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Reaction of barley to top-dressing with different types of nitrogen fertilizer

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Abstract. The study was carried out to investigate effect of mineral (CAN) and organo-mineral (OMF) top-dress nitrogen fertilizers on physiological and morphological parameters in three barley cultivars. The study revealed significant differences in the reaction of the cultivars in magnitude and direction of the yield structure elements. CAN had smaller effect on the studied parameters than OMF. CAN had no effect on grain yield and straw mass. Only for the cv. Novichok, there was an increase in grain weight from the main ear (15%), the length of the main ear (15%), the 1000-grain weight (2.9%). OMF led to increase grain yield in the cv. Novichok (43%), Pamiaty Rodinoy (16%), and did not change in the cv. Rodnik Prikamya. Only the cv. Novichok has increased the grain mass from the main ear (17%). The length of the main ear increased in the cv. Novichok (13%), Pamiaty Rodinoy (11%) but decreased in the cv. Rodnik Prikamya (7.5%). The influence of OMF increased the 1000-grain weight in the cv. Novichok (4.9%) and Pamiaty Rodinoy (2.5%), but decreased in the cv. Rodnik Prikamya (1.5%). Statistically differences were revealed in reaction of pigment complexes of flag and second leaves in all cultivars.

1 Introduction

Barley (Hordeum vulgare L.) is widely grown cereal crops in Russian federation as well as in the world. The United States Department of Agriculture (USDA) reported that world barley production in 2019/2020 growing season was 156.70 million tons and estimates it in 2020/2021 growing season at the level of 159.98 million metric tons. In Russian Federation, there are 20,629 and 19,939 million metric tons correspondingly [https://www.fas.usda.gov/data/grain-world-markets-and-trade]

Barley grain and straw is mainly grown as animal feed, human food and malt products. According to its biological features, barley is unique crop that may be produced in unfavorable climate and soil conditions of the world. Thus, barley is the only cereal and only staple food resource in countries having arid and semi arid climates in West Asia, North Africa, and East Asia. In general, barley has more stable yield against seasonal weather variation than wheat and other small grains.

Rational practice of nitrogen fertilization is essential for barley production and environment safety. It is considered that only 30–50% of nitrogen fertilizer applied as basal

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pre-sowing application is taken up by agricultural crops [1], so soil N rarely supplies all the N required by the barley crop. For this reason, selection of more N-efficient cultivars as well as improved N management practices has become a desirable goal in barley research [2].

Profitable of high quality grain production of spring barley is significantly determined by correct use of cost effective source of nitrogen nutrition, its type (ammonia, nitrite or complex), way of application and use at the right stage of growth. Uptake of soil nitrogen by barley plants is rather moderate at initial stages of plant growth (less than 10% of the total N requirements) but after tillering additional amounts of the element could be applied for ensuring high grain yield [3]. This addition amount (about 1/3 of total N fertilizer) is applied as top-dressing within tillering stage [4]. As it is pointed out by [5], top dressing of wheat and barley crops in Mediterranean agroecosystems could increase grain yield by an average of 18% in compare with full pre-plant fertilizers.

Nitrogen top-dresses application after tillering is needed by most crops. In agricultural soils nitrate concentrations are generally 10 times higher than ammonium [6], so in some studies like [7, 8] use of top-dressing with ammonium leads to increase in growth, grain yield, photosynthetic rate in cereals. If it is used before GS30 (Start of stem elongation), it can increase tiller numbers and dry matter, leading to yield increases; but nitrogen top-dress after GS30 can improve tiller survival and so maintain yields because of rapid N uptake and increases in canopy size through leaf emergence. When nitrogen is applied after GS59 (Ear fully emerged on main stem), N uptake slows as canopy size peaks and ears begin to form. Nitrogen application at this stage generally increases grain protein content and total yields [9]

The objective of this paper was to investigate effect of mineral and organo-mineral top-dresses nitrogen preparations on development of physiological and morphological parameters in three barley cultivars.

