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YIELD STABILITY AND PHYTOSANITARY STATUS OF ORGANIC AND CONVENTIONAL BARLEY (*HORDEUM VULGARE* L.) UNDER DROUGHT STRESS

Dina Atanasova✉, **Vasilina Maneva**

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Abstract

Climate change and increasing drought frequency pose significant threats to global cereal production. This study evaluates the yield stability and phytosanitary status of winter barley (*Hordeum vulgare* L.), Sitara variety, grown under organic and conventional farming systems in Southeast Bulgaria over a six-year period (2019–2024). Results indicate that conventional farming achieved a higher average yield (4277 kg/ha^{-1}) compared to organic farming (3898 kg/ha^{-1}), but the difference was not statistically significant. Crucially, the organic system demonstrated superior yield stability with a significantly lower coefficient of variation (CV = 8.39%) compared to the conventional system (CV = 29.7%), where yield dropped sharply under stress conditions. Phytosanitary monitoring revealed higher weed density and biodiversity in organic plots, with *Anthemis arvensis* L. identified as a major competitor. Biochemical analysis showed higher crude protein content in conventional grain (12.34%) due to mineral fertilization, while thousand-grain weight (TGW) remained slightly higher in organic samples. The findings suggest that organic cultivation of Sitara barley offers enhanced agroecosystem resilience and predictable productivity under drought stress.

Key words: barley, organic and conventional farming, yield stability, phytosanitary status

Introduction. Climate change is widely recognized as one of the most significant challenges facing agriculture in the 21st century. Increasing air temperatures, altered precipitation patterns, and the growing frequency and intensity

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of extreme weather events are already affecting crop productivity and stability worldwide [1, 2]. Among these factors, drought has emerged as a major abiotic stress limiting agricultural production, particularly in semi-arid and temperate regions where water availability is becoming one of the important issues [3].

Barley (*Hordeum vulgare* L.) is one of the most important cereal crops globally, valued for its adaptability to diverse environmental conditions and its role in food, feed, and malting industries. Despite its relatively high tolerance to environmental stress compared to other cereals, barley is significantly affected by water deficit, especially during critical growth stages such as heading and grain filling [4]. Drought stress can lead to a significant reduction in yield and disrupt certain processes in plants, which ultimately affects yield stability [5].

With climate change, improving crop resilience has become a key priority for sustainable agriculture. Yield stability, defined as the ability of a crop to maintain consistent productivity across varying environmental conditions, is increasingly used as a critical indicator of adaptive capacity [6]. At the same time, the phytosanitary status of crops plays a crucial role in determining overall plant performance, as environmental stress can predispose plants to increased susceptibility to pathogens and pests [7].

In recent decades, there has been growing interest in comparing organic and conventional farming systems in terms of their resilience to climate-related stresses [8]. Organic farming is often associated with improved soil structure, higher organic matter content, and enhanced biological activity, which may contribute to better water retention and increased drought tolerance [9]. However, the response of crops, including barley, to drought conditions under different management systems remains insufficiently understood and sometimes inconsistent across studies [10]. Barley cultivation in an organic farming system in Bulgaria is a relatively underdeveloped but is a growing area of scientific research. Publications address the problems of weed infestation, diseases and pests on the quality of the produce. According to Ginchev et al. [11], in organic farming, weeding is the main limiting factor for yield. Diseases and pests in organic barley are usually less important than weeds, as their development is highly dependent on environmental conditions. In a number of cases, natural regulation of pests by beneficial organisms (entomophages) is observed [12].

Therefore, the aim of the present study is to evaluate the yield stability and phytosanitary status of organic and conventional barley (*Hordeum vulgare* L.) under drought stress conditions, with a focus on identifying differences in adaptive responses between the two production systems.

Materials and methods. At the Institute of Agriculture in Karnobat, cereals have been grown on a certified organic field since 2007; i.e. the principles of organic farming have been applied on this experimental field for 18 years now. Experiments have been conducted in the conventional experimental field since 1925, when the Institute was established.

