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Productivity of Spring Triticale under Conditions of the Southern Steppe of Ukraine

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ABSTRACT
Triticale is a valuable grain forage and food crop. Application of fertilizers enables to both increase the grain yield and improve its quality indicators. Triticale responds positively to fertilization, foliar top dressing, and the action of growth-regulating drugs. The presented field experiments were carried out in 2014–2016 in the educational-scientific-practical center of the Mykolaiv national agrarian university on the southern chernozem, typical for the southern Steppe of Ukraine. Pre-sowing seed treatment, application of mineral fertilizers and foliar nitrogen fertilization had a positive effect on the length of the ear, the number of grains in it, the mass of grain from the ear of the main stem and the level of the formed yield of spring triticale grain. Among the studied fertilizer options, the introduction of $N_{30}P_{30}$ before sowing and top dressing with ammonium nitrate at a dose of N_{30} against the background of pre-sowing seed treatment with Escort-Bio was advantageous. In this variant, the yield was 3.61 t/ha, the length of the ear was 10.4 cm, the number of grains in the ear was 30.2 PCs, the weight of grain from the ear of the main stem was 1.43 g. Creating an optimal nutrition background for plants improved the quality indicators of the spring triticale grain. The most favorable conditions for the formation of grain nature were provided by applying $N_{60}P_{30}$ before sowing and $N_{30}P_{30}$ before sowing with top dressing in a dose of N_{30} in the form of ammonium nitrate, urea or double top dressing with D2. The maximum protein content in the grain of the spring triticale was ensured by the introduction of $N_{30}P_{30}$ into the sowing with feeding with carbamide at a dose of N_{30}. Due to the higher yield, the highest conditional protein yield per hectare of spring triticale sowing was provided by the introduction of $N_{60}P_{30}$ before sowing and $N_{30}P_{30}$ before sowing with top dressing with ammonium nitrate in the phase of stooling at a dose of N_{30}. Improving the background of plant nutrition in cultivation technology is a promising measure to increase the productivity of spring triticale.

Keywords: spring triticale, mineral fertilizers, growth-regulating preparations, pre-sowing seed treatment, foliar top dressing, grain yield, grain nature, protein content in grain.

INTRODUCTION

Stable grain production has always been a priority. This encourages farmers to develop the measures that allow not only to increase the yield levels, but also to significantly improve the main indicators of grain quality. An important reserve for increasing the grain production can be the introduction of modern varieties of spring crops with a high potential for grain yield and quality. They must be adapted to the growing conditions, resistant to adverse stress abiotic environmental factors, and characterized by high quality of grain and its processed products [Grebennikova et al. 2016].

The yield and grain quality of spring crops largely depends on the optimization of nutrition and especially on the supply of nitrogen to plants [Liu et al. 2010, Mansour et al. 2017]. Obtaining high yields of spring triticale grain is influenced by the level of soil fertility and the fertilizer system in the technology of growing the crop. It is known that spring triticale responds very well to fertilizer application [Sydiakina et al. 2018, Wysokiński and Kuziemska 2019].

The productivity of spring triticale varieties under various fertilizer systems was studied on typical low-humus chernozem in the field crop rotation of the Nubip of Ukraine. The varieties of spring triticale, including Aist Kharkiv, Veresoch and Losinovskoe, were grown. The results of studies showed that the protein content in grain of all varieties increased along with the norm of mineral nitrogen. When applying phosphorus-potassium fertilizers under the main tillage in the P60K60 norm, the physical quality indicators of spring triticale grain were close to control. Nitrogen fertilizers played a leading role in shaping the quality indicators of spring triticale [Kushnirenko 2010]. The primary importance of nitrogen nutrition for obtaining stable and high quality yields of spring triticale is also confirmed by the results of other studies [Knapowski et al. 2009, Janusauskaite et al. 2017].