2 Materials and methods

Under the conditions of field experiments in 2020, three cultivars of spring barley were grown, bred at the Federal Agricultural Research Center of the North-East (Kirov, Russian Federation): Pamiaty Rodinoy, Rodnik Prikamya and Novichok. The soil of the experimental site is sod-podzolic, heavy loam, on the eluvium of Perm clays. Agrochemical indicators of the soil: humus content 2.00%, pH_{KCl} 4.83, P_2O_5 - 191 mg kg^{-1} of soil, K_2O - 130 mg kg^{-1} of soil. Before sowing, background mineral fertilizer was used at a rate of NPK 25:4:4 at a dose of 0.3 t ha^{-1} (control variant). In the experimental variants, top-dress feeding of crops was carried out in the tillering stage with combined nitrogen fertilizer (carbamide-ammonium nitrate = CAN) or organo-mineral fertilizer Polydon AminoStart (OMF). The composition of CAN includes ammonium nitrate in an amount of 37-41%, carbamide - 29.5-30.5% and water - 29-31%. The main active substances of organ-mineral fertilizer are (g l^{-1}): total nitrogen - 130; P_2O_5 – 75; K_2O – 25; complex of L-amino acids - 200. The manufacturer recommends this fertilizer to increase number of ear-bearing tillers, grain yield, and increase resistance to abiotic stresses.

Plants were grown on 10 m^2 plots in quadruple repetition. Harvesting was carried out by Wintersteiger combine in the phase of full wax ripening of grain. The assessment of plant development indicators and product quality was carried out in accordance with the methods generally accepted in the Russian Federation [10] in a sample of 30 plants of each variant in quadruple repetition.

In the flowering stage, the state of the pigment complex of spring barley leaves was evaluated. To do this, from each repetition of each investigated variant, flag and second leaves from 30 individual plants were selected. Under laboratory conditions, the content of three main type of pigment (chlorophylls *a* = *Chl a;* chlorophyll *b* = *Chl b;* carotenoids = *Car*), their weight ratios as well as the ratio of chlorophylls in LHC = light-harvesting complexes of photosystems was estimated according to [11] using 100% acetone extraction medium. Concentration of the pigments was determined with UVmini-1240 spectrophotometer (Shimadzu Corporation, Japan) and their content in leaves was calculated on a basis of 1 mg of dry matter.

The meteorological conditions of 2020 growing season were close to the average long-term data for the Kirov region of Russia, with a slight shortage of precipitation in June. A similar nature of the weather was generally favorable for obtaining a harvest of spring barley grains at the level of 3-5 t ha^{-1}.

Obtained data were statistically processed with the software StatSoft Statistica 10 (descriptive statistics and correlation analysis). Data in tables and figure represent the average arithmetic means and their differences according to Dunkan's test. The significance of differences was assessed at $p \leq 0.05$.

3 Results and discussion

Top-dressing treatment of barley plants at the tillering stage (with CAN or OMF) revealed differences in the responsiveness of the studied barley cultivars according to the total yield level (tab. 1): cv. Novichok and Pamiaty Rodinoy, unlike the variety Rodnik Prikamya, statistically significantly increased the yield in variant with the use of organ-mineral fertilizer; in the first cultivar this increasing was about 43%, but in the second cultivar - only 16%.

Table 1. Effects of top-dressing treatments on barley cultivars yield.

Type of top-dressing	cv. Novichok	cv. Rodnik Prikamya	cv. Pamiaty Rodinoy
Control	2.95 a	5.03 c	5.17 c
CAN	3.38 a	5.37 cd	5.48 cd
OMF	4.22 b	5.01 c	5.99 d

Note: values followed with the same letter does not differ statistically at $p \leq 0.05$

At the same time, according to the yield parameter, no statistically significant effect of top-dressing treatment with the CAS preparation was noted in any of the varieties.

In literature, there are contradiction results on effect of N application as top-dressing on grain yield and weight. Thus, [12] pointed out increasing in these parameters when barley treatment was at heading stage; however, [13] showed that such nitrogen application had no effect on them. Under dry conditions of growing season top-dressing of spring barley with organo-mineral fertilizer significantly lowered grain yield in compare with the conventional fertilizer treatment [14]. In the study [15], authors proposed that the differences in response of barley cultivars (expressed via obtained grain yield and weight) might be explained with influence of environmental factors (the year prevailing climate and site characteristics) as well as exact cultivar. Therefore, our results may reflect both differences in cultivar reaction on nitrogen application and timing of its use. In any case, the effect of organo-mineral fertilizer was more pronounced.

