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Adaptive capabilities and phytosanitary status of organic and conventional wheat (*Triticum aestivum* L.) under drought conditions

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Abstract: Climate change is leading to an increase in the frequency and intensity of extreme weather events, among which drought represents one of the most significant challenges for agriculture. The present study follows the response of wheat variety Miryana, cultivated using organic and conventional technology for six consecutive years. The relationship between productivity and phytosanitary condition of plants depending on the technology applied was analyzed. The results show that in conventional cultivation, yields are significantly affected by changes in agrometeorological conditions. Organically grown wheat shows better adaptability to adverse climatic factors, which leads to more sustainable and stable yields over the years.

Keywords: organic and conventional wheat; yield; phytosanitary status

INTRODUCTION

Climate change is leading to an increase in the frequency and intensity of extreme weather events, among which drought represents one of the most significant challenges for agriculture (Bouabdelli, et al., 2022; Georgieva, et al., 2022; Furtak and Wolińska, 2023). In the context of a changing climate, yield stability is becoming increasingly important for farmers (Müller et al., 2018; Reckling et al., 2021). The adaptive potential of plants is their ability to adapt to growing conditions and to show resistance to adverse environmental factors, while maintaining stable high productivity and good grain quality. Part of the solution to the problem can be organic farming. At the heart of organic farming is an environmentally friendly approach that limits the use of synthetic chemicals and encourages natural processes of restoring soil fertility, or in other

words, organic farming reflects the concepts of sustainability today (Gamage et al., 2023).

Common wheat (*Tr. aestivum* L.) is one of the most important cereal crops in the world. Due to its valuable chemical composition of the grain and its exceptional technological properties, wheat is a major cereal crop for food processing. The yield and quality of wheat grain are determined by many factors, including genotype (variety), habitat conditions (soil and climate) and agricultural practices (Rozbicki et al., 2015). Some quality characteristics such as flour yield and sedimentation values are significantly influenced by the genotype, while other parameters are mainly influenced by the environment and the cultivation method (protein content, gluten content, 1000-grain weight (TGW), etc.) (Triboi et al., 2000).

In organic farming, the yield and technological qualities of wheat depend to a greater ex-

tent on the phytosanitary condition of the crop – weed, disease and pest infestation. In organic fields, there is a greater coverage of broadleaf weeds and three times more weed species than in conventional fields, where herbicides are used (Moreby and Sotherton, 2012; Tyšer et al., 2021). In the study of organic and conventional systems, endangered and rare species, as well as some invasive weed species, were found. However, significantly more species and with greater coverage were found in organic than in conventional farming systems (Berbeć et al., 2020). Species diversity and insect biodiversity indices in organic wheat fields are higher than in conventional ones (Rad et al., 2024). Organic fields have higher densities of some weed-eating insects, which in turn are food for birds (Moreby and Sotherton, 2012; Tyšer et al., 2021). In terms of diseases, the infection pressure from *Septoria* spp., *Blumeria graminis* and *Puccinia recondite* is mainly determined by weather conditions and the applied cultivation system. Wachowska et al. (2015) also found that the leaves of winter wheat plants grown in the organic farming system were more often infected with brown rust, while plants grown in the integrated system were affected by the diseases leaf spot and powdery mildew.

In Bulgaria, there are several publications on weeding and attack by diseases, and enemies in organically grown wheat. Zhekova et al. (2016) found that differences in weeding of wheat and barley are related to the amount of weeds per square meter and the biological characteristics of the plants, while the species composition and population density of beneficial insects are important for effective pest control. Donkova (2015) does not find differences in the species composition of weeds in wheat depending on the predecessor. Maneva and Atanasova (2018) analyzed the phytosanitary status of wheat and spelt in both farming systems, and emphasized greater resistance of spelt under organic farming conditions. Most studies on wheat and other cereal crops consider the phytosanitary status of crops depending on the predecessor (Atanasova et al., 2013; Atanasova and Maneva 2014; Atanasova et al., 2016; Atanasova et al., 2019; Atanasova and

Maneva, 2019a; Atanasova and Maneva, 2019b; Atanasova and Maneva, 2021; Atanasova and Maneva, 2023) and sowing dates (Maneva et al., 2012a; Maneva et al., 2012b; Maneva et al., 2013; Maneva et al., 2014; Atanasova et al., 2021).

The aim of the study is to monitor the adaptive capabilities and phytosanitary status of common wheat grown in organic and conventional agriculture under drought conditions.

