INFLUENCE OF METHODS AND TECHNOLOGY OF NITROGEN FERTILIZER APPLICATION IN EARLY SPRING FERTILIZATION ON WINTER WHEAT PRODUCTIVITY IN ARID ZONE OF SOUTH OF RUSSIA

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Annotation. The relevance of the nitrogen fertilization is difficult to overestimate. Currently, winter wheat crops impose special requirements on nitrogen nutrition, as a rule, in early spring due to the unfavorable temperature conditions and excess moisture soil nitrification is suppressed. As a result, plants starve from lack of nitrogen and reduce the yield. At the same time, the variety represented on the nitrogen fertilizers market is able to satisfy practically any soil type in various conditions of wetting, and is limited only by the energy availability of agricultural producers. One of the factors, which have an impact on the effectiveness of nitrogen use, is the form of nitrogen-containing fertilizers. The experimental plots to study the influence of methods and technology of nitrogen fertilizer application in early spring on the winter wheat productivity were located in the arid zone of the south of Russia, where 350-400 mm of precipitation falls annually, the hydrothermal coefficient is within 0.6-0.8 units, and the soil cover is represented by dark chestnut and chestnut soils. The forecrop of the research period was winter wheat; the studied varieties of winter wheat are Yesaul and Nota. The seeder John Deere was usedfor the root fertilization in the experiment, and the Amazon spreader was used for the surface application. The analysis of the obtained data allows us to draw the following conclusions; the yield of the Nota variety was higher compared to the Yesaul variety on the fertilized variants by 0.15-0.28 $t \cdot ha^{-1}$. The highest productivity indicators are formed when fertilizing with the nitrogen dose of 52 $kg \cdot ha^{-1}$ application rateregardless of the fertilizer application method. The advantage of the root fertilization method is not reliable compared with the superficial method of applying manure. Studied doses and methods of nitrogen fertilizer application had a significant impact on the protein content in the grain of winter wheat.

Keywords: fertilization, fertilizers, productivity, method of application.

Introduction

Winter wheat yield and quality are determined by a host of environmental factors; however, the high grain yield and quality can be achieved only by maximally approximating the crop growth, development, wintering, nutrition, yield structural elements' formation and other conditions, varying in relation to natural-climatic factors, soil peculiarities, agronomic practices applied or crop cultivation technologies to the optimal ones. The quality of winter wheat yield depends on physiological-biochemical processes, which occur in plants during ontogenesis [1].

Nitrogen nutrition of winter wheat, and in particular its optimization, is one of the main factors for rational use of natural nitrogen reserves, maintaining soil fertility and reducing the negative effects of incorrect use of nitrogen fertilizers. This technique is possible only on the basis of an integrated approach to the study of methods of nitrogen fertilizer application, nitrogen transformation processes, as well as in the implementation of quantitative and qualitative assessment of the processes direction in specific soil and climatic conditions [2].

Autumn, winter and spring monitoring with the use of visual and chemical diagnostics of the winter crops mineral nutrition is critical, and it is necessary to take into account the reserves of productive moisture, the weather forecast for the future, and the weather forecast during the planned period of nitrogen fertilization [3].

A big role in obtaining high yields is played by: climatic conditions, fertilizer system and variety. A variety is not only a means of increasing crop yields, but also a factor without which it is impossible to realize the achievements of science and technology. In agricultural production, the variety acts as a biological system, which cannot be replaced by anything [4;5].

Big relevance is gained by a problem of decrease in the costs of energy of production of agricultural production. It is important to develop and use energy saving technologies at which less energy is spent for production of agricultural production. Increasing the costs of production and use of fertilizers, more and more actual there is a question of efficiency of their application [6].

Materials and methods

The main objective of the research is to study the influence of methods and technology of nitrogen fertilizer application in early-spring fertilization on the winter wheat productivity in the arid zone of the South of Russia.

Two-factor experience is based on the method of organized repetitions. The size of the plot is 2.15 hectares, the repetition of experience is threefold. Agricultural technology is generally accepted for the arid zone of the region. The studied varieties of winter wheat are Yesaul and Note. The forecrop is winter wheat. Ammonium nitrate was used as a nitrogen fertilizer; the studied doses are N – 17.5; N – 35; N – 52.5; N – 70. The seeder John Deer 455 with a working width of 10.7 meters was used for root fertilization, and the mineral fertilizer spreader AMAZONE ZF-M 1500 was used for surface application. Acros580 was used for direct harvesting.

