Quality indicators and nitrate accumulation in winter wheat grain when applying fertilizers in conditions of plain irrigated zone of Dagestan

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Abstract. The introduction of new highly productive high-impact varieties into production requires a revision of the rules and methods of fertilizer application in relation to these varieties' possibilities under specific cultivation conditions. Thus, the studies carried out on meadow-chestnut soil in the conditions of the flat irrigated zone of Dagestan in the study of new zoned winter wheat varieties Bezostaya 100 and Sila showed high productivity in the application of N90P45 fertilizers. The aim of the research was to study grain quality indicators and nitrate accumulation of the main food crop in the systemic application of fertilizers. In this article we present the scientific research results on the dependence of yield, protein, and gluten of new winter wheat varieties on the mineral fertilizers' application. The dependence of nitrate accumulation in winter wheat grain on mineral fertilizers' introduction was revealed.

1 Introduction

The land resources of Dagestan are diverse in agroclimatic and soil conditions, which is important in the cultivation of new winter wheat varieties. The need for precise definition of mineral nutrition norms in the flat irrigated zone of Dagestan causes its relevance and national economic importance [2,6].

Due to current economic and environmental situation in the republic, the strategy of adaptive intensification of agricultural production has been defined, which is oriented to rational use of resources and conservation.

In the republic, winter wheat occupies the main place, therefore increasing its yield and obtaining quality products is closely related to the rationality of mineral fertilizers' use. Being 17% protein, nitrogen plays an important role in the development of plant organisms. The wheat grain quality is interconnected with the biochemical composition; with the participation of nitrogen, plants are photosynthesized. It was noted that mineral fertilizers increase productivity on all soils in general, and the need for nitrogen is greatest out of nutrients [4,5].

However, it must be borne in mind that high doses introduction of mineral fertilizers is not only a useless waste, but also leads to adverse consequences, for example, increase of

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nutrients salts in crops, which result in affecting the grain quality. Nitrates take a special place from the number of harmful elements that affect crop productivity. Therefore, to eliminate soil contamination and obtain a high-quality crop, optimization of applied fertilizers' doses is required [2,6].

2 Materials and methods

Studies on the influence of mineral fertilizers on quality indicators of winter wheat grain and the accumulation of nitrates in it were conducted on meadow-chestnut soil of the experimental field of FSBEI HE Dagestan SAU in 2017-2019. We studied the combination of five fertilizer norms: N_{45} P_{45}; $N_{60}P_{45}$; N_{90} P_{45}; N_{120} P_{45}; N_{150} P_{45} (Table 1), their impact on grain quality indicators and nitrates accumulation in the main food crop grain. Plots area 150 m^2 (15.0 m x 10 m), accounting - 100 m^2 (16 m x 6.2 m), repetition - 4 times. Methodology is generally accepted [1,4]. Statistical processing of experimental data was carried out according to Dospekhov B.A. [3]. The arable layer contains 2.21% humus, P_2O_5 - 1.5 mg /100 g soil, K_2O- 28.2 mg/100 g of soil. Density of arable layer — 1.30 g/cm^3, NV — 30.5%.

The materials of the experiments were winter wheat varieties Sila and Bezostaya 100 selected in the FSBSI “National Grain Center named after P.P. Lukyanenko”.

Qualitative indicators of grain were determined in the laboratory of seed production and biotechnology of the breeding and seed breeding center of FSBEI HE Dagestan SAU using the analyzer of whole grain quality Inframatic 9500, Perten. Seed samples were selected according to GOST R 50436-92, experiments were carried out at t - 22-24^{0}C. Nitrates and nitrites in grain were additionally determined according to the approved methodical instructions of V.I. Chiburaev, N 5310-90.

Table 1. Experimental scheme.

Varieties (factor A)	Mineral fertilizer norm (Factor B)
Sila	No fertilizer - B_1
	N_{45} P_{45} - B_2
	$N_{60}P_{45}$ - B_3
	N_{90} P_{45} - B_4
	N_{120} P_{45} - B_5
	N_{150} P_{45} - B_6
Bezostaya 100	No fertilizer - B_1
	N_{45} P_{45} - B_2
	$N_{60}P_{45}$ - B_3
	N_{90} P_{45} - B_4
	N_{120} P_{45} - B_5
	N_{150} P_{45} - B_6

3 Results and discussion

Fertilizer is one of the effective means of increasing the yield of winter wheat and improving grain quality [2].

There is still no consensus on the specific effect on the harvest and grain quality of various forms of nitrogen fertilizers [5, 6].

The conducted studies showed that nitrogen fertilizers introduced into the soil are quickly fixed in it in the form of organic compounds and, as a rule, increase the grain quality indicators, particularly protein. Therefore, even when applying sufficiently high fertilizers' doses, the soil remains the main nitrogen source for winter wheat with total

nitrogen enleaching of about 90%. The fertilizers introduced undergo deep changes in the soil and mainly act as an activating agent of mineralization processes of nitrogen-containing organic substances [5].

Research results showed that the yield and quality indicators of wheat grain improve on meadow-chestnut soil with the introduction of estimated norms of mineral fertilizers. On option $B_2$with mineral fertilizers' introduction, yield increase of 31 -65% to B_1 was noted. According to our research, the maximum yield and the limiting response curve area of winter wheat varieties' productivity is achieved with option $B_4$with the introduction of fertilizers in the norm N_{90} P_{45}. On options B_5 and B_6 with increasing the fertilizer application dose to $N_{150}P_{45}$, there is a decrease in yield and deterioration in grain quality of winter wheat varieties (Table 2).

