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Biological and biodynamic cultivation of wheat

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Abstract: *The aim of this study was to determine the influence of fertilization with organic and biodynamic preparations and their combined influence on the elements of grain yield under organic farming conditions. The experiment includes one variant of wheat treatment with biodynamic preparations 500 + preparation Fladen + preparation 501; one treatment with organic preparations: Heliosulphur + Free N; one combined variant between biodynamic and organic preparations and one control variant without treatment. The plant height, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike indicators were recorded. The IBM SPSS Statistics software using the method of variational statistics and Student's test was used for evaluation was used to process the obtained results. It was found that the variants treated with organic preparations have the highest level of evidence of differences compared to the control with 2.67 number of spikelets per spike, 7.59 number of grains per spike and 0.37 grain weight per spike (g) at $P < 0.05$. The methods of biodynamic and organic cultivation of soft wheat without the use of artificial fertilizers and pesticide can be successfully applied by farmers on soil type calcic chernozem*.

Keywords: *Triticum aestivum* L., treatment, evaluation, organic fertilizers, calcic chernozem

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 (Tarasenko et al., 2018).

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There are data on 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 biologically produced products, various ecological fertilizers and biostimulants have appeared on the market. The application of biofertilizers has emerged as a promising component of an integrated food supply system in agriculture (Shehata & El-Khawas, 2003).

Some products have shown beneficial effects in various crops, as documented by (Shternshis, 2005; Komarova et.al. 2020). The use of organic fertilizers helps to increase productivity by stimulating nutrient transport and improving root system architecture (Nardi et al., 2002). Research on organic and biodynamic preparations would be beneficial for farmers who apply them and for their more effective use. Biodynamic farming results in higher soil organic matter content (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*), research with organic and biodynamic preparations is increasingly presented (Reevea et al., 2010; Șulea & Sala, 2010; Dochev et al., 2019a; 2019b). Biodynamic agriculture is an upgrade of organic agriculture, with its main goal being to revive the soil, harmonize ecosystems and obtain healthy food for humans (Maneva & Atanasova). The goal of biodynamic agriculture is to produce products that nourish not only the body, but also the soul and spirit and thus promote human development (Brock et. al., 2019). The author of the study did not find similar publications for this area in the scientific literature. This necessitated the carrying out of the present research.

The aim of the present study is to determine the influence of fertilization with organic and biodynamic preparations and their combined influence on the elements of grain yield under organic farming conditions.

MATERIALS AND METHODS

Locations of experimental area

The study was conducted in the period 2018-2022 in the experimental field of the Shumen Agricultural Institute, Tsarev Brod village – 43°19' 44.15" N; 25°00' 37.05"E, of the soil type calcic chernozem with winter common wheat (*Triticum aestivum L.*) variety "Venka 1". The experiment was performed using a randomized block method, in four replications, with an experimental area size of 10 m^2. Sowing was done in October with a seeding rate of 500 germinating seeds m^{-2} after a predecessor sugar beet (*Beta vulgaris L.*). During the respective periods, treatments were conducted in four variations: 1) Control - untreated variant, 2) Application of biodynamic preparations: 500 + Fladen preparation + 501 preparation, 3) Application of organic preparations: Heliosulfur + Free N, and 4) Combined application of the same biodynamic and organic preparations.

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During the autumn growth stages (GS 20–22) and spring tillering (GS 22–25) of wheat, BD 500 - a 5% solution - is applied. It is prepared from fresh cow manure, placed inside a cow horn, and buried in the soil at a depth of 40 cm, where it remains from autumn to spring. In spring, the contents are ready for use. BD 501 is applied during the ear formation stage (GS 50–55), at a dose of 1.5 g per 300 l of water per hectare. BD 501 is made from quartz crystal powder, placed in a cow horn. The prepared horns are placed in a wooden container in spring and buried in the ground at a depth of 40 cm, where they are ready for use by autumn. Fladen preparation is applied as a 1.5% solution during the growth stages (GS 20–22) and spring tillering (GS 22–25) of the crop. To prepare the Fladen preparation, fresh cow manure is mixed with basalt flour and eggshells. In spring, it is placed in a wooden container, buried in pits in the soil at a depth of 40 cm, where it remains until autumn.

At the same time, compost BD preparations are added: chamomile (*Matricaria chamomilla* L.) - flowers, yarrow (*Achillea millefolium* L.) - flowers, oak (*Quercus robur* L.) - bark, nettle (*Urtica dioica* L.) - roots, valerian (*Valeriana officinalis* L.) - extract, and dandelion (*Taraxacum officinale* Weber) - flowers.