MATERIALS AND METHODS

At the Institute of Agriculture – Karnobat, cereals have been grown in a certified organic farming field since 2007, i.e. in the experimental field, the principles of organic farming have been applied for 18 years (Atanasova & Maneva, 2018). Experiments have been conducted in the conventional experimental field since 1925, when the Institute was established.

During the period 2019 – 2024, wheat of the Miryana variety, grown in conventional and organic farming was studied. The experimental plots are 500 m² in four replications. Predecessor – peas. Sowing rate – 550 germinating seeds /m².

In conventional cultivation, nitrogen fertilizer (N10), herbicides Florasulam + Tritosulfuron and Fenoxaprop-P-etil, fungicide Epoxiconazole + Pyraclostrobin and insecticide Cypermethrin (at recommended doses) were applied to wheat.

In organic farming, no plant protection products or mineral fertilizers were applied.

The following parameters were analyzed: grain yield in kg/ha-1; mass of 1000 grains (TKW, g); crude protein content (PC, %); wet gluten content (WGC, %).

The phytosanitary condition of wheat was monitored in both agricultural systems. Weeds were determined according to Delipavlov et al. (2011), number/m². The size of the aphid population was determined by direct measurement at 10 locations on 10 stems of each crop (Dewar et al., 1982). Taxonomic analyses of aphids were made according to Emden (1972) and Blackman and Eastop (1984). Disease counts were carried out

using the route method, through the plants (Stepanov and Chumakov, 1972; Krivchenko, 1984).

The climate in the Karnobat region is transitional-continental. The absolute minimum air temperature measured in Karnobat is -26°C , and the absolute maximum is $+42.0^{\circ}\text{C}$. The average annual precipitation is 551 mm. During the study period, data on air temperature and precipitation were collected from the meteorological station in the town of Karnobat.

The data were processed using the BIO statistical program. The protein content (PC), %; wet gluten content (WGC), % and W index were determined using a NIR analyzer (CropScan 1000B). The experimental data were processed using Microsoft Excel and STATISTICA, version 7.0 (StatSoft Inc., 2004).

RESULTS AND DISCUSSION

The meteorological conditions and yields of Miryana wheat in conventional and organic farming were monitored from 2019 to 2024 (Table 1.)

In recent years, the sum of the average monthly temperature from October to September has been higher than the multi-year data measured in the Karnobat region since 1931 (2019 - by 503; 2020 - by 722; 2021 - by 499; 2022 - by 308; 2023 - by 742; 2024 - by 985 $^{\circ}\text{C}$).

Two years are extreme in terms of precipitation, the rest are less than the multi-year data measured since 1901. (2019 – by 116; 2020 – by 212; 2022 – by 73; 2023 – by 80; 2024 – 87 mm). And in 2021 alone, precipitation was 141 mm more.

In the years that we can conditionally accept as close to the multi-year data, the yields of organic and conventional wheat do not differ significantly.

In conventionally grown wheat, in years with favorable weather conditions (2021), we get a high yield - 6200 kg/hectare. And in unfavorable years (2020), when firstly, the precipitation for the year is 38% below the multi-year data, and secondly, a very significant factor - long dry periods between them and as a consequence - very low yields in conventional agriculture - 3450 kg/hectare, 25% less than the average yield for the period. Yields in organic agriculture reach 3800 kg/hectare, only 12% less than the average for the period.

During the spring-summer growing season of 2024, heavy precipitation, accompanied by local hail, proved to be decisive for wheat yields. It was more intensive and stronger in conventional agriculture, and therefore, yields were drastically reduced.

In organically grown wheat, the standard deviation is significantly smaller than in conventional cultivation.

Table 1. Meteorological conditions and yield of Miryana wheat in 2019-2024

Year	Sum of average monthly temperature X – IX	Sum of precipitation, l X – IX	Yield, kg/h ⁻¹	
			Organic farming	Conventional farming
2019	4757	435	3970	5020
2020	4976	339	3800	3450
2021	4753	692	4950	6200
2022	4562	478	4790	5750
2023	4981	471	4530	4550
2024	5239	464	4080	2480 (local hail)
Multi-year data	4254	551		
Mean			4336	4608
Standart deviation (SD)			434.91	1428.33
Variance Coefficient (CV)			0.101	0.308

The average yield for the period from organic and conventional wheat is slightly different, with in 5 - 6%. We see that the standard deviation in yield in conventional wheat is almost three times higher than in organic. And as a result - the coefficient of variation is also three times (3.05) higher in conventionally grown wheat.

