sciendo
ASN, Vol. 11, No 1, Pages 40–49, 2024

Acta Scientifica Naturalis

Former Annual of Konstantin Preslavsky University of Shumen: Chemistry, Physics, Biology, Geography

Journal homepage: https://content.sciendo.com/view/journals/asn/asn-overview.xml

Structural elements of grain yield in triticale (x *Triticosecale* Wittmack) grown under organic farming conditions

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Abstract: *During the period 2018-2020 in the experimental field of the Agricultural Institute, Shumen, on calcic chernozem soil type, a field experiment with triticale (x Triticosecale Wittmack) was conducted. The experiment was based on the block method, in four replications with a size of the experimental plot of 10 m^2. Sowing was carried out in October with a sowing rate of 500 germinate able seeds/ m2 after the predecessor sugar beet (Beta vulgaris L.). In the appropriate periods treatments were made in 4 variants: 1) Control-untreated variant. 2) Treatment with biodynamic preparations: Preparation 500 (5% solution) + Fladen preparation (1.5% solution) + preparation 501 (1.5 g for 300 l H_2O/ha). 3) Treatment with biological preparations: Heliosulfur (500 ml/ha) + Free N (500 ml/ha). 4) Combined treatment with the same biodynamic and biological preparations. The following indicators were studied: plant height, number of spikelet's per spike, number of grains per spike, grain weight per spike. After the statistical analysis for the first year of the study, a proven positive difference was found in all indicators in the combined biodynamic + biological method of cultivation, as well as in the stand-alone biological. In the second year of the study, a proven positive difference was obtained in all studied indicators in the variants treated with biodynamic preparations and the combination of biodynamic + biological preparations, with statistical significance for $p<0.001$. A positive correlation was found between all variants of the observed indicators at $p<0.05$.*

Keywords: triticale, yield, biodynamic and biological preparations

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DOI: 10.2478/asn-2024-0004

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Introduction

With the increase in the consumption of agricultural products there is a need to increase its production. In the pursuit of higher yields, control over the quality of production is lost. The desire to increase the amount requires an increase in chemical protection in plant protection practices and the introduction of high doses of mineral fertilizers. This in turn implies the use of hybrids that tolerate high doses of chemicals and are selectively tolerant to them. The production of clean, healthy and high-quality agricultural products is becoming increasingly important.

There is evidence of the beneficial effect of pre-sowing electromagnetic seed treatment in some crops (Palov et al., 2012; Ganeva et al., 2015; Sirakov et al., 2016; Sirakov et al., 2021). In response to the increased demand and supply of organically produced products, various ecological fertilizers and bio-stimulants have appeared on the market. The application of biofertilizers is emerging as a promising component of an integrated food supply system in agriculture (Shehata & El-Khawas, 2003). Experiments of our and foreign biological products have been made and continue to be made. There are data on the beneficial effect of some products tested in different crops (Shternshis, 2005; Komarova et al., 2020). Experimenting and analyzing the integrated use of organic fertilizers would provide farmers with valuable information on organic products for the effective use of these fertilizers to improve soil fertility (Enchev et al., 2018a; 2018b). The use of organic fertilizers helps to increase productivity by stimulating nutrient transport and improving the architecture of the root system (Nardi *et al.*, 2002). The biodynamic agriculture leads to higher organic soil matter (Reganold et al., 1993; Droogers & Bouma, 2006) and more efficient use of nitrogen supplied to the biodynamic system (Fliessbacha et al., 2007). In modern agriculture with wheat (*Triticum aestivum*), studies with biological and biodynamic preparations are increasingly presented (Reevea et al., 2010; Șulea & Sala, 2010; Dochev et al., 2019a; 2019b).

The aim of the present study is to establish the influence of fertilization with biological and biodynamic preparations and their joint influence on the elements of grains yield, under organic farming conditions.

Materials and Methods

During the period 2019-2020, a study was conducted on soil type calcic chernozem with winter triticale (x *Triticosecale* Wittmack) variety “Kolorit”. The experiment is based on the randomized block method, in four replications with a size of the experimental plot of 10 m^2. Sowing was carried out in October with a sowing rate of 500 germinate able seeds/m^2 after the predecessor of sugar beet (*Beta vulgaris* L.). In the appropriate periods, treatments were made in 4 variants: 1) Control - untreated variant, 2) Treatment with biodynamic preparations: 500 + Fladen preparation + preparation 501, 3) Treatment with biological

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preparations: Heliosulfur + Free N, 4) Combined treatment with the same biodynamic and biological preparations.