The soil cover of the experimental area is represented by dark chestnut soils. This type of soil has a high absorption capacity, due to the high content of superfine silty particles. The absorption capacity of the arable layer is 36-38 mEq per 100 g of soil. In the composition of absorbed bases, the proportion of calcium is 27.6 mEq per 100g of soil, the pH of the aqueous soil solution is 8.4. Soils are characterized by a low content of humus (2.59 %), an average content of mobile phosphorus, and elevated exchange potassium: 18 and 341 $mg \cdot kg^{-1}$ of soil, respectively. The availability of nitrate nitrogen is medium. The boron content is high 0.78 $mg \cdot kg^{-1}$ of soil; sulfur, copper, zinc, cobalt content is low and consequently 3.6; 0.15; 0.4; 0.11 $mg \cdot kg^{-1}$; manganese is average 12.7 $mg \cdot kg^{-1}$.

Results and discussion

In the experiment one of the determining factors in the winter wheat productivity turned out to be the weather conditions. The period of the research 2016-2018 was characterized byan excess of the average annual precipitation rate by 8 and 33 %, respectively, the temperature regime was characterized as elevated, the air temperature exceeded the average annual values by 0.9 and 1.7 ºC, respectively (Tables 1, 2).

The climatic conditions of the early spring periods during the first two years of the research were extremely unsatisfactory, in April 2015-2016 there was a half-month norm of precipitation and an excess of temperature was recorded in relation to long-term values (6.1 ºC in March and 3.9 ºC in April) , in 2016-2017, the precipitation deficit was in April, which coincided with the critical moment in the water consumption of winter wheat (interphase periods, spring tillering–stem elongation), that was 70 %. All this contributed to the rapid and significant desiccation of the soil surface layer, which did not allow full usage of the nitrogen fertilizer applied with fertilization, and as a result, caused low crop productivity and a relatively low level of responsiveness to the use of fertilizers.

Table 1

Temperature conditions in the research years according to the weather station data of Blagodarniy city (ºC)

Indicator	Month												Per year
	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	
Average year	22.7	9.4	10.0	3.2	-1.7	-4.6	-4.1	1.2	8.7	15.9	20.4	23.7	9.4
2015-2016	25.2	10.3	12.6	2.0	-0.5	-9.1	-3.6	7.3	12.6	14.5	19.7	23.4	10.3
2016-2017	25.3	11.1	9.4	7.2	3.4	-5.8	-3.1	2.6	9.3	16.7	23.7	25.6	11.1
2017-2018	22.4	10.1	11.2	5.1	-1.1	-3.9	-4.6	1.1	8.1	15.8	20.7	29.5	10.1

Table 2

Precipitation mode in the research years according to the meteorological station data of Blagodarniy city, mm.

Indicator	Month												Amount
	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	
Average year	14	15	16	35	61	72	54	41	36	25	27	20	416
2015-2016	21	24	76	48	45	26	28	40	53	52	56	111	555
2016-2017	7	40	87	5	1	7	13	42	11	83	32	165	492
2017-2018	18	19	65	22	35	7	8	41	76	64	94	2	452

The weather conditions of 2017-2018, in general, were most favorable for the formation of winter wheat. The autumn and winter in 2017-2018 favored the development of winter wheat plants, in these conditionssignificant reserves of productive moisture during the resumption of the spring growing season contributed to creation of programmable winter wheat productivity.

Early spring soil and plant diagnostics of winter wheat sowingsis one of the most effective methods contributing to the formation of consistently high yields of winter wheat, while of high quality (Table 3). Low availability of soil labile phosphorus dramatically reduces the effect of nitrogen fertilizing on the amount of the crop and it negatively affects the qualityof the products. Conducting nitrogen fertilization with high doses of nitrogen in the early spring period, in working areas with productive moisture content below 100 mm, it does not contribute to obtaining high productivity of winter wheat [7].

Table 3

Indicators of the reproduction period in spring vegetation

Indicators	2016	2017	2018
Reserve N-NO_3 (0-100 soil layer), kg·ha^{-1}	62	103	48
Reserve of productive moisture (0–100 soil layer), mm	119	63	105

The culture's high response to early-spring nitrogen fertilization during the experimental period was facilitated by the satisfactory condition of winter wheat after overwintering, and considerable reserves of productive moisture in the meter-high soil profile. The highest yield of winter wheat, regardless of the variety, the implement used for applying nitrogen fertilizers, and the application rate for fertilizing was obtained 4.96 t·ha^{-1} in 2018 (Tables 4, 5).