On dark gray podzolized soils, in order to obtain a grain harvest at the level of 4.5–5.0 t/ha with high technological quality indicators, it is advisable to grow Arsenal spring triticale using the technology that provides for the introduction of P90K90 in the main fertilizer and differentiated application of nitrogen: such as 1/2 dose (45 kg/ha of active substance) for pre–sowing tillage and 1/2 dose-in top dressing at the IV stage of organogenesis. In the farms with a high level of farming on the soils that are sufficiently provided with phosphorus and potassium, it is cost-effective to use only mineral nitrogen fertilizers, taking into account the overall level of soil fertility [Blazhevych 2005]. The effect of foliar top dressing of spring triticale crops of the Karavay Kharkivsky Variety was studied on the chernozem of a typical deep heavy loamy experimental field of the Kharkiv NAU. Top dressing was carried out with urea and water as soluble complex of fertilizer kristallon special. The studies of the photosynthetic potential of sowing and pure photosynthetic productivity showed that the above-mentioned indicators were found in the areas with complex top dressing of spring triticale crops with urea (N30) simultaneously with microfertilizer kristallon special during the stooling period of crops [Rozhkov and Gutyansky 2015].

The influence of the main application of mineral fertilizers and foliar top dressing of spring triticale crops was studied in grain- on row crop rotation on typical deep low-humus chernozem. In the experiment, the spring triticale of the Khlebodar Kharkiv variety was grown. The experiment scheme included 4 fertilizer options, such as:

- without fertilizers (control);
- N50R50K50 – for the main tillage;
- N20R50K50 – for the main tillage + N30 for top dressing in the tillering phase of plants;
- N70R70K70 – for the main tillage + N30 for top dressing in the tillering phase of plants.

The maximum level of grain yield (4.45 t/ha) and the content of crude protein in it according to the results of four-year studies was provided by the application of mineral fertilizers in the dose of N70P70K70 for basic tillage + N30 for top dressing in the tillering phase. A slightly lower yield (4.23 t/ha) was obtained in the variant of the main application N20P50K50 with top dressing N30 in the tillering phase. However, the calculations of economic efficiency showed that this version of the experiment turned out to be more cost-effective and provided profitability at the level of 92% [Onychko and Berdin 2011].

When developing a fertilizer system for a particular agricultural crop, it is very important to take into account the removal of nutrients by commercial and non-commercial parts of the crop. This makes it possible to determine how much the nutrient elements are alienated and which are returned to the soil as organic substances [Płaza et al. 2020, Wright and Ghezzi-Haeft 2020] The removal of nutrients per unit of formed products with the appropriate amount of non-commodity part of the crop depends both on the biological characteristics of the crop and on the technology of its cultivation [El-Ramady et al. 2014]. To a large extent, the relative removal of nutrients from the soil is determined by the fertilizer system, and especially those crops that have the intense tillering ability, and accordingly, the formation of a significant share of the non-commodity part of the crop. Therefore, the balance of basic nutrient elements is one of the objective economic indicators of the degree of intensification and culture of agriculture. Acute deficiency of basic macronutrients in soils leads to a decrease in their fertility, and as a result, to significant crop shortages [Gamajunova et al. 2004, Barrett and Bevis 2015, Sharma et al. 2016].

The protein content of triticale grain is higher than that of other cereals and it ranges from 10 up to 28% [Roques et al. 2017]. The high protein content and its balance in the amino acid composition ensure the versatility of using this culture. It is widely used for food, technical and nutrition purposes [Ates et al. 2017, Zhu 2018].

Triticale flour contains high-quality gluten, so it is often added to low-quality wheat flour in bakery production. Thus, after mixing sixth-grade wheat flour with a baking score of 2.1 points with triticale flour (4.6 points), bread with a score of 5 points is baked [Doxastakis et al. 2002, Tohver et al. 2005].

The studies conducted on podzolized heavy–loam chernozem of the Uman NUS experimental field determined that the gluten content in the spring triticale grain of the Khlebodar Kharkiv Variety in the unfertilized control variant was 18.1%, and with the application of 30–180 kg/ha DG of nitrogen fertilizers against the background of P120K120 increased to 20.2–25.7%. The increase in the rate of nitrogen fertilizers to N210 did not affect the gluten content in triticale grain, but this indicator changed over the years of research and largely depended on the weather conditions of the growing season. At the same time, based on the results of three years of research, it was found that fertilizers slightly reduced the elasticity, hydration ability and average stretchability of gluten [Sukhomud and Lyubich 2013].