Conventional wheat usually contains more protein and gluten, with better baking characteristics, which is emphasized in many studies (Mazzonecini et al., 2007; Mitura et al., 2023; Vrček et al., 2014). In our studies, the trend is maintained. However, in conventional cultivation, probably depending on the agrometeorological conditions of the years, the variation coefficient ranges from 14.3 to 27.24, while in organically grown wheat the variation is significantly lower, depending on the indicator. This also corresponds to the yield in both farming systems (Table 2).

In the observations regarding weed infestation of the wheat – when the field was switched to organic farming, in the first years we recorded significant weed infestation. Gradually over the years, a balance begins to occur between the plants in the ecosystem thus created, and we do not observe an increase in the density of weeds, even a decrease, depending on the conditions of the specific year.

Table 3 presents the results of the survey of wheat in the conditions of organic and conventional farming. When we first recorded weed infestation in the two fields, there was almost no difference – 35.9 pcs/m² in the organic and 34.0

– in the conventional. In the organic field, there is a greater species diversity of weeds – 20 species, and in the conventional – 11. A finding that is in line with the results of the studies by Moreby et al. (1994); Hyvönen, et al. (2003); Berbeć, et al. (2020), and can be explained by the non-application of herbicides. We believe that the greater species diversity in the organic field is a positive trend in relation to the loss of biodiversity in the European Union.

In the organic field with winter wheat Miryana at the second count, the weed density was significantly reduced. This is clearly visible in the ephemeral ivy-leaved Easter creeper (*Veronica hederifolia* L.), which by mid-May had already completed its development and was not counted, as well as in the field of cowslip (*Polygonum aviculare* L.). The general condition and density of the crop in organic farming is good, which is also reflected in the reduction in weed density between the first and second counts (Table 3). In conventional farming, almost all weeds are destroyed with herbicides.

During the study period, only isolated instances of leaf rust (*Puccinia recondita*) and Septoria leaf blotch (*Septoria tritici*) were observed in wheat crops under both organic and conventional farming systems. This did not allow for the establishment of a clear trend regarding the influence of the type of farming on the incidence of disease in winter wheat.

Throughout the study period, in organically farmed wheat, pests were recorded from three or-

Table 2. Biochemical parameters of wheat variety Miryana

Parametrs	Average	CV, %	Min	Max	Range
Conventional farming					
Grude protein, %	13.87	16.13	11.3	15.4	4.1
Wet gluten, %	26,1	14,3	21,8	28,5	6,7
Gluten weakening	10,3	27,24	7,4	13,0	5,6
Organic farming					
Grude protein, %	10.13	9.98	9.5	11.3	1.8
Wet gluten, %	17.57	5.38	16.5	18.3	1.8
Gluten weakening	8.27	6.88	7.8	8.9	1.1

Table 3. Species composition and weed density in winter wheat cultivation under two types of farming system, average for period

Weeds species	Organic farming		Conventional farming	
	1 st weed reporting	2 nd weed reporting	1 st weed reporting	2 nd weed reporting
<i>Alopecurus myosuroides</i> Hudson	1.2	0.6	0.0	0.0
<i>Anthemis arvensis</i> L.	3.1	3.6	0.9	0.0
<i>Avena fatua</i> L.	1.0	1.6	1.3	0.0
<i>Caucalis daucoides</i> L.	0.9	1.0	0.0	0.0
<i>Capsella bursa pastoris</i> L.	1.4	0.0 ⁺	0.0	0.0
<i>Chenopodium album</i> L.	0.0	0.7	2.1	1.0
<i>Cirsium arvense</i> (L.) Scop.	0.3	0.4	0.3	0.0
<i>Convolvulus arvensis</i> L.	0.4	2.6 ⁺	2.5	2.7
<i>Delphinium orientale</i> L.	1.0	4.6 ⁺	7.9	5.8
<i>Lamium amplexicaule</i> L.	0.9	0.0	0.0	0.0
<i>Lithospermum arvense</i> L.	1.0	1.2	0.0	0.0
<i>Myagrum perfoliatum</i> L.	0.3	0.3	0.0	0.0
<i>Papaver rhoeas</i> L.	3.3	3.5	0.0	0.0
<i>Polygonum convolvulus</i> L.	1.0	0.8	5.0	0.0 ⁻⁻⁻
<i>Polygonum aviculare</i> L.	4.2	2.6 ⁻⁻⁻	0.7	0.0
<i>Ranunculus arvensis</i> L.	1.0	0.3	0.0	0.0
<i>Scandix pecten-veneris</i> L.	0.7	1.7	0.0	0.0
<i>Sinapis arvensis</i> L.	2.7	1.5 ⁻⁻⁻	2.3	0.0
<i>Veronica hederifolia</i> L.	9.8	0.3 ⁻⁻⁻	7.3	0.0 ⁻⁻⁻
<i>Viola tricolor</i> L.	2.7	2.2	3.7	0.0 ⁻⁻⁻
Total weeds, nb/m ²	35.9	27.6	34.0	9.5
Evidence of differences compared to AI: +/- at GD 5.0 %; ++/-- at GD 1.0 %; +++/--- at GD 0.1 %.				

