr><th>tillering (in spring)</th><th>exit to the tube</th><th>colo-sheniye</th><th>dairy grain maturity</th></tr>
<tr><td rowspan="4">Ammonium nitrate</td><td>Without fertilizer (k)</td><td>3.7</td><td>3.2</td><td>2.9</td><td>2.1</td></tr>
<tr><td>Main-N140</td><td>7.2</td><td>3.9</td><td>3.5</td><td>2.9</td></tr>
<tr><td>Main-N70
Early spring - N70</td><td>6.5</td><td>4.2</td><td>4.0</td><td>2.7</td></tr>
<tr><td>Main - N70
Early spring-N35
In tubing - N35</td><td>7.2</td><td>4.6</td><td>4.1</td><td>2.5</td></tr>
<tr><td rowspan="3">Ammonium sulfate nitrate</td><td>Without fertilizer (k)</td><td>3.6</td><td>3.3</td><td>2.9</td><td>2.2</td></tr>
<tr><td>Main-N140</td><td>7.4</td><td>4.1</td><td>3.6</td><td>3.0</td></tr>
<tr><td>Main - N70</td><td>6.5</td><td>4.1</td><td>4.0</td><td>2.4</td></tr>
</table>

	Early spring - N70				
	Main - N70 Early spring - N35 In tubing - N35	6.1	4.8	4.1	2.3

Establishing a highly productive winter wheat crop requires a comprehensive set of timely agricultural practices tailored to the biological needs of the plants, the characteristics of the specific field, and the variety, in order to maximize the support of the plant's primary process—photosynthesis. This process is determined by the size of the plant's assimilative surface area and its intensity. Therefore, it must be optimal in both size and growth rate.

Observations of the dynamics of winter wheat leaf surface area in our experiment showed that, across all experimental variants, it increased most rapidly during the booting phase and reached its maximum size during the heading phase—39.5–57.6 thousand m²/ha (Table 3). By the onset of the milky stage of grain maturity, the assimilation surface area had decreased by 1.8–2.6 times compared to the heading phase.

The use of ammonium nitrate and ammonium sulfate-nitrate contributed to the formation of an assimilation surface close to the optimal value, which was larger compared to unfertilized variants, in the tillering phase in spring by 0.93-1.27 and 1.34-1.38 thousand m²/ha, in booting by 5.3-8.6 and 6.5-10.5 thousand m²/ha, in heading by 14.5-17.7 and 15.6-18.1 thousand m²/ha, and in milk ripeness of grain by 15.0-16.5 and 15.4-17.0 thousand m²/ha.

Table 3 - Effect of the period of application of various forms of nitrogen fertilizers on the formation of the assimilation surface of leaves in winter wheat crops, thousand m²/ha (2025).

A form of nitrogen fertilizer	Fertilizer application period	Vegetation phase			
		tillering (in spring)	exit to the tube	colo-sheniye	dairy grain maturity
Ammonium nitrate	Without fertilizer (k)	1.20	30.9	39.6	15.2
	Main-N_{140}	2.13	36.2	54.1	30.2
	Main-N_{70} Early spring-N_{70}	2.17	40.0	56.5	30.9
	Main- N_{70} Early spring-N_{35} In tubing- N_{35}	2.47	39.5	57.3	31.7
Ammonium sulfate nitrate	Without fertilizer (k)	1.23	30.7	39.5	15.0
	Main-N_{140}	2.57	37.2	55.1	30.4
	Main- N_{70} Early spring - N_{70}	2.55	37.9	56.7	30.3
	Main- N_{70} Early spring - N_{35} In tubing- N_{35}	2.61	41.2	57.6	32.0

With fractional application of nitrogen fertilizers, leaf area developed somewhat more intensively than with a single application, reaching its greatest size during the heading phase in the N70 base + N35 early spring + N35 booting treatment. The form of nitrogen fertilizer, however, had little effect on this indicator.

The main indicator of the winter wheat yield structure is the grain weight per 1 m², which in turn depends on the number of plants per 1 m² and the grain weight per plant.