An important factor in increasing the yield and improving the quality of spring triticale grain is the use of growth regulators and fertilizing with micro-fertilizers. Micro-elements, as components of the most important physiologically active substances, increase the enzymatic activity of plants, improve their absorption of nutrients, as well as enhance the intensity of photosynthesis and assimilation activity. When fed with micro-fertilizers, plants become more resistant to adverse environmental conditions, pest and disease damage. As a result, the yield increases and grain quality indicators improve [Dobreva 2016, Kshnikatkina et al. 2017].

Creating a favorable nutrition background is of exceptional importance for the growth and development of spring triticale plants, their formation of vegetative mass and significant increases in grain yield with high quality indicators. When growing modern varieties of spring triticale, it is extremely important to balance the norms and terms of fertilizer application. This area of research is very relevant and requires a comprehensive study.

MATERIALS AND METHODS

The field experiments were carried out in the period from 2014 to 2016 on the fields of educational-scientific-practical center of the Mykolaiv national agrarian university (latitude 46°57’57”N and longitude 32°00’12”E). The study was devoted to determining the effect of mineral fertilizers and growth-regulating substances on the formation of yield and quality of spring triticale grain under the arid conditions of the southern Steppe of Ukraine.

The experimental design included the following factors and their variants: Factor A – background of plant nutrition: without fertilizers (control); $N_{30}P_{30}$ before sowing; $N_{60}P_{30}$ before sowing; $N_{30}P_{30}$ before sowing + N_{30} (ammonium nitrate (AN) in the phase of plants stooling (1)); $N_{30}P_{30}$ before sowing + D_2 (in the phase of plants stooling (1)); $N_{30}P_{30}$ before sowing + Escort-Bio (in the phase of plants stooling (1)); $N_{30}P_{30}$ before sowing + D_2 (in the phase of plant exit into the tube (1) and earing (2)); $N_{30}P_{30}$ before sowing + Escort-Bio (in the phase of plant exit into the tube (1) and earing (2)); $N_{30}P_{30}$ before sowing + N_{30} (carbamide in the earing phase (2)); Factor B – pre-sowing seed treatment: seed treatment with water; seed treatment Escort-Bio. The field experiments were carried out in accordance with the generally accepted requirements and recommendations [Dospehov 1985, Yeshchenko et al. 2014]. The trial was based on a split plot method with a three-fold replication. The sown area of the second-order elementary plot was 80 m^2; the record plot was 30 m^2.

The objects of the present study were mineral fertilizers (ammonium nitrate, granular superphosphate, Carbide) and biological products (Escort-Bio, D2). Escort-Bio is a natural microbial complex that includes a consortium of highly active live strains of microorganisms of the Azotobacter, Pseudomonas, Rhizobium, Lactobacillius, and Bacillus genera as well as biologically active substances found by them. D2 is a complex organo-mineral preparation containing physiological and growth-regulating substances, characterized by high agrochemical efficiency and the property of mobilizing hard-to-reach indigestible phosphates. On the day of sowing, the seeds of spring triticale were treated with Escort-Bio at the rate of 50 ml of the drug per hectare rate of seeds at 1% concentration of the working solution, in accordance with the experiment scheme. Sowing in the phases of stooling and earing was treated with the D2 preparations at the rate of 1 l/ha, Escort-Bio at the rate 0.5 l/ha with a working solution rate of 200 l/ha.

The yield was taken into account from each site of the experiment by continuous weighing, adjusted for 14% humidity and 100% grain purity. The structure of the crop was determined with the weight method during harvesting. The protein content in the grain was determined by infrared spectroscopy [DSTU 4117:2007], the grain nature was determined using a liter purk [GOST 10840-64].