Table 4. Species composition of wheat pests grown in two types of agriculture

Order	Species	Organic farming	Conventional farming
Coleoptera	<u>Chrysomelidae</u>		
	<i>Chrysolina sanguinolenta</i> (Linnaeus, 1758)	-	+
	<i>Oulema melanopus</i> (Linnaeus, 1758)	+	+
	<u>Cetoniidae</u>		
	<i>Epicometis hirta</i> (Poda, 1761)	+	+
Hemiptera (suborder Homoptera)	<u>Aphididae</u>		
	<i>Sitobion avenae</i> Fabricius	+	+
	<i>Schizaphis graminum</i> (Rondani, 1852)	+	+
	<i>Rhopalosiphum maidis</i> (Fitch, 1856)	+	+
	<i>Rhopalosiphum padi</i> (Linnaeus, 1758)	+	+
Hemiptera	<u>Scutelleridae</u>		
	<i>Eurygaster</i> sp.	+	+
	<u>Pentatomidae</u>		
	<i>Aelia</i> sp.	+	+

Table 5. Species composition of beneficial entomofauna during the study period

Species	Family	Order	Organic farming	Conventional farming
Predators				
<i>Coccinella septempunctata</i> L.	<i>Coccinellidae</i>	<i>Coleoptera</i>	+	+
<i>Cantharis</i> sp.	<i>Cantaridae</i>	<i>Coleoptera</i>	+	+
<i>Chrysopa</i> sp.	<i>Chrysopidae</i>	<i>Neuroptera</i>	+	+
<i>Syrphus ribesii</i> L.	<i>Syrphidae</i>	<i>Diptera</i>	+	+
Parasitoids				
<i>Aphidius</i> sp.	<i>Braconidae</i>	<i>Hymenoptera</i>	+	+
<i>Praon</i> sp.	<i>Braconidae</i>	<i>Hymenoptera</i>	+	+
<i>Ichneumonidae</i>	<i>Ichneumoni-dae</i>	<i>Hymenoptera</i>	+	+
<i>Asolcus</i> sp.	<i>Encyrtidae</i>	<i>Hymenoptera</i>	+	+
<i>Phasia</i> sp.	<i>Tachinidae</i>	<i>Diptera</i>	+	+

ders, five families, and eight species. In conventional farming, the situation was similar, except that pests belonged to nine species. In the first year of the survey, seven pest species were identified, while in the following years – nine species (Table 4).

A higher pest density and greater species diversity were observed under conventional farming compared to organic farming. A likely reason for this is the richer and more abundant beneficial entomofauna in organic systems, which supports the natural regulation of pest populations. Among this entomofauna, four predator species were identified, belonging to four families and three orders, as well as five parasitoid species from four families and two orders (Table 5).

CONCLUSION

In the long term, the difference in average yields between organic and conventional wheat is small – around 5 - 6%. In unfavorable climatic years (e.g. 2020), organic wheat demonstrates more stable yields compared to the multi-year average. Organic farming shows significantly lower yield variability, as measured by (i) standard deviation – substantially lower in organic wheat and (ii) coefficient of variation – in conventional wheat, which is three times higher in convention-

al wheat (3.05), indicating greater yield instability.

Conventional wheat contains higher levels of protein and gluten and exhibits better baking quality. However, yield-related parameters under conventional farming show significantly greater variability (coefficient of variation ranging from 14.3 to 27.24), whereas variations under organic farming are much lower, contributing to greater yield stability.

At the first weed assessment, weed infestation was nearly identical in both systems, but the organic field exhibited greater species diversity (20 versus 11 species), likely due to the absence of herbicide application. By the second assessment, weed density in the organic field had significantly declined, while in the conventional field weeds were eliminated through herbicide treatment. The higher weed species diversity in the organic field is considered a positive ecological effect.

Due to the low disease incidence during the study period, it was not possible to clearly establish how the type of farming affects the spread of winter wheat diseases.

Pests with similar taxonomic composition were recorded in both systems - three orders and five families, with eight species identified under organic farming and nine under conventional farming. The conventional system showed higher pest density and greater species diversity, likely

due to the reduced presence of beneficial entomofauna compared to the organic system. In the latter, four predator species and five parasitoid species were identified, contributing to the natural regulation of pest populations.

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