In the ear formation stage (GS 50–55) - flowering, on an appropriate date according to the biodynamic calendar, Heliosulfur (liquid sulfur combined with pine terpenes) is applied at a dose of 500 ml ha-1. It acts as a growth stimulator for plants and as a fungicide. During the autumn (GS 20–22) and spring (GS 22–25) tillering stages of wheat, free N (strains specialized in nitrogen fixation from the air, mainly Azotobacter chroococcum), 0.02 % molybdenum, and 2 % manganese in the form of water-soluble sulfates) is applied to the soil at a dose of 500 ml ha^{-1}, following Maria Thun's biodynamic calendar. Free N helps in the assimilation of atmospheric nitrogen and enriches the soil.

The growth stages are according to the Zadoks scale (Zadoks et al., 1974). For the proper application of the preparations, treatments must be aligned with Maria Thun's sowing calendar. Each year, we selected 30 plants from the three repetitions of all variants in the experimental scheme.

Statistical analysis

The initial data were processed using statistical processing software IBM SPSS Statistics (www.ibm.com, 2024) using the method of variational statistics and Student's test was used for evaluation. The following indicators were recorded: plant height, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike.

Weather conditions analysis

The sowing of autumn crops was carried out on time, but in conditions of soil and air drying. The plants sprouted in early January, which is extremely rare. It is produced only on the basis of spring breeding. The precipitation in April of 1.6 mm is of no economic importance, and that in May of 26.4 mm is significantly below the norm (64 mm) (Figure 1). The next month of June has precipitation around the norm.

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The air temperature during the spring vegetation period of the crop is close to the corresponding norm for the region. The year is moderately favourable for the development of wheat.

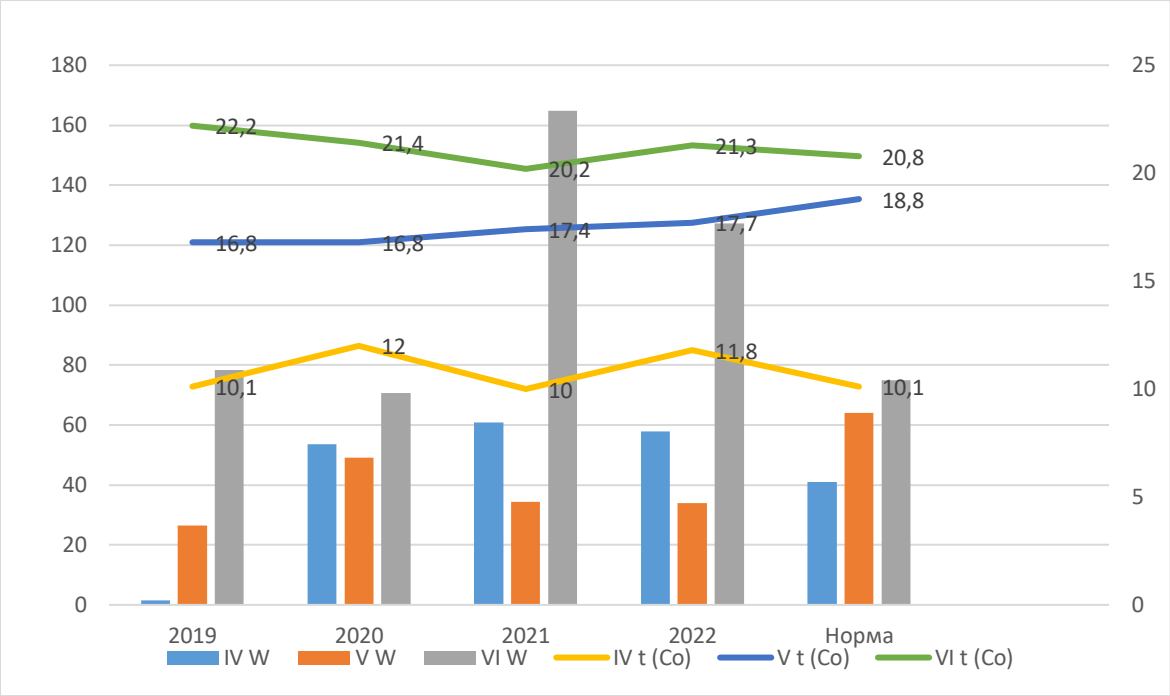

Figure 1. Precipitation and average daily air temperature

Meteorologically, the year 2020 is also moderately favourable for the growth and development of wheat. Precipitation during the spring vegetation period is around the corresponding norm, while the air temperature for the month of April is 2°C above the norm, and for May it is 2°C below the norm.

In the third year of bringing out the experience, meteorologically the year differed from the previous two. Precipitation in April and June exceeded the norm by 19.8 mm and 89.8 mm, respectively.