The soil of the experimental plot is chernozem southern low-humus weakly saline heavy loam, typical for the southern steppe zone of Ukraine. The arable layer of the soil contains humus (3.2%), nitrates (25), movable phosphorus (40), and exchangeable potassium (460 mg/kg of soil).

The climate of the research area is moderately continental, moderately hot and very arid. The consumption of moisture for evaporation is twice as high as the amount of its intake. On average, 470 mm of precipitation falls per year, the relative humidity of the air is 73%, the hydrothermal coefficient is 0.5–0.7. Small amount of precipitation with a significant supply of thermal resources (the sum of active temperatures above 10°C is 3200–3400°C), leads to the fact that farming is on the verge of constant risk, and the yield of cultivated crops varies widely. The years of research varied under weather conditions, but in general they were typical for the Southern steppe of Ukraine.

RESULTS AND DISCUSSION

The results of the studies showed that the optimization of the nutrition background contributes to the formation of much higher grain yield compared to unfertilized control. The control collected 1.99 t/ha of triticale grain for an average of three years of research (Table 1). Depending on the doses and terms of applying mineral fertilizers and spraying plants on the leaf with growth–regulating preparations, the yield of spring triticale grain increased by 34.2 up to 69.5% compared to the control.

Pre-sowing treatment of seeds with Escort-Bio increased the yield of spring triticale grain in the control without fertilizers from 1.99 up to 2.13 t/ha or by 7.0%. In the fertilized versions of the experiment, this increase was 0.20 up to 0.27 t/ha or 7.4 up to 8.1%. The maximum grain yield on average for three years of research was determined by applying N30P30 before sowing and fertilizing with ammonium nitrate at a dose of N30 against the background of pre-sowing seed treatment with applying Escort – Bio as 3.61 t/ha.

A higher grain yield due to the application of fertilizers, top dressing and the use of

Table 1. Grain yield of spring triticale on different plant nutrition backgrounds, t/ha

Plant nutrition background	Years of research				Increase to control	
	2014	2015	2016	Average for 2014–2016	t/ha	%
Seed treatment with water						
Without fertilizers (control)	1.39	2.22	2.36	1.99	0.00	0.0
$N_{30}P_{30}$ before sowing	1.81	3.08	3.12	2.67	0.68	34.2
$N_{60}P_{30}$ before sowing	2.30	3.55	3.62	3.16	1.17	58.8
$N_{30}P_{30}$ before sowing + N_{30} (AN[1])	2.48	3.74	3.81	3.34	1.35	67.8
$N_{30}P_{30}$ before sowing + D_2[1]	1.92	3.26	3.31	2.83	0.84	42.2
$N_{30}P_{30}$ before sowing + Escort-Bio[1]	1.95	3.32	3.39	2.89	0.90	45.2
$N_{30}P_{30}$ before sowing + D_2[1, 2]	2.12	3.42	3.52	3.02	1.03	51.8
$N_{30}P_{30}$ before sowing + Escort-Bio[1, 2]	2.15	3.55	3.61	3.10	1.11	55.8
$N_{30}P_{30}$ before sowing + N_{30} (carbamide[2])	2.13	3.38	3.40	2.97	0.98	49.2
Seed treatment Escort-Bio						
Without fertilizers (control)	1.53	2.34	2.51	2.13	0.00	0.0
$N_{30}P_{30}$ before sowing	2.02	3.21	3.38	2.87	0.74	34.7
$N_{60}P_{30}$ before sowing	2.48	3.75	3.97	3.40	1.27	59.6
$N_{30}P_{30}$ before sowing + N_{30} (AN[1])	2.69	3.93	4.22	3.61	1.48	69.5
$N_{30}P_{30}$ before sowing + D_2[1]	2.08	3.43	3.64	3.05	0.92	43.2
$N_{30}P_{30}$ before sowing + Escort-Bio[1]	2.14	3.52	3.70	3.12	0.99	46.5
$N_{30}P_{30}$ before sowing + D_2[1, 2]	2.28	3.64	3.84	3.25	1.12	52.6
$N_{30}P_{30}$ before sowing + Escort-Bio[1, 2]	2.33	3.72	3.94	3.33	1.20	56.3
$N_{30}P_{30}$ before sowing + N_{30} (carbamide[2])	2.32	3.55	3.74	3.20	1,07	50.2