The form of nitrogen fertilizers and the timing of their application influenced such elements of the yield structure as the productive stem stand, the grain content of the ear, and the fullness of the grain (Table 4). Nitrogen fertilizers, regardless of the form and timing of application, against the background of P90K60 significantly increased the density of the productive stem stand. Thus, if in unfertilized variants it fluctuated from 361 to 377 pcs/m², then in fertilized variants, respectively, from 658 to 673 pcs/m². With split application of nitrogen fertilizers (N70 main + N35 early in spring or N70 in spring + N35 during booting), a tendency towards an increase in ear-bearing stems per unit of sowing area was observed compared to a single application (N140 under primary tillage). When studying the effect of nitrogen fertilizer form on the stem stand density of winter wheat, no noticeable differences were found. Thus, in the variants using ammonium nitrate, the value of this indicator increased by 11-13 pcs/m², and ammonium sulfate nitrate by 9-12 pcs/m².

Table 4 - Effect of the application period of different forms of nitrogen fertilizers on the elements of the winter wheat crop structure, 2025

A form of nitrogen fertilizer	Fertilizer application period	Number of productive stems, pcs/m²	Number of grains in an ear, pcs.	Weight, g		Biological yield, g/m²
				1000 grains	grains from the ear	
Ammonium nitrate	Without fertilizer (k)	361	28.2	40.86	1.16	422
	Main-N140	660	31.4	35.93	1.12	731
	Main-N70 Early spring - N70	671	31.2	36.92	1.16	779
	Main - N70 Early spring-N35 In tubing - N35	673	31.0	38.13	1.18	780
Ammonium sulfate nitrate	Without fertilizer (k)	377	28.5	40.13	1.14	426
	Main-N140	658	30.2	38.61	1.17	757
	Main - N70 Early spring - N70	670	29.7	39.66	1.17	777
	Main - N70 Early spring - N35 In tubing - N35	667	29.5	40.08	1.18	771

Application of various forms of nitrogen fertilizers one-time or fractionally against the background of $P_{90}K_{60}$The addition of saltpeter increased the grain content per spike by 2.8-3.2 grains, and ammonium nitrate sulfate by 1.0-1.7 grains, compared to unfertilized variants, due to the formation of a greater number of spikelets per spike. The 1,000-grain weight in the fertilized variants decreased by 2.73-4.93 g and 0.05-1.52 g, respectively, compared to unfertilized variants. Therefore, the grain weight per spike was approximately the same in all experimental variants, ranging from 1.12 to 1.18 g.

The analysis of the winter wheat yield structure elements results in the determination of its biological yield. The experiment established that when ammonium nitrate and ammonium sulfate nitrate are applied as a one-time treatment and as a supplementary fertilizer against the background of the main application of $P_{90}K_{60}$The biological yield of winter wheat increased from 422 to 780 g/m3 and was highest where various forms of nitrogen fertilizer were applied fractionally. This is explained by the improved supply of plant nutrients, primarily nitrogen, which contributed to an increase in the density of productive stems. It should be noted that the biological yield, i.e., the amount of produce grown in the experiment per unit of sowing area, exceeded the economic or actual yield by 0.8–2.8%. Economic yield is always less than the biological yield by the amount of losses during harvesting, as a result of grain shattering during overmature plants, and grain weight loss during respiration due to increased humidity in the agrocenosis during the full ripeness phase of winter wheat grain.

When sowing winter wheat of the Homer variety after sunflower on an unfertilized background, 4.04-4.10 t/ha of grain was obtained, and when applying $N_{140}P_{90}K_{60}$The yield increased to 7.26-7.73 t/ha. (Table 5).

The form of nitrogen fertilizer did not have a significant effect on winter wheat yield.