Table 2. Dependence of yield and nitrate grain accumulation on mineral fertilizers in the conditions of the flat irrigated zone of Dagestan

Option No.	Yield, cwt/ha	Yield increase, %	Vitreousity, %	Content, %		Nitrates, mg/kg
				protein in grain	gluten in flour	
Sila						
No fertilizer - B_1	27.2		77	13.80	27.2	122.40
N_{45} P_{45} - B_2	34.6	127.2	78	15.89	28.8	129.23
$N_{60}P_{45}$ - B_3	41.3	151.1	80	16.01	29.0	133.47
N_{90} P_{45} - B_4	52.0	189.1	84	17.37	29.7	140.13
N_{120} P_{45} - B_5	50.5	184.7	83	16.63	28.4	149.90
N_{150} P_{45} - B_6	48.2	177.3	83	15.90	27.3	151.07
LCD_{05}	7.63					
Bezostaya 100						
No fertilizer — B_1	28.2		78	13.89	27.30	121.93
N_{45} P_{45} - B_2	37.2	131.5	79	15.98	28.89	126.90
$N_{60}P_{45}$ - B_3	46.9	165.3	80	16.11	29.10	131.57
N_{90} P_{45} - B_4	53.5	189.1	85	17.46	29.79	139.03
N_{120} P_{45} - B_5	51.0	179.0	85	16.72	28.46	144.93
N_{150} P_{45} - B_6	47.6	168.7	84	15.97	27.56	150.03
LCD_{05}	7.42					

One of the causes of land pollution is the introduction of unreasonably high doses, as well as violation of the principles of mineral fertilizers' use, which can lead to a decrease in yields and nitrate accumulation in winter wheat grain. Also, scientific-based application of mineral fertilizers becomes relevant due to the transition of many producers to the organic agricultural production, which will help to protect the health of the population from poor quality crop production [2].

When cultivating winter wheat, the grain content of protein and gluten are considered no less important than the yield. Based on the research results, on fertilizer-free options on average by varieties, protein content amounted to: Sila - 13.7 and Bezostaya 100 -13.9%. Improved quality indicators were noted within the third and sixth options in relation to the control option, where there was a reliable increase in both yield and improvement in all grain quality indicators. The grain quality assessment of winter wheat varieties showed that the accumulation of protein and gluten depends on mineral fertilizers. Gluten accumulation at B_1 averaged to 27.2-27.3%, with fertilizer options it was between 28.8-29.7% for Sila variety and 28.8-29.7% for Bezostaya 100 variety. Optimal conditions contributing to grain qualities formation meeting baking qualities are observed on the options with the introduction of $N_{60}P_{45}$; $N_{90}P_{45}$ (Figure 1).

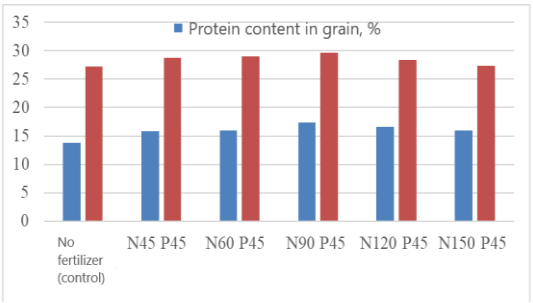

Fig. 1. Dependence of protein and gluten content levels in Sila variety winter wheat grain on mineral nutrition.

In accordance with the results of our studies, the varieties studied are among varieties that meet the requirements of strong wheat.

For ecological assessment of fertilizer application on winter wheat plants, we studied the accumulation of nitric nitrogen in stems and grains. Thus, nitrate content in winter wheat grain ranged from 120 to 151 mg/kg. The indicators slightly increased on options with fertilizers' introduction (Fig. 2). A comparatively high nitrate accumulation was found on the option with the introduction of $N_{190}P_{50}$.

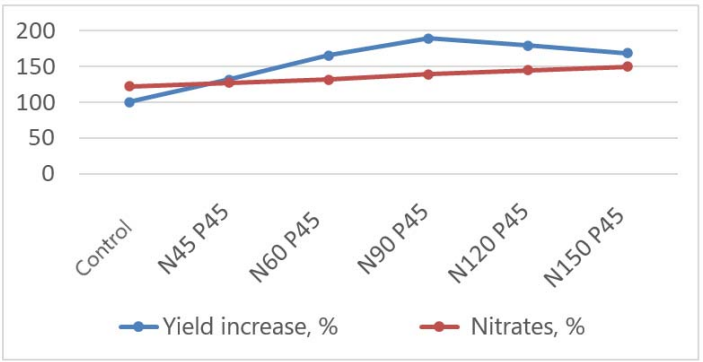

Fig. 2. Dependence of yield increase (%) and nitrate accumulation in winter wheat grain of Bezostaya 100 variety on mineral nutrition.

4 Conclusion

The influence of fertilizers on grain quality indicators depends on their effect on the winter wheat yield amount. Yield of winter wheat peaks when applying $N_{90}P_{45}$ and is maintained at this level until the introduction of $N_{150}P_{45}$. Further increase in fertilizer doses leads to nitrate accumulation in winter wheat grain, a decrease in yields and grain quality indicators.

Accordingly, optimizing the mineral nutrition conditions of winter wheat, it is possible to regulate the process of nitrate accumulation within the maximum permissible concentration in accordance with all environmental requirements.

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