Note: 1 – stooling, 2 – earing.

growth-regulating preparations was formed due to the different length of the ear, the number of grains in it and the weight of grain from the ear of the main stem (Table 2). These indicators were defined as minimal in the experiment variant without fertilization: the average length of the ear was 8.8 cm (Fig. 1); the number of grains in the ear was 26.8 PCs. (Fig. 2); grain weight from the ear of the main stem was 1.25 g (Fig. 3).

The introduction of N30P30 before sowing increased the length of the ear, compared to the control, by 6.8%. This indicator was even higher when making N60P30. Carrying out one- and two-time top dressing with growth-regulating preparations against the background of N30P30 slightly increased the length of the ear, compared to the N30P30 variant, but it was lesser than when applying N60P30. The maximum length of the ear was formed by plants in the variant of top dressing with ammonium nitrate at a dose of N30 – 10.0 CM. This is an increase of 13.6% compared to the control without fertilizers.

The number of grains in the ear under the influence of fertilizers and growth–regulating preparations increased by 4.9–10.1%. This indicator is determined to be the maximum for applying N30P30 before sowing and fertilizing with ammonium nitrate. The use of urea was less effective, and double nutritioning with growth–regulating preparations contributed to an increase in the number of grains in the ear, compared to the background of N30P30, by 2.5–2.8%.

Over three years of research, the mass of grain from the ear of the main stem increased by 4.0–11.2%, on average, due to the optimization of the nutrition background. This indicator, as well as other elements of the crop structure, is determined by applying N30P30 before sowing and fertilizing with ammonium nitrate.

The pre-sowing treatment of seeds with the Escort- bacterial preparation Bio led to an increase in all elements of the crop structure that were studied. Thus, the length of the ear due to the drug increased from 9.2 to 9.9 cm, the number of grains in the ear increased by 6.9%, and the mass of grain from the ear of the main stem increased by 7.0%.

In order to ensure the competitiveness of grain products in the domestic and foreign grain markets, the quality and safety of products are a priority. It is well known that under conditions of insufficient supply of nutrients, and especially nitrogen, spring triticale forms low-quality grain. If high yield levels are obtained, the grain quality will not be high enough, which is associated with a lack of nitrogen nutrition during the grain filling period [Janusauskaite 2013].

Modern varieties of spring triticale are characterized by high indicators of physical properties, in terms of grain quality and technological properties, flour is not inferior, and in some respects even prevails over wheat of baking classes. Owing to this, spring triticale can be grown as the main food crop [Zhu 2018].

The quality of grain of spring crops is affected by almost all agrotechnical methods of cultivation and, above all, the plant nutrition system. It is possible to significantly improve the quality of grain by carrying out top dressing, which was confirmed by the results of our research. With the improvement of the nutritional regime during the growing season of spring triticale plants,

Table 2. Elements of crop structure (average for 2014–2016)

Plant nutrition background	Seed treatment with water			Seed treatment Escort-Bio		
	Ear length, cm	Number of grains in an ear, pcs.	Weight of grain from the ear of the main stem, g	Ear length, cm	Number of grains in an ear, pcs.	Weight of grain from the ear of the main stem, g
Without fertilizers (control)	8.5	25.6	1.21	9.1	27.9	1.29
$N_{30}P_{30}$ before sowing	9.0	27.1	1.25	9.7	29.0	1.34
$N_{60}P_{30}$ before sowing	9.5	28.5	1.32	10.3	29.9	1.41
$N_{30}P_{30}$ before sowing + N_{30} (AN[1])	9.6	28.8	1.34	10.4	30.2	1.43
$N_{30}P_{30}$ before sowing + D_2[1]	9.2	27.4	1.27	9.9	29.3	1.36
$N_{30}P_{30}$ before sowing + Escort-Bio[1]	9.2	27.5	1.28	9.9	29.5	1.37
$N_{30}P_{30}$ before sowing + D_2[1, 2]	9.3	27.7	1.29	10.1	29.8	1.39
$N_{30}P_{30}$ before sowing + Escort-Bio[1, 2]	9.4	27.9	1.30	10.1	29.9	1.39
$N_{30}P_{30}$ before sowing + N_{30} (carbamide[2])	9.3	27.6	1.27	10.0	29.6	1.36

Note: 1 – stooling, 2 – earing.