Preparation 500 was applied in the phase of autumn (GS 20–22) and spring (GS 22–25) triticale tillering - 5% solution. It is prepared from fresh cow dung, which is filled into cow horn. In order to become suitable for use, the preparation must remain from autumn to spring in the soil, being placed in pits at a depth 40 sm. In the spring it is dug up and the contents of the horn are ready for use. Preparation 501 was applied in the phase ear formation (GS 50–55) - 1.5 g for 300 l of water/ha. This preparation is prepared from quartz crystal powder placed in cow horn. It is buried in the ground in the spring and taken out in the autumn. Then the drug is ready for use. Fladen preparation is applied in the phase of (GS 20–22) and spring (GS 22–25) tillering - 1.5% solution. Fladen preparation is prepared from fresh cow manure to which eggshells and basalt flour are added. It is placed in a wooden container, placed in pits, in the soil at a depth of 40 cm. It stays there from spring to autumn. During this time, compost biodynamic preparations are added: yarrow (*Achillea melifolium* L.) - flowers, chamomile (*Matricaria chamomill*a L.) - flowers, nettle (*Urtica dioica* L.) - roots, oak (*Quercus robur* L.) - bark, dandelion (*Taraxacum officinale* Weber) - flowers, valerian (*Valeriana officinalis* L.) - extract. Heliosulfur (liquid sulfur formulation in combination with pine terpenes) was applied in the ear formation phase (GS 50–55) - flowering at a dose of 500 ml/ha, at an appropriate date on the biodynamic calendar. Free N (selected strains of specialized in the fixation of nitrogen from the air (mainly *Azotobacter chroococcum*), 0.02% molybdenum and 2% manganese in the form of water-soluble sulfates) was applied to the soil in the phase of autumn (GS 20–22) and spring (GS 22–25) tillering at a dose of 500 ml/ha, at an appropriate date on the biodynamic calendar. Preparations 500, Fladen preparation and Free H were applied on the following dates: 23.11.2018; 17.04.2019; 22.11.2019; 04/06/2020. Preparation 501 and Heliosulfur were applied on 03.06.2019 and 08.06.2020. The different stages of growth are according on the Zadoks scale (Zadoks et al., 1974). In 2019, 30 plants were selected from 3 replicates of all variants in the experimental scheme. The following year, 20 plants were selected from the variant, again in three replications. The initial data were processed using SPSS by the method of variation statistics and the student's criterion was used for evaluation. The following indicators have been reported: plant height, spike length, number of spikelet's per spike, number of grains per spike, grain weight per spike. No significant differences were reported between the individual variants, so only the comparisons with the control variant are presented in the final tables. A correlation analysis was performed.

Results and Discussion

Moisture storage during the autumn-winter period of the first year of the experiment was extremely low. As a result of the drought, the wheat sprouted only in early January. Precipitation in March and April

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were 5.8 mm and 1.6 mm, at the appropriate rate 31 mm and 41 mm. The air temperature during the winter months was higher than the norm for the region. For the period of spring vegetation, the precipitation and the average daily temperature were around the norm, as only in April the average daily temperature was lower than the norm (Fig. 1).

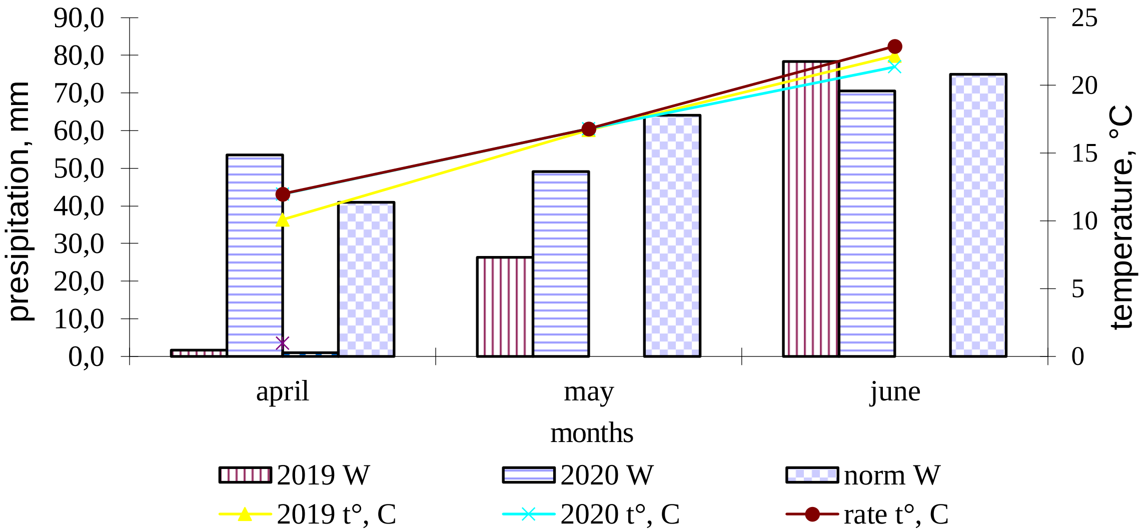

Figure 1. Precipitation and average daily air temperature for the period 2019-2020