Between 2019 and 2024, barley of the Sitara variety, grown in conventional and organic farming, was studied. The experimental plots are 500 m^2 in four replications. Predecessor – peas. Sowing rate – 420 germinating seeds/m^2.

In conventional cultivation, nitrogen fertilizer (N8), herbicides Florasulam + Tritosulfuron and Fenoxaprop-P-etil, fungicide Epoziconazole + Pyraclostrobin and insecticide Cypermethrin (at recommended doses) were applied to barley.

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

The following parameters were analysed: grain yield in kg/ha^{-1}; crude protein content (%); mass of 1000 grains (TGW, g), test weight (g).

The phytosanitary condition of barley was monitored in both agricultural systems. Weeds were determined according to [13], plants/m^2. The size of the aphid population was determined by direct measurement at 10 locations on 10 stems of each crop. Taxonomic analyses of aphids were made according to [14]. Disease counts were carried out using the route method, through the plants [15].

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 °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), %, was determined using a NIR analyzer (CropScan 1000B). The experimental data were processed using Microsoft Excel and STATISTICA, version 7.0.

Results and discussion. ***Meteorological conditions.*** The meteorological conditions and yields of Sitara barley 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 °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.

Productivity and yield stability. The analysis of the yield of winter barley Sitara reveals a significant influence of climatic conditions during the studied period. The average yield in the organic farming system is 3898 kg/ha, while the conventional one has a higher result – 4277 kg/ha (+9.7%). Despite this trend, the lack of a statistically significant difference between the two average values ($p > 0.05$) shows that in years with meteorological conditions close to the average for the region, barley yields from the two systems do not differ significantly. Key

Table 1

Meteorological conditions and yield of Sitara barley 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	4020	4852
2020	4976	339	3264	2330
2021	4753	692	4315	5885
2022	4562	478	4100	5180
2023	4981	471	3895	4753
2024	5239	464	3799	2666 (local hail)
Multi-year data	4254	551		
Mean			3898	4277
Standard deviation (SD)			326.96	1270.01
Variance coefficient (CV)			0. 839 (8.39%)	0.297 (29.7%)

differences are observed in terms of yield stability (Table 1). In the organic system, low standard deviations (326.96) and coefficient of variation (CV = 8.39%), which is an indicator of high yield stability, were recorded. This stability can be explained by the better ecological adaptability of the crop in conditions of low-input and more balanced use of resources, which leads to lower sensitivity to extreme climatic factors. This is also confirmed by other authors [16, 17].

In contrast, the conventional farming system shows high variability (CV = 29.7%), which indicates a strong dependence of the yield on the specific conditions of the year. Under favourable agrometeorological conditions, the conventional system realizes a significantly higher potential, but in stressful situations, the yield drops sharply. This indicates lower stability and increased risk in a variable climate, despite the implementation of intensive agrotechnical measures.

While the conventional system offers higher productivity, the organic cultivation of Sitara winter barley provides better adaptability and predictability of results, minimizing the negative impact of abiotic stress.

Comparative analysis of the main parameters of the grain. The data in Table 2 reveal a clear differentiation between conventional and organic farming in terms of grain quality. A significantly higher protein content is observed in conventionally grown barley (12.34%) compared to organic (10.64%). Conventional systems rely on easily digestible mineral fertilizers, which directly affect protein

synthesis. Many authors confirm this trend [18, 19].

While the hectoliter weight (Test weight) is higher in the conventional growing system (70.48 g vs. 68.74 g), the weight per 1000 grains (TKW) is almost the same, with a slight increase in organic farming (51.60 g vs. 51.12 g). This suggests that under organic farming barley manages to form well-nourished grains, despite the lower nitrogen content. In their research SINKOVIČ et al. [19] point out that it is not unidirectional, but depends on the conditions.