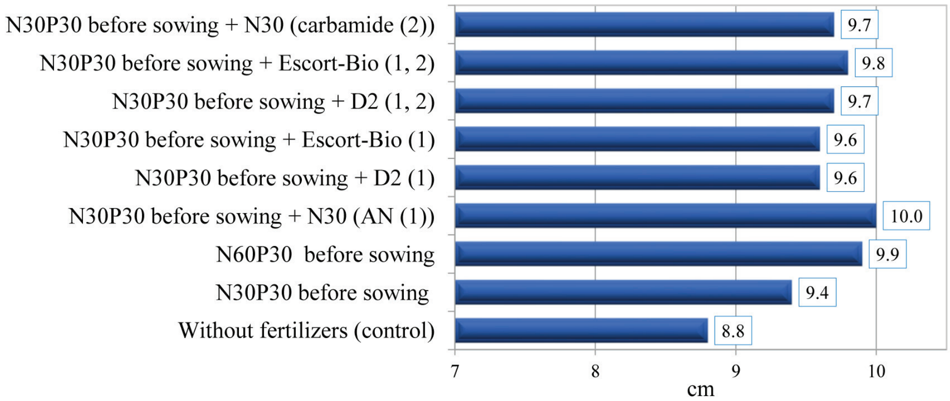

Figure 1. Ear length on the factor under study (average for 2014–2016)

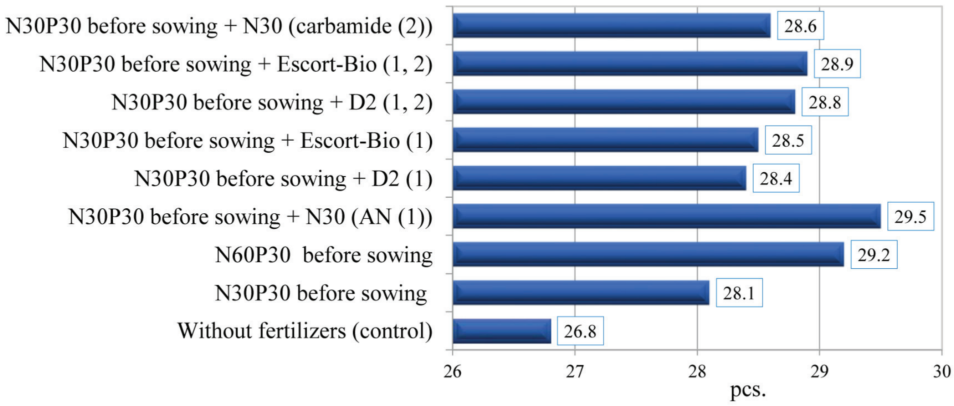

Figure 2. The number of grains in the ear on the studied factor (average for 2014–2016)

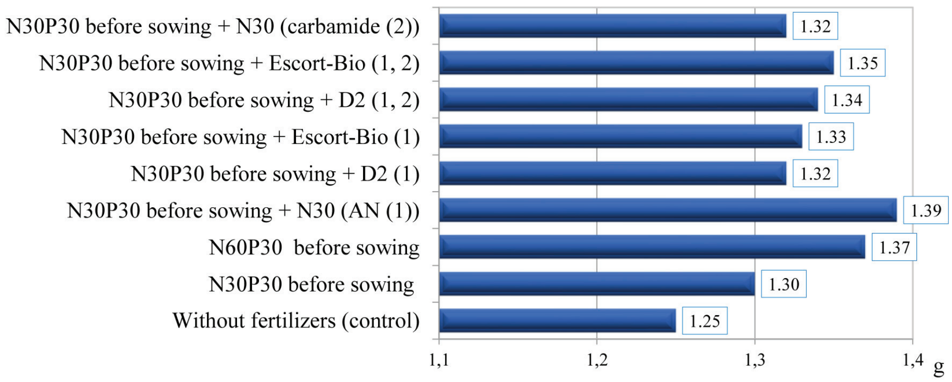

Figure 3. Weight of grain from the ear of the main stem on the studied factor (average for 2014–2016)