In the following year of the experiment, the precipitation in the autumn-winter period was insufficient, with a more significant deviation from the norm observed in the winter months. The drought continued in the spring. The first significant rainfall fell in the first ten days of May– 12.3 mm. Subsequent rains at the end of May and in the second ten days of June helped to better nourish the grains. In terms of temperature, the months of spring vegetation of triticale (x *Triticosecale* Wittmack) were favorable, as the month of June was slightly cooler than the norm. Lack of moisture in the period of spring triticale tillering had a negative impact on the structural elements of yield and the grain yield itself.

Table 1 and Table 2 present the results of the statistical analysis of five quantitative traits of triticale for the two reporting years. The different climatic conditions in the two consecutive years significantly affect the final results for most signs. In 2019, the significantly increased values of three of the important productive traits stand out - class length, number and weight of grains. The other two methods of cultivation - biodynamic and combined (biodynamic + biological) did not show significant changes in the listed traits compared to the control. The sign number of spikes is also not proven to affect the standard.

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The change in the structural elements of yield, such as class length, number of spikelet's in the class, number of grains in the class, grain weight in the class and height of plants from the studied triticale variety are shown in Table 1 and Table 2.

Table 1. Plant height, spike length and some structural elements of grain yield depending on the studied treatments, in 2019

Variants	Traits			
	Mean	Difference	Significance	Group
	Plant height (cm)			
1. Control	63.06	x	x	a
2. Biodynamic	61.89	-1.17	ns	a
3. Biological	68.91	5.86	***	b
4. Biodynamic + Biological	82.25	19.19	***	c
Spike length (cm)				
1. Control	8.77	x	x	a
2. Biodynamic	9.38	0.61	*	b
3. Biological	11.20	2.43	***	c
4. Biodynamic + Biological	13.44	4.68	***	d
Number of spikelet's per spike				
1. Control	12.61	x	x	a
2. Biodynamic	12.68	0.07	ns	a
3. Biological	18.19	5.58	***	b
4. Biodynamic + Biological	22.89	10.28	***	c
Number of grains per spike				
1. Control	17.77	x	x	a
2. Biodynamic	17.35	-0.41	ns	a
3. Biological	26.17	8.4	***	b
4. Biodynamic + Biological	36.52	18.76	***	c
Grain weight per spike (g)				
1. Control	0.61	x	x	a
2. Biodynamic	0.65	0.04	ns	a
3. Biological	1.03	0.41	***	b
4. Biodynamic + Biological	1.46	0.84	***	c

Legend: Different letters indicate statistically significant differences among variants at p<0.05.

*, **, *** - Statistically significant differences of the variants vs. control at p<0.05; p<0.01 and p<0.001, respectively.

The different climatic conditions during the two consecutive years have a significant impact on the final results for most indicators in the cultivation of triticale with organic preparations. The biometric analysis of

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the obtained results in Table 1 in the economic year 2019 shows that the largest differences in plant height 19.19 cm; 5.86 cm, spike length 4.68 cm; 2.43 cm, number of spikelet's per spike 10.28; 5.58, number of grains in the spike 18.76; 8.4 g and grain weight 0.84 g; 0.41 g are observed in the combined biodynamic + biological method of cultivation, as well as in the independent biological. Differences between variants and controls were demonstrated with statistical significance for p<0.001%. In the case of the variant with biodynamic method of cultivation, the differences between the variant and the control were not proved, except for the indicator of the length of the class with statistical significance p<0.05%.