The last year of the trial, meteorologically, followed the course of the previous year. It is noteworthy that during the four years of the study, precipitation in April and June was significantly higher than the norm for the area, and precipitation in May was about half of the norm (64 mm). An exception is the month of April in 2019, which is extremely dry.

RESULTS AND DISCUSSION

The results of statistical processing are summarized in Table 1. After the biometric analysis of some structural elements of the yield in wheat, it becomes clear that the variants grown under biological conditions

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have a proven higher number of ears per year, grains per year and weight of grains per year. The wheat grown under biodynamic conditions and also in combination with organic treatment have a greater number of grains in a class compared to the untreated control. In the last combination, the difference was also proven in the indicator of the number of ears per year. After an experiment (Goldstein et. al., 2019) found that wheat grown under biological and biodynamic conditions has been proven to have more ears per year and greater weight of grains per year compared to conventionally grown wheat. Although wheat grown under biodynamic conditions has more ears per year than that grown organically, the latter has a greater number of grains per year (Goldstein et. al., 2019).

Table 1. Quantitative traits in organically and biodynamically grown wheat

Variant	Spike length (cm)		
	Average	**Difference**	**Evidence**
1. Control	12.59		
2. Biodynamic	8.80	-3.78	---
3. Organic	9.71	-2.87	---
4. Biodynamic + Organic	9.55	-3.03	---
Number of ears per ear			
1. Control	18.16		
2. Biodynamic	18.62	0.46	ns
3. Organic	20.83	2.67	++
4. Biodynamic + Organic	19.37	1.21	+
Number of grains per ear			
1. Control	24.77		
2. Biodynamic	27.48	2.71	+
3. Organic	32.36	7.59	++
4. Biodynamic + Organic	28.26	3.49	+
Weight of grains per ear (g)			
1. Control	1.11		
2. Biodynamic	1.19	0.08	ns
3. Organic	1.48	0.37	+
4. Biodynamic + Organic	1.20	0.09	ns

*Differences between variants are statistically proven at $P < 0.05$ if they have different letters

*, **, *** - Statistical significance of differences between variants and control for $P < 0.05$; 0.01 and 0.001

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Before starting and after the end of the experiment in order to follow the dynamics of mineral elements and the influence of unconventional crop cultivation on them, soil samples were taken. The results of the agrochemical analysis of the soil taken from the fields with different treatment methods were summarized in (Table 2).

Table 2. Agrochemical characteristics of the soil in the 0-40 cm layer, from an experimental ecological field of the Agricultural Institute, Shumen in the village of Tsarev Brod, 2022

Elements	2018	2022			
		Control	Biodynamic	Organic	Biodynamic + Organic
N	0.146	0.2	2.891	2.05	3.307
P_2O_5	26.2	19.30	20.25	18.38	22.78
K	37.2	35.79	42.25	38.73	38.32
Hummus	6.72	3.65	3.98	4.32	4.16
pH		7.84	7.74	7.67	7.94

Nitrogen in the soil was found to increase in all three treatment options. Nitrogen is a volatile element and does not remain in the soil for long. In the case of phosphorus, a noticeable decrease in its content was observed in all three treatment options compared to its content at the beginning of the experiment. This reduction is weakest in the variant treated with biodynamic and organic preparations. The content of potassium in the soil in the treated variants increased, both compared to the untreated control and compared to its content at the beginning of the experiment. There is a decrease in the humus content of the whole field compared to its initial content in 2018, the decrease being more sensitive in the untreated section. There is no significant difference in the pH of the soil in the different variants of the experiment. Some studies (Vaitkevičienė et al., 2019) summarize that on the 14th day, after the soil application of preparation 500, the soil contains a significantly higher content of basic nutrients: P, K and N, decreasing at the end of the experiment. Vaitkevičienė suggests that preparation 500 activates soil microbiological processes, during which mineralization and humification of organic matter occur intensively. In this way, microorganisms supply plants with nutrients by processing relatively stable organic compounds into a form that is readily available to plants. Goldstein also found a higher nitrogen content in the soil in variants treated with biological preparations, compared to those grown in a conventional way (Goldstein et al., 2019).

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CONCLUSION

The treated variants with wheat have better indicators in terms of yield structural elements. The applied biodynamic method of growing wheat does not use chemical preparations. In this way, the soil is kept clean of pesticides, and together with this, its vitality is increased and soil fertility is improved. The resulting produce is of very good quality and is healthy. The biocenosis develops properly, and this contributes to the protection of the environment. With this method of production, significantly less costs of labour and funds are incurred. The author believes that scientific research can be deepened in this area and that this can be the subject of further research.

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