Table 5 - Winter wheat yield depending on the period of application of various forms of nitrogen fertilizers, t/ha (2025)

A form of nitrogen fertilizer (factor A)	Fertilizer application period (factor B)	Average by:		
		options	factor A	factor B
Ammonium nitrate	Without fertilizer (k)	4.10	6.67	
	Main-N140	7.26		
	Main-N70 Early spring - N70	7.61		
	Main - N70 Early spring-N35 In tubing - N35	7.73		
Ammonium sulfate nitrate	Without fertilizer (k)	4.04	6.68	4.07
	Main-N140	7.45		7.35
	Main - N70 Early spring - N70	7.68		7.64
	Main - N70 Early spring - N35 In tubing - N35	7.57		7.65
HSR05		0.23	0.12	0.16

When nitrogen fertilizers were applied one-time at the rate of N140 and N70 for primary tillage, followed by additional fertilizing in early spring and in the booting phase at doses of N70 and N35 + N35, respectively, against the background of P90K60, a statistically significant increase in grain yield was obtained, compared to the control, which amounted to 3.16 – 3.63 t/ha or 77.1 – 88.5%.

Double application of ammonium nitrate and ammonium sulfate-nitrate before sowing (N70) and early in the spring (N70) resulted in a significant increase in winter wheat yield (by 0.23-0.35 t/ha at HSR05-0.16 t/ha) compared to a single application. Top dressing of winter wheat crops with N35 in early spring and N35 during booting, combined with the primary application of N70, did not significantly differ in grain yield compared to the N70 primary + N70 early spring treatment.

The forms of nitrogen fertilizers studied in the experiment - ammonium nitrate and ammonium sulfate-nitrate, which were applied both as part of the main fertilizer and in combination with the main fertilizer and additional feeding during the resumption of spring vegetation and in the booting phase - increased not only the yield, but also the quality of winter wheat grain, and, above all, the content of protein and gluten in it (Table 6).

Table 6 - Grain quality of winter wheat depending on the period of application of various forms of nitrogen fertilizers, 2025

A form of nitrogen fertilizer	Fertilizer application period	Total vitreousness, %	Content in grain, %		Gluten quality IDK, units of product
			squirrel	raw gluten	
Ammonium nitrate	Without fertilizer (k)	34.5	10.3	16.5	76.4
	Main-N_{140}	39.6	11.2	18.0	71.8
	Main-N_{70} Early spring-N_{70}	39.2	12.0	19.4	76.8
	Main- N_{70} Early spring-N_{35} In tubing- N_{35}	40.4	12.4	20.2	72.9
Ammonium sulfate nitrate	Without fertilizer (k)	34.9	10.6	16.4	76.0
	Main-N_{140}	40.4	12.6	18.3	74.5
	Main- N_{70} Early spring - N_{70}	40.7	13.4	20.5	77.0
	Main- N_{70} Early spring - N_{35} In tubing- N_{35}	41.7	13.5	21.1	75.1

Obtaining a high yield of winter wheat grain with an increased protein content is possible under conditions of a good supply of nitrogen to plants, some moisture deficit and elevated air temperatures during the grain filling period [2]. However, if the forms of nitrogen fertilizers and the timing of their application had almost the same effect on the formation of grain yield, the use of ammonium sulfate nitrate ensured the production of winter wheat grain with higher quality indicators. In our experiment, the protein content in variants without fertilizers was 10.3-10.6%, crude gluten - 16.4-16.5%, the total vitreousness of the grain was 34.5-34.9%; with the main application of N140P90K60, respectively, 11.2-11.6; 18.0-18.3 and 39.6-40.4%; with one spring top dressing in early spring N70 against the background of the main fertilizer N70 P90K60 - 12.0-13.4; 19.4-20.5 and 39.2-40.7%; with two top dressings in early spring N35 + N35 during booting - 12.4-13.5%, 20.2-21.1 and 40.4-41.7%. It should be noted that ammonium sulfate nitrate had a greater positive effect on grain quality than ammonium nitrate, regardless of the timing of their application. Sulfur-containing nitrogen fertilizer increased the overall vitreousness of the grain, compared to ammonium nitrate, by 0.8-1.3%, protein content by 1.1-1.4%, and wet gluten by 0.3-0.9%. In this case, ammonium sulfate nitrate was more effective than ammonium nitrate. This is confirmed by data from other researchers who have shown that the use of sulfur-containing fertilizers improves the use of nutrients from the soil by plants, increases the efficiency of winter wheat in using nitrogen from fertilizers, is involved in protein synthesis, is a component of amino acids and chloroplast protein, which ensures the direct participation of sulfur in photosynthesis [5].