Table 4

Effect of nitrogen fertilizers and methods of their application on the yield of winter wheat variety Yesaul, t·ha^{-1}

Nitrogen doses, kg·ha^{-1} application rate, A	Methodofapplication, B						A, HCP_{05} = 0.4 t·ha^{-1}
	AMAZONE ZF-M 1500			JOHN DEER-455			
	2016	2017	2018	2016	2017	2018	
1. Control	3.28	2.64	4.45	3.25	2.66	4.45	3.46
2.Naa17.5	3.52	3.09	4.66	3.49	3.10	4.89	3.79
3.Naa35	3.74	3.23	5.07	3.56	3.25	5.01	3.98
4.Naa52.5	3.50	3.34	5.70	3.40	3.23	5.78	4.16
5.Naa70	3.63	3.32	5.37	3.43	3.23	5.42	4.07
B, HCP_{05} = 0.5 t·ha^{-1}	3.53	3.12	5.05	3.43	3.09	5.11	HCP_{05} = 0.3 t·ha^{-1} S_x = 3.0 t·ha^{-1}

The surface method of nitrogen fertilizer application with AMAZONE ZF-M 1500 or the radical planter JOHN DEER-455 did not have a significant impact on the winter wheat yield of the studied Yesaul and Nota varieties, and the difference depending on the nitrogen fertilizer dose and the research periodwas 0.03 t·ha^{-1}. The maximum yield of winter wheat of the Esaul variety is 4.18 t·ha^{-1} and the Nota variety is 4.50 t·ha^{-1}with the surface application method by the spreader AMAZONE ZF-M 1500, which provided a nitrogen dose of 52.5 kg·ha^{-1} application rate.

The highest level of crop productivity over the research period, on the natural agrochemical background, regardless of the weather conditions of winter wheat, was observed in the experiment on the variety Nota 3.62 t·ha^{-1}.

The introduction of ammonium nitrate in doses of 35, 52.5 and 70 kg·ha^{-1} application rate contributed to a significant increase in crop yield by 0.32-0.70 t·ha^{-1}, compared with the natural agrochemical background on average by the experiment.

The largest increase, regardless of the variety and method of the nitrogen fertilizer application, is noted in the best weather conditions of 2017-2018 0.77 t·ha^{-1}, the increase from fertilization in the conditions of 2015-2016 it was 0.63 t·ha^{-1}.

Table 5

Effect of nitrogen fertilizers and methods of their application on the yield of winter wheat variety Nota, $t \cdot ha^{-1}$

Nitrogen doses, $kg \cdot ha^{-1}$ application rate, A	Methodofapplication, B						A, HCP_{05} = 0.5 $t \cdot ha^{-1}$
	AMAZONE ZF-M 1500			JOHN DEER-455			
	2016	2017	2018	2016	2017	2018	
1. Control	4.12	2.55	4.19	4.11	2.52	4.21	3.62
2.Naa17.5	4.35	2.93	4.50	4.36	3.02	4.47	3.94
3.Naa35	4.69	3.29	4.76	4.58	3.28	4.77	4.23
4.Naa52.5	4.49	3.30	5.43	4.60	3.31	5.48	4.44
5.Naa70	4.57	3.32	5.07	4.69	3.33	5.13	4.35
B, HCP_{05} = 0.4 $t \cdot ha^{-1}$	4.44	3.08	4.79	4.47	3.09	4.81	HCP_{05} = 0.2 $t \cdot ha^{-1}$ S_x = 3.1 $t \cdot ha^{-1}$

The studied doses and methods of nitrogen fertilizer application had a significant impact on the protein content in the grain of winter wheat. In direct proportion to the dose of nitrogen applied to fertilization, the protein content in the grain significantly increased, and the difference compared with the control was: Yesaul, 0.7-1.8 % and Nota, 0.3-1.3 %.

The yield of the Note variety was higher compared to the Yesaulvariety on the fertilized soils by 0.15-0.28 $t \cdot ha^{-1}$. The highest productivity indicators are formed, when a nitrogen dose of 52 $kg \cdot ha^{-1}$ application rate is introduced, regardless of the fertilizer application method.

Conclusions

1. Thus, crop production is highly dependent on the weather conditions. The surface method of nitrogen fertilizer application with the spreader AMAZONE ZF-M 1500 or the radical planter JOHN DEER-455 did not have a significant impact on the winter wheat yield of the studied Yesaul and Nota varieties, and the difference depending on the nitrogen fertilizer dose and the research period was 0.03 $t \cdot ha^{-1}$. The maximum yield of winter wheat of the Esaul variety is 4.18 $t \cdot ha^{-1}$ and the Nota variety is 4.50 $t \cdot ha^{-1}$ with the surface application method by the spreader AMAZONE ZF-M 1500, which provided a nitrogen dose of 52.5 $kg \cdot ha^{-1}$ application rate.
2. The yield of the Note variety was higher compared to the Yesaul variety on the fertilized soils by 0.15-0.28 $t \cdot ha^{-1}$. The highest productivity indicators are formed, when a nitrogen dose of 52 $kg \cdot ha^{-1}$ application rate is introduced, regardless of the fertilizer application method.
3. Fertilization withthe seeder JOHN DEER-455 increased the protein content in the grains of the studied varieties compared to the surface method of nitrogen application using the fertilizer spreader AMAZONE ZF-M 1500. The protein content in the winter wheat grain Yesaul turned out to be higher than 2.3 % in the control and 2.6-2.9 % in the fertilized variants.

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