the natural weight increased as an important feature which characterizes the quality of grain. In the flour industry, this indicator is given great importance due to the fact that it affects the yield of flour. The nature of grain for three years of studies in the control was 732 G/L, on average (Table 3). Optimization of nutrition contributed to an increase in the indicator by 6–13 G/L or 0.8–1.8%. To the smallest extent, the natural weight of grain increased in the variant involving N30P30 application before sowing. In all other fertilizer options, the increase in the indicator was more significant. The maximum nature of spring triticale grain was determined in the variants of N60P30 application to sowing and N30P30 application to sowing with top dressing in a dose of N30 in the form of ammonium nitrate, urea or double top dressing with a complex organo-mineral preparation D2.

An important component of spring grain is protein. To a large extent, the protein content in the grain is affected by fertilizers. Their use on

Table 3. The nature of spring triticale grain for yrs of cultivation by the factor, g/l

Plant nutrition background	Years of research			
	2014	2015	2016	Average for 2014–2016
Without fertilizers (control)	735	731	730	732
$N_{30}P_{30}$ before sowing	741	738	736	738
$N_{60}P_{30}$ before sowing	749	743	742	745
$N_{30}P_{30}$ before sowing + N_{30} (AN[1])	749	744	743	745
$N_{30}P_{30}$ before sowing + D_2[1]	747	743	743	744
$N_{30}P_{30}$ before sowing + Escort-Bio[1]	747	743	742	744
$N_{30}P_{30}$ before sowing + D_2[1, 2]	749	743	742	745
$N_{30}P_{30}$ before sowing + Escort-Bio[1, 2]	748	743	742	744
$N_{30}P_{30}$ before sowing + N_{30} (carbamide[2])	748	744	743	745

Note: 1 – stooling, 2 – earing.

various soils can both positively and negatively affect the protein content of grain, which is associated with the effect of both biotic and abiotic factors on this indicator [Ramazanova et al. 2018, Abdelaal et al. 2019].

The minimum protein content in spring triticale grain was provided by the control version of the experiment without fertilization as 11.3% on average for three years of research (Table 4). Optimization of the nutrition background increased this quality indicator by 0.9 up to 1.6%. The maximum protein content of grain was determined in the variant of applying N30P30 to sowing with top dressing at the beginning of earing with urea at a dose of N30 as 12.9%. Slightly lower protein content in the grain was provided by the options with double top dressing with growth-regulating preparations. This quality indicator was least affected by the single application of N30P30 and N60P30 before sowing, which convincingly indicated the effectiveness of foliar top dressing on spring triticale.

A slightly different pattern between the variants of the experiment was observed for the conditional protein yield per hectare of spring triticale sowing. It is determined to be minimal for growing plants in the areas of unfertilized control as 0.24 t/ha on average for three years of research (Table 5). It turned out to be slightly larger when N30P30 was applied before sowing it was 0.34 t/ha. A single top dressing of crops with growth–regulating preparations provided a conditional protein yield of 0.37–0.38 t/ha, which was by 54.2–58.3% more than in the control. Double top dressing with growth-regulating preparations and the introduction of urea at a dose of N30 proved to be more effective. The conditional protein yield per hectare of sowing was 0.40–0.41 t/ha, that is, it was almost twice as high as the control version of the experiment. However, the maximum indicator was provided by the introduction of N60P30 before sowing and N30P30 before sowing with top dressing with ammonium nitrate in the phase of stooling at a dose of N30 as 0.42 up to 0.45 t/ha.