The effects of CAN and OMF differed in magnitude and direction for both individual elements of the yield structure and for different genotypes (tab. 2).

Table 2. Impact of top-dressing treatments on the development of elements of barley yield structure.

Type of top-dressing	Grain mass per main ear, g	Length of main ear, cm	Plant height, cm	Grain mass per 1 m^2	Straw mass per 1 m^2
cv. Novichok					
Control	0.94 a	6.21 a	109.2 a	208.2 a	210.0 a
CAN	1.09 b	7.12 d	108.7 a	346.8 ab	348.0 ab
OMF	1.10 b	7.06 bcd	108.4 a	388.4 ab	402.0 b
cv. Rodnik Prikamya					
Control	1.15 b	8.07 f	119.6 e	466.2 bc	423.0 b
CAN	1.09 b	7.76 ef	119.3 de	477.4 bcd	441.0 b
OMF	1.08 b	7.55 de	110.3 a	657.3 cd	441.0 b
cv. Pamiaty Rodinoy					
Control	1.11 b	6.42 a	114.6 bc	585.5 bcd	519.0 bc
CAN	1.08 b	6.24 a	116.1 cde	550.5 bcd	528.0 bc
OMF	1.17 b	7.11 cd	131.1 f	723.4 d	636.0 c

Note: in each column values followed with the same letter does not differ statistically at $p \leq 0.05$

Therefore, the grain mass per main ear increased only in plants of the cv. Novichok: under the influence of CAN treatment - by 15%, under the influence of OMF - by 17%. At the same time, the length of the main ear also increased significantly by 13-15% (at $p \leq 0.05$). The ear length of plants of the cv. Rodnik Prikamya and Pamiaty Rodinoy was influenced only by the OMF - but in the first cultivar there was a decrease of 7.5%, and in the second cultivar - on the contrary, an increase of 11%.

Organo-mineral fertilizer led to a change in the plant height of the cv. Rodnik Prikamya (reduced by 8%) and Pamiaty Rodinoy (increased by 15%) as well as an increase in the straw mass per one square meter in the cv. Novichok by almost twice (by 91%). The absence of the effect of top-dressing application of mineral fertilizer on the straw mass of barley has also been previously noted in the studies of other researchers [12].

The final consumer of agricultural products is interested not only in the yield of grain, but also in its quality. Particular attention is paid to parameters such as test weight, 1000-grain weight, content of protein and fiber in the grain. Test weight is an important indicator of barley quality because it tightly correlates with proportion of large, plump kernels having endosperm rich in starch and lower protein content [16]. Low test weight reflects poor grain fill and unfavorable field environmental conditions before harvest.

It is known that in barley grain weight is highly stable cultivar characteristic. As the results of our study (tab. 3) showed, the largest 1000-grain weight was characterized by the cv. Pamiaty Rodinoy; on average for study, it amounted to 51.23 g. The lightest grain was in the cv. Novichok - the 1000-grain weight was only 44.60 g.

Among the factors determining this indicator, the conditions of mineral nutrition are of particular importance. So, in the experiments of [17], the use of top-dress feeding led to an increase in the 1000-grain weight of spring barley by 10-16%. In our study, top-dressing with OMF increased this parameter in the cv. Novichok (by 4.9%) and Pamiaty Rodinoy (by 2.5%), but slightly decreased in the cv. Rodnik Prikamya (1.5%, statistically significant at $p \leq 0.05$). The increase in the parameter when the use of CAN was significant only for the cv. Novichok (by 2.9%), while the effect was lower than at the use of organic-mineral fertilizer. In the study [12, 18], authors showed that 1000-grain weight was not influenced markedly by nitrogen top-dressing.

The cv. Novichok turned out to be the only one of the studied cultivars in which the use of organ-mineral fertilizer led to a statistically significant increase in the test mass of grain (by 7.7 g l^{-1}); in all other studied variants changes of the parameter were within the standard error. Increase in test weight with N application was pointed out in study of [Tanaka. 2019], but they also established simultaneously increasing in protein concentration in grain.

Table 3. Impact of top-dressing treatments on grain quality of barley cultivars.