T a b l e 2

Biochemical parameters of Sitara barley variety

Parameters	Mean	CV, %	Min	Max	Range
Conventional farming					
Crude protein, %	12.34	11.02	11.1	14.1	3.0
Test weight, g	70.48	4.54	65.8	74.0	8.2
TKW (thousand grain weight)	51.12	8.28	44.9	57.2	12.3
Organic farming					
Crude protein, %	10.64	10.62	9.0	11.8	2.8
Test weight, g	68.74	2.79	65.8	70.8	5.0
TKW (thousand grain weight)	51.60	6.53	47.6	57.7	10.1

Phytosanitary status. Table 3 presents the results of the study of weed infestation in barley under organic and conventional farming conditions. The results show a significant difference in the total number of weeds per m^2 between the two systems. In organic farming, the total density is higher in both surveys (38.81 and 27.19 plants/m^2, respectively) compared to the conventional one (28.81 and 15.8 plants/m^2). The decrease in the total number of weeds in the second reading in both systems is indicative of the natural self-regulation of the crop and the competitiveness of barley, but is more pronounced in the conventional system due to the application of herbicides. The analysis of the species composition reveals specific dynamics. The initially high density in both systems of the weed *Veronica hederifolia* L. drops significantly in the second reading, which is typical of early spring ephemerals that quickly end their life cycle. The species *Consolida orientalis* L. and *Convolvulus arvensis* L. show a statistically significant increase in the second reading in both systems, which makes them problematic for control even under conventional conditions.

Organic farming is characterized by a higher species biodiversity of weeds. The species *Caucalis daucoides* L., *Lithospermum arvense* L., *Ranunculus arvensis* L., and *Scandix pecten-veneris* L. are present almost exclusively in organic farming and completely absent in conventional farming.

The lower values in the conventional system in the second reading (e.g. *Sinapis arvensis* L. and *Polygonim convolvulus* L. fall to 0.00) confirm the high efficiency of chemical control. However, the presence of *Chenopodium album* L.

Table 3

Species composition and weed density in Sitara winter barley variety cultivation under two types of farming systems, average for 2019–2024 (plants/m^2)

Weeds species	Organic farming		Conventional farming	
	1st weed reporting	2nd weed reporting	1st weed reporting	2nd weed reporting
Anthemis arvensis L.	4.16	4.27	2.66	0.66
Avena fatua L.	0.33	0.33	0.50	0.00
Caucalis daucoides L.	3.16	2.60	0.00	0.00
Capsella bursa pastoris L.	1.66	1.33	0.66	0.00
Chenopodium album L.	0.16	0.17	2.00	2.33
Cirsium arvense (L.) Scop.	0.00	0.00	0.33	0.00
Consolida orientalis L.	1.27	1.27	3.16	5.33^{+}
Convolvulus arvensis L.	0.00	2.16^{+}	0.33	3.33^{+}
Galium spp.	0.16	0.16	0.33	0.00
Lamium amplexicaule L.	0.16	00.0	00.0	0.00
Lithospermum arvense L.	3.22	1.50	0.00	0.00
Myagrum perfoliatum L.	0.00	0.00	0.08	0.00
Papaver rhoeas L.	2.91	1.77	1.72	0.66
Polygonum convolvulus L.	1.00	1.00	1.00	0.00^{-}
Polygonum aviculare L.	2.00	2.16	2.00	2.50
Ranunsulus arvensis L.	0.66	0.83	0.00	0.00
Scandix pecten-veneris L.	1.66	2.00	0.00	0.00
Sinapis arvensis L.	1.60	1.0	3.16	0.00^{-}
Torilis arvensis L.	1.00	0.66	0.00	0.00
Veronica hederifolia L.	11.88	2.66^{---}	8.72	0.66^{---}
Viola tricolor L.	0.16	0.00	0.00	0.00
Total weeds, nb/m^2	38.81	27.19	29.81	15.8

Evidence of differences compared to A1: +/− at GD 5.0%; ++ / −− at GD 1.0%; +++/ −−− at GD 0.1%.

and *Polygonum aviculare* L. in both systems suggests their high adaptability and lower sensitivity to standard agrotechnical and chemical measures.

The organic system leads to 40–70% higher weed density, but maintains higher species diversity. Winter barley Sitara shows a good ability to suppress part of the weed vegetation in earlier weed phases.