The quality of gluten in the fertilized variants in the experiment differed little from that in the unfertilized variants and met the requirements of the first group.

Conclusions:

1. The number of stems per winter wheat plant in the fertilized variants exceeded the control by 2.4-3.7 pcs. during the spring tillering phase, by 0.9-1.6 pcs. during booting, by 0.6-1.2 pcs. during heading, and by 0.2-0.9 pcs. During the spring tillering phase, plants showed the highest tillering coefficient when the full rate of N140P90K60 fertilizer was applied under primary tillage - 7.2-7.4, and during the booting and heading phases with their split application: 4.1-4.8 and 4.0-4.1, respectively.

2. The assimilation surface area of winter wheat increased from 2.13 to 2.61 thousand m²/ha during the spring tillering stage, from 36.2 to 41.2 thousand m² during booting, and from 30.2 to 32.0 thousand m²/ha during the milk ripeness stage of grain. With split application of nitrogen fertilizers (N70 base + N70 in

top dressing), the leaf surface developed somewhat more intensively than with a single application (N140 base). The form of nitrogen fertilizer did not have a noticeable effect on the process of leaf formation of wheat.

3. Winter wheat yield increased to 7.26-7.73 t/ha, or 77.1-88.5%, with ammonium nitrate and ammonium sulfate nitrate applied at a dose of N140 against the background of the main fertilizer P90K60, compared to 4.04-4.10 t/ha in the control. The form of nitrogen fertilizer did not significantly affect the productivity of this crop. Early spring fertilization of winter wheat at a dose of N70 against the background of the main application of N70 P90K60 provided a reliable (by 0.23-0.35 t/ha with an NSR05 of 0.16 t/ha) increase in grain yield compared to a single application before sowing. The increase in grain yield with double fertilization of winter wheat crops (N35 in early spring + N35 at booting) did not differ significantly from a single fertilization in early spring at a dose of N70.

4. Nitrogen fertilizers had a noticeable positive effect on the quality of winter wheat grain, regardless of the form and time of application, but the highest vitreousness - 41.7%, protein content in grain - 13.5% and 21.1% crude gluten were provided by ammonium sulfate-nitrate with fractional application: N70 - main + N35 in early spring + N35 at booting.

Literature

1. Dospekhov, B.A. Methodology of field experiment (with the basics of statistical processing of research results). - M.: Lan, 2022. - 352 p.

2. Eroshenko, F.V. Efficiency of late foliar nitrogen fertilization of winter wheat / F.V. Eroshenko, A.A. Eroshenko, I.G. Storchak // Achievements of science and technology in the agro-industrial complex. - 2014 - No. 8. - P. 32-35.

3. Zavalin, A.A. Nitrogen and quality of wheat grain / A.A. Zavalin, O.A. Sokolov // Fertility, 2018. - No. 1 (100). - P. 14-17.

4. Kravtsov, A.M. The influence of soil fertility, fertilizers and herbicides on the yield and grain quality of winter wheat for various row-crop predecessors / A.M. Kravtsov, A.V. Zagorulko, N.N. Kravtsova // Proceedings / Kuban State Agrarian University. - 2018. - Issue 5 (74). - P. - 71-81.

5. Kurkaev, V.T., Sheudzhen A.Kh. Agrochemistry. Textbook / V.T. Kurkaev, H.T. Sheudzhen. - Maykop, -GURI IP "Adygea", 2000. - 552 p.

6. Features of caring for winter crops, perennial grasses and cultivation of spring crops: recommendations / I.T. Trubilin, N.G. Malyuga, A.V. Zagorulko [et al.]. - Krasnodar, 2003. - 46 p.

7. Slyusarev, V.N. Sulfur in the soils of the North-West Caucasus (agroecological aspects): monograph. - Krasnodar: KubSAU, 2007. - 230 p.