Type of top-dressing	1000-grain weight, g	Protein content, g kg^{-1}	Fiber content, g kg^{-1}	Test weight, g l^{-1}
cv. Novichok				
Control	43.12 a	109.2 a	34.9 bcd	671.8 a
CAN	44.35 b	108.7 a	39.5 d	676.2 ab
OMF	45.23 c	108.4 a	36.4 bcd	679.5 b
cv. Rodnik Prikamya				
Control	49.68 ef	119.5 ab	28.1 a	690.8 c
CAN	49.57 de	119.3 ab	32.1 abc	688.5 c
OMF	48.91 d	110.3 a	28.1 a	687.5 c
cv. Pamiaty Rodinoy				
Control	50.82 g	114.6 ab	34.5 bcd	671.8 a
CAN	50.31 fg	116.1 ab	30.6 abc	676.0 ab
OMF	52.10 h	131.1 c	29.2 ab	669.2 a

Note: in each column values followed with the same letter does not differ statistically at $p \leq 0.05$

Information on the content of protein and raw fiber in the barley grain is necessary to determine the class of forage grain (according to the Russian State Standard R53900-2010): the grain of the first class contains more than 130 g kg^{-1} of raw protein and less than 70 g/kg of raw fiber; grains of the second class - 120-130 and 70-90 g/kg, respectively; grains of the third class - less than 120 and more than 90 g kg^{-1}, respectively. Therefore, when breeding new highly productive varieties of fodder barley, it is necessary to maintain the quality of the grain. As can be seen from the data of tab. 3, the protein content in the grain increased only in the one variant of the experiment - when treatment of sowings of the cv. Pamiaty Rodinoy with organ-mineral fertilizer (by 14.5%). No statistically significant differences from the control were found in the remaining studying variants. As it was shown by [19], nitrogen application at heading stage leads to increase in grain protein content. It should be mentioned that in our study a positive correlation of the medium degree ($r = 0.68$ at $p \leq 0.05$) was detected between this parameter and the 1000-grain weight.

As for the fiber content of the grain, this component although reduces the nutritional value of the feed is needed in moderate amounts to stimulate the gastrointestinal tract of animals [20]. The content of this grain component was also correlated with the 1000-grain weight but this relationship was negative ($r = -0.75$ at $p \leq 0.05$). For each cultivar, there were no significant differences between the studied variants in fiber content; all the studied cultivars can be classified as the first class quality, i.e. the applied top-dressing treatments did not lead to deterioration in the feed quality.

Since any top-dressing application of plant nutritional elements primarily affects the leaf assimilating apparatus it is logical to assess the effect of the preparations used on the leaf pigment complex. It is known previously that nitrogen nutrition plays an important role in the synthesis of chlorophyll. Using 70% of nitrogen and full P and K fertilizers as basal and the rest nitrogen as top-dressing gave the highest yield, grain protein content and total chlorophyll content in research of [21]. One reason for this is improvements in soil nitrogen and phosphorus uptake in proper quantity [22]. Topdressing nitrogen fertilizer in study [12] significantly changed chlorophyll content where this practice led to the highest chlorophyll content whereas the minimum one was related to no such application of nitrogen. In barley breeding, physiological studies are mainly focused on correlation between grain yield and its components [23], but we try to assess the relationship between changes in leaf pigment complex and some elements of yield structure.

The use of top-dress plant feeding with a complex carbamide-ammonia mixture (CAN) led to a statistically significant increase in chlorophyll content in flag leaves of the cv. Novichok (8%) and Rodnik Prikamya (9%); for the cv. Pamiaty Rodinoy significant differences from control were not revealed according to this parameter (fig.). An increase in chlorophyll *b* was noted only for the cv. Novichok; and this increase was more significant than in chlorophyll *a* and amounted to 18%. The reaction of the pigment complex of second leaves in plants of the cv. Novichok differed only in magnitude (6 and 10.5%, respectively). In the cv. Rodnik Prikamya the content of chlorophylls *a* and *b* remained at the control level; in the cv. Pamiaty Rodinoy the content of both forms of chlorophyll decreased (*Chl a* - by 4.5, *Chl b* - by 8.5%).