Table 2. Plant height, spike length and some structural elements of grain yield depending on the studied treatments, in 2020

Variants	Traits			
	Mean	**Difference**	**Significance**	**Group**
	Plant height (cm)			
1. Control	75.0	x	x	a
2. Biodynamic	78.93	3.93	**	b
3. Biological	79.98	4.98	***	b
4. Biodynamic + Biological	81.72	6.72	***	b
Spike length (cm)				
1. Control	12.83	x	x	a
2. Biodynamic	13.0	2.5	***	cb
3. Biological	14.53	0.17	ns	a
4. Biodynamic + Biological	15.33	1.7	***	b
Number of spikelet's per spike				
1. Control	24.88	x	x	a
2. Biodynamic	28.37	3.48	***	b
3. Biological	23.55	1.33	ns	a
4. Biodynamic + Biological	27.0	2.12	***	b
Number of grains per spike				
1. Control	35.02	x	x	a
2. Biodynamic	46.5	11.48	***	b
3. Biological	36.72	1.7	ns	a
4. Biodynamic + Biological	45.25	10.23	***	b
Grain weight per spike (g)				
1. Control	1.33	x	x	a
2. Biodynamic	1.83	0.50	***	b
3. Biological	1.54	0.21	ns	ab
4. Biodynamic + Biological	1.79	0.46	***	b

Legend: Different letters indicate statistically significant differences among variants at p<0.05.

*, **, *** - Statistically significant differences of the variants vs. control at p<0.05; p<0.01 and p<0.001, respectively.

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From the analysis of the obtained results in Table 2. for the 2020 economic year, the largest differences in plant height 3.93 cm; 6.72 cm, spike length 2.5 cm; 1.7 cm, number of spikelet's per spike 3.48; 2.12, number of grains per spike 11.48; 10.23 and grain weight 0.5 g; 0.46 g were found in the biodynamic and combined biodynamic + biological method of cultivation, with statistical significance for $p<0.001$. An exception is the plant height indicator in the biodynamic method where the difference is proved for $p<0.05$. In the case of the variant with biological cultivation method, the differences between the variant and the control were not proved, except for the indicator of class height with statistical reliability for $p <0.001$.

In both experimental years there were significant differences of the studied variants in the probability of $p<0.001$ compared to the control. A steady increase in the differences in biometric indicators compared to the control is observed in the combined biodynamic + biological method of cultivation, which confirms the effectiveness of the application of environmentally friendly non-standard methods of triticale cultivation.

From Table 3 and Table 4 a positive correlation is seen between all variants of the observed indicators at $p<0.05$.

Table 3. The relationship between biometric indexes of triticale for 2019

Biometric indexes	**Plant height**	**Spike length**	**Number of spikelet's per spike**	**Number of grains per spike**	**Grain weight per spike**
Plant height	1.00	**0.68**	**0.74**	**0.62**	**0.60**
Spike length	**0.68**	1.00	**0.88**	**0.74**	**0.72**
Number of spikelet's per spike	**0.74**	**0.88**	1.00	**0.81**	**0.81**
Number of grains per spike	**0.62**	**0.74**	**0.81**	1.00	**0.95**
Grain weight per spike	**0.60**	**0.72**	**0.81**	**0.95**	1.00

Note: shown correlation coefficients are significant at $p<0.05$.

A positive correlation was found between plant height and spike length, number of spikes per spike, number of grains per spike and grain weight per spike. A positive correlation has also been established between the length of the spike and the number of spikelet's per spike, the number of grains per spike and the weight of the grain per spike, and between the number of spikelet's per spike with the number of grains per spike and the weight of the grain per spike, and between the number of grains per spike and the weight of grain per spike. These dependencies are stronger in the first year of the study.

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Table 4. The relationship between biometric indexes of triticale for 2020

Biometric indexes	Plant height	Spike length	Number of spikelet's per spike	Number of grains per spike	Grain weight per spike
Plant height	1.00	**0.48**	**0.40**	**0.46**	**0.35**
Spike length	**0.48**	1.00	**0.82**	**0.72**	**0.55**
Number of spikelet's per spike	**0.40**	**0.82**	1.00	**0.67**	**0.53**
Number of grains per spike	**0.46**	**0.72**	**0.67**	1.00	**0.73**
Grain weight per spike	**0.35**	**0.55**	**0.53**	**0.73**	1.00

Note: shown correlation coefficients are significant at $p<0.05$.

Conclusions

After the statistical analysis for the first year of the study, a proven positive difference was found in all indicators in the combined biodynamic + biological method of cultivation, as well as in the independent biological. In the second year of the study, a proven positive difference was obtained in all studied indicators in the variants treated with biodynamic and the combination of biodynamic + biological preparations, with statistical significance for $p<0.001$. A positive correlation was found between all variants of the observed indicators at $p<0.05$.

Acknowledgement

This article is published with the financial support of Project No. RD-08-126/01.02.2024 of the Konstantin Preslavsky University of Shumen.

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