Table 4. Protein content in spring triticale grain on the studied factor, %

Plant nutrition background	Years of research			
	2014	2015	2016	Average for 2014–2016
Without fertilizers (control)	11.6	11.2	11.2	11.3
$N_{30}P_{30}$ before sowing	12.5	12.0	12.2	12.2
$N_{60}P_{30}$ before sowing	12.7	12.3	12.5	12.5
$N_{30}P_{30}$ before sowing + N_{30} (AN[1])	12.8	12.4	12.6	12.6
$N_{30}P_{30}$ before sowing + D_2[1]	12.7	12.3	12.5	12.5
$N_{30}P_{30}$ before sowing + Escort-Bio[1]	12.7	12.3	12.5	12.5
$N_{30}P_{30}$ before sowing + D_2[1, 2]	12.9	12.5	12.6	12.7
$N_{30}P_{30}$ before sowing + Escort-Bio[1, 2]	12.9	12.5	12.7	12.7
$N_{30}P_{30}$ before sowing + N_{30} (carbamide[2])	13.1	12.8	12.8	12.9

Note: 1 – stooling, 2 – earing.

Table 5. Conditional protein yield per hectare of spring triticale sowing on the studied factor, t/ha

Plant nutrition background	Years of research			
	2014	2015	2016	Average for 2014–2016
Without fertilizers (control)	0.17	0.27	0.27	0.24
$N_{30}P_{30}$ before sowing	0.24	0.39	0.40	0.34
$N_{60}P_{30}$ before sowing	0.30	0.47	0.48	0.42
$N_{30}P_{30}$ before sowing + N_{30} (AN[1])	0.33	0.50	0.51	0.45
$N_{30}P_{30}$ before sowing + D_2[1]	0.25	0.43	0.44	0.37
$N_{30}P_{30}$ before sowing + Escort-Bio[1]	0.26	0.44	0.44	0.38
$N_{30}P_{30}$ before sowing + D_2[1, 2]	0.28	0.46	0.46	0.40
$N_{30}P_{30}$ before sowing + Escort-Bio[1, 2]	0.29	0.47	0.48	0.41
$N_{30}P_{30}$ before sowing + N_{30} (carbamide[2])	0.29	0.46	0.46	0.40

Note: 1 – stooling, 2 – earing.

CONCLUSIONS

Optimization of the nutrition background contributed to the significantly higher yield of spring triticale grain, compared to the control without fertilization. The increase in yield was 0.68–1.35 t/ha in the water treatment options and 0.74–1.48 t/ha in the Escort-Bio use options. The maximum grain yield was provided by the treatment of seeds with Escort-Bio, the introduction of the N30P30 mineral fertilizer with top dressing with ammonium nitrate. Seed treatment with Escort-Bio contributed to an increase in grain yield by 7.6%.

A higher yield of spring triticale grain due to the application of fertilizers, top dressing and the use of growth-regulating preparations was formed due to the different length of the ear, the number of grains in it and the weight of grain from the ear of the main stem. These indicators were determined to be minimal in the control areas of the experiment, and the maximum values were determined for fertilizing with ammonium nitrate at a dose of N30 against the background of the main application of N30P30. Pre-sowing treatment of seeds with Escort-Bio led to an increase in all the elements of the crop structure that were identified in the studies.

The maximum values of the nature of spring triticale grain were provided by the options for applying N60P30 to sowing and N30P30 to sowing with top dressing in a dose of N30 in the form of ammonium nitrate, urea or double top dressing with a complex organo-mineral preparation D2. Under the influence of mineral fertilizers and top dressing, the protein content in spring triticale grain increased from 11.3 up to 12.2–12.9%. The maximum protein content of grain was determined in the variant of applying N30P30 to sowing with top dressing at the beginning of earing with urea at a dose of N30. The conditional protein yield per hectare of sowing reached its maximum values in the variant of applying N60P30 before sowing and N30P30 before sowing with top dressing with ammonium nitrate in the phase of stooling at a dose of N30.

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