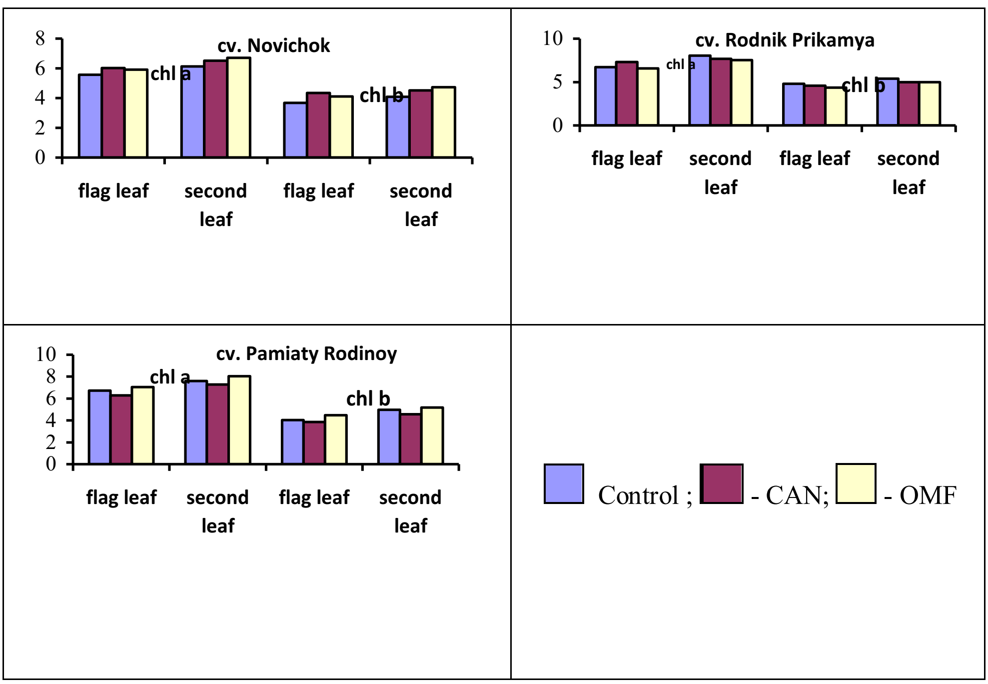

Fig. 1. Influence of top-dressing on chlorophylls content in flag and second leaves of barley plants (mg g^{-1} of dry matter).

Treatment of barley plants with organ-mineral fertilizer Aminostart statistically significantly changed the content of both chlorophyll pigments in the cv. Novichok in both flag and second leaves: for flag leaves, the increase was 6 and 12%; for second leaf - 9 and 16% (chlorophylls *a* and *b*, respectively). For the cv. Rodnik Prikamya, the statistically significant influence of the OMF was noted only on the content of chlorophyll *b* in flag leaves (a decrease of 9.5%). In the flag leaves of plants of the cv. Pamiaty Rodinoy, an increase in the content of this pigment by 10.5% was noted; the content of both chlorophyll *a* (by 6%) and chlorophyll *b* (by 4%) increased statistically in second leaves.

However, in general, both fertilizers did not affect the ratio of chlorophylls *a*/*b* in the cv. Pamiaty Rodinoy and Rodnik Prikamya, while significantly lowering this ratio for plants of the cv. Novichok (by 4.0-8.5%). As for the structural rearrangement of the pigment complex, in the cv. Novichok, both preparations slightly increased the pigment content in the light-harvesting complexes of photosystems (by 2.3-5.4%), in the cv. Rodnik Prikamya, the pigment content in the light-harvesting complexes decreased (by 3.1-7.9%), in the cv. Pamiaty Rodinoy, the rearrangement of the pigment complex were not noted.

Both fertilizers used had no effect on the carotenoid content in barley leaves.

Since the photosynthetic apparatus of leaves creates an organic substance from which all tissues and organs of plants are built, we estimated the degree of correlation between the change in the state of the pigment complex and the examined elements of productivity of spring barley plants.

As the analysis of data in tab. 4, 5 shows, in general, for the studied cultivars and variants of top-dressing treatment, the largest number of statistically significant links (at $p \leq 0.05$) with the used plant development parameters was found for the parameter "*Chl a* content" and "carotenoid content".

Table 4. Values of correlation coefficients between parameters of flag leaf pigment complex and some yield characteristics in barley.

Parameter	Content of *Chl a*	Content of *Chl b*	Content of *Car*	*Chl a/b* ratio	*Chl / Car* ratio	Part of *Chl* in LHC**
Yield	0.846*	0.441	0.883*	0.567	-0.800*	-0.537
Grain mass per main ear	0.677*	0.724*	0.514	-0.016	-0.242	0.050
Lenth of main ear	0.543	0.939*	0.363	-0.485	-0.015	0.502
Plant height	0.750*	0.489	0.677*	0.386	-0.538	-0.359
Grain mass per 1 m^2	0.729*	0.366	0.740*	0.488	-0.669*	-0.470
Straw mass per 1 m^2	0.714*	0.325	0.688*	0.530	-0.606	-0.508
1000-grain mass	0.847*	0.421	0.909*	0.607	-0.841*	-0.566
Protein content in grain	0.753*	0.490	0.679*	0.388	-0.539	-0.362
Fiber content in grain	-0.577	-0.411	-0.732*	-0.276	0.735*	0.239
Test weight	0.336	0.649	0.342	-0.371	-0.155	0.393

Note: * - correlation is statistically significant at $p \leq 0.05$
** - Light-Harvesting Complex

Table 5. Values of correlation coefficients between parameters of second leaf pigment complex and some yield characteristics in barley.

Parameter	Content of *Chl a*	Content of *Chl b*	Content of *Car*	*Chl a/b* ratio	*Chl / Car* ratio	Part of *Chl* in LHC**
Yield	0.912*	0.754*	0.921*	0.658	-0.690*	-0.649
Grain mass per main ear	0.787*	0.869*	0.624	0.064	-0.143	-0.056
Lenth of main ear	0.531	0.725*	0.323	-0.243	0.121	0.264
Plant height	0.779*	0.637	0.747*	0.555	-0.527	-0.561
Grain mass per 1 m^2	0.822*	0.695*	0.819*	0.561	-0.596	-0.549
Straw mass per 1 m^2	0.792*	0.659	0.783*	0.547	-0.546	-0.542
1000-grain mass	0.933*	0.756*	0.968*	0.708*	-0.770*	-0.704*
Protein content in grain	0.778*	0.636	0.747*	0.555	-0.527	-0.562
Fiber content in grain	-0.773*	-0.625	-0.803*	-0.618	0.674	0.607
Test weight	0.346	0.471	0.255	-0.122	-0.020	0.148

Note: * - correlation is statistically significant at $p \leq 0.05$
** - Light-Harvesting Complex

On the contrary, such parameters of the pigment complex of flag leaves as the "mass ratio of chlorophylls a/b" and the "part of chlorophylls included in the light-harvesting complexes of photosystems" did not have reliable connections with the tested elements of productivity. However, in the case of the second leaf, an increase in the chlorophyll a/b ratio reliably (at $p \leq 0.05$) contributed to an increase in the 1000-grain weight, while an increase in the part of chlorophyll in light-harvesting complexes negatively affected the 1000-grain weight.

Earlier, based on long-term field experiments, we came to the opinion that the activity of the photosynthetic apparatus of flag and second leaves is associated to varying degrees with the final productivity of barley plants, and the content of pigments in the second leaf is a more suitable parameter for assessing the potential productivity of the cultivar [24]. As shown in tab. 5, all six used parameters of the state of the pigment complex of second leaves had a highly significant correlation with such an important parameter of the yield structure as "1000-grain weight," while for the flag leaf there were only three parameters.

On the other hand, the parameter "test weight" was not statistically significantly associated with any of the parameter of pigment complexes of both flag and second leaves.

Thus, if take into account only the absolute content of the three main forms of photosynthetic pigments, it can be assumed that the change in the conditions for the synthesis and accumulation of chlorophyll a under the influence of top-dressing treatment affects the development of seven (in the case of flag leaf) or eight (for second leaf) out of ten studied elements of productivity of spring barley plants. Changes in the content of chlorophyll b are closely associated with changes in the length and grain mass of the main ear (for flag leaf), as well as the yield, grain mass per 1 m2 and 1000-grain weight. The accumulation of carotenoids in both leaves of barley showed the same in direction and values relationship with the studied plant parameters as chlorophyll a. The exception is several cases: for both leaves, there was no link with the parameter "Grain mass per main ear," but for the flag leaf, there was a negative link with parameter "Fiber content in grain."

4 Conclusions

Top-dress treatment of barley plants with mineral (CAN) and organo-mineral fertilizer (OMF) at tillering stage revealed significant differences in the reaction of the studied cultivars in magnitude and direction of some elements of the yield structure.

The use of CAN had a smaller effect on the development of the studied parameters of spring barley plants than the use of OMF. CAN had no significant effect on grain yield and straw mass in any of the experimental variants. For the cv. Novichok, there was an increase in grain weight from the main ear by 15%, the length of the main ear by 15%, the 1000-grain weight by 2.9%.

CAN led to an increase in the content of *Chl a* in flag leaves of the cv. Novichok (by 8%) and Rodnik Prikamya (by 9%); no changes were found for the cv. Pamiaty Rodinoy; an increase in the content of *Chl b* was noted only for the cv. Novichok (by 18%). An increase in the content of *Chl a* and *Chl b* (by 6 and 10.5%, respectively) was noted for second leaves of the cv. Novichok. In the cv. Rodnik Prikamya, the content of *Chls* has not changed; in the cv. Pamiaty Rodinoy there was a decrease in content (*Chl a* - by 4.5, *Chl b* - by 8.5%).

OMF led to a change in the plant height of cv. Rodnik Prikamya (reduced by 8%) and Pamiaty Rodinoy (increased by 15%) and an increase in the straw mass per 1 m^2 in the cv. Novichok by almost twice (by 91%). The grain yield increased in the cv. Novichok by 43%, the cv. Pamiaty Rodinoy by 16%, and did not change in the cv. Rodnik Prikamya. Only the cv. Novichok has increased the grain mass from the main ear (by 17%). The length of the main ear increased in the cv. Novichok (by 13%), Pamiaty Rodinoy (by 11%) but decreased in the cv. Rodnik Prikamya (by 7.5%). The influence of OMF increased the

1000-grain weight in the cv. Novichok (by 4.9%) and Pamiaty Rodinoy (by 2.5%), but decreased in the cv. Rodnik Prikamya (1.5%, statistically significant at $p \leq 0.05$).

The use of organ-mineral fertilizer led to an increase in the test weight of grain in cv. Novichok (by 7.7 g l^{-1}) and the grain protein content in the cv. Pamiaty Rodinoy (by 14.5%).

For flag leaves of cv. Novichok, the increase in *Chl a* and *Chl b* was 6 and 12%; for second leaf - 9 and 16%, respectively. For the cv. Rodnik Prikamya, there was a statistically significant decrease in the *Chl b* content in flag leaves (by 9.5%). In the flag leaves of the cv. Pamiaty Rodinoy, an increase in the content of this pigment by 10.5% was noted; the content of both *Chl a* (by 6%) and *Chl b* (by 4%) increased statistically in second leaves.

The effect of both preparations on the grain fiber content was not revealed; all the studied cultivars can be classified as the first quality class, i.e. the applied top-dress treatments did not lead to a deterioration in the feed quality.

One can note the similarity in the action of the preparations: both top-dressing fertilizers did not affect the ratio of *Chl a*/*b* in the cv. Pamiaty Rodinoy and the Rodnik Prikamya; at the same time significantly reduced this ratio for plants of the cv. Novichok (by 4.0-8.5%). In the cv. Novichok, both preparations slightly increased the pigment content in the light-harvesting complexes of photosystems (by 2.3-5.4%), in the cv. Rodnik Prikamya, the pigment content in the LHC decreased (by 3.1-7.9%), in the cv. Pamiaty Rodinoy, the rearrangement of the pigment complex was not noted.

The change in the synthesis and accumulation of *Chl a* under the influence of top-dress treatment is reflected in the development of seven (for flag leaf) or eight (for second leaf) out of ten studied elements of the productivity of spring barley plants. Changes in the content of *Chl b* are closely related to changes in the length and mass of the grain of the main ear (for flag leaf), and in addition to the yield, grain mass per 1 m^2 and 1000-grain weight (for second leaf). The accumulation of carotenoids in both leaves of barley showed the same relationship with the studied plant parameters as for *Chl a*. Several cases are the exception: for both leaves, there was no link with the parameter "grain mass per main ear"; for the flag leaf there was a negative link with "fiber content in grain". The parameter "test weight" was not statistically associated with any of the parameters of pigment complexes of both flag and second leaves.

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