During the study period, only isolated instances of *Dreshlera teres* and *Puccinia hordei* were observed in barley 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 barley.

The conducted study covers a comparative analysis of the species composi-

tion of pests and beneficial entomofauna in barley cultivation under organic and conventional farming conditions for the period 2019–2024. The data presented in Table 4 allow conclusions to be drawn regarding the structure of the entomocomplexes in both agroecosystems.

The results of Table 4 show that the species composition of pests is identical in both types of agriculture. The identified representatives belong mainly to the orders Coleoptera and Hemiptera, with the most significant species being the Aphididae family (*Sitobion avenae, Schizaphis graminum, Rhopalosiphum maidis,*

Table 4

Species composition of barley pests and beneficial entomofauna grown in two types of agriculture, average for 2019–2024

Order	Species	Organic farming	Conventional farming
Pests			
Coleoptera	*Chrysomelidae*		
	Oulema melanopus (Linnaeus, 1758)	+	+
	Cetoniidae		
	Epicometis hirta (Poda, 1761)	+	+
Hemiptera (suborder *Homoptera*)	*Aphididae*		
	Sitobion avenae Fabricius	+	+
	Schizaphis graminum (Rondani, 1852)	+	+
	Rhopalosiphum maidis (Fitch, 1856)	+	+
	Rhopalosiphum padi (Linnaeus, 1758)	+	+
Hemiptera	*Scutelleridae*		
	Eurygaster sp.	+	+
	Pentatomidae		
	Aelia sp.	+	+
Predators			
Coleoptera	*Coccinella septempunctata* L.	+	+
Coleoptera	*Cantharis* sp.	+	+
Neuroptera	*Chrysopa* sp.	+	+
Diptera	*Syrphus ribesii* L.	+	+
Parasitoids			
Hymenoptera	*Aphidius* sp.	+	+
Hymenoptera	*Praon* sp.	+	+
Hymenoptera	*Ichneumonidae*	+	+
Hymenoptera	*Asolcus* sp.	+	+
Diptera	*Phasia* sp.	+	+

Rhopalosiphum padi), as well as the grain bugs of the genera *Eurygaster* and *Aelia*. The presence of these species in both cultivation systems shows that they are typical components of agrocenoses in barley and their distribution is not limited by the applied agrotechnical practices. Aphids are of particular importance, which, in addition to direct damage, also act as vectors of viral diseases.

The analysis of Table 4, reflecting the beneficial entomofauna, also shows a complete coincidence of species between organic and conventional agriculture. Both predators and parasitoids have been registered, which play a key role in the natural control of pests. Among the predators, *Coccinella septempunctata, Chrysopa* sp. and *Syrphus ribesii* stand out, known for their high efficiency against aphids. The parasitoid complex is represented by species from the Braconidae family (*Aphidius* sp., *Praon* sp.), Ichneumonidae and Tachinidae, which contribute to regulating the number of harmful species.

The comparison between the two farming systems shows a lack of differences in the species composition of both pests and beneficial entomofauna. This suggests that the ecological conditions in the studied agroecosystems are similar and allow the development of identical trophic complexes. However, the assessment approach used, based on qualitative indicators (presence/absence), does not allow for definitive conclusions regarding quantitative differences in the abundance and dominance of individual species. In conclusion, it can be noted that both types of agriculture maintain similar entomological potential both in terms of pests and their natural enemies. For a more in-depth assessment of the sustainability and effectiveness of agroecosystems, additional quantitative studies are needed, including analysis of population density, biodiversity and interactions between individual trophic levels.

Conclusion. The comparative analysis of organic and conventional farming systems for Sitara winter barley variety leads to several key conclusions regarding resilience to drought:

– Yield resilience: Although conventional farming realizes higher potential under favourable conditions, it exhibits high vulnerability to climatic fluctuations. In contrast, organic farming provides a "buffer effect", ensuring high yield stability and consistent performance across variable environments.

– Quality and efficiency: Conventional management is superior for grain protein accumulation due to direct mineral inputs. However, the ability of organic barley to maintain high thousand-grain weight (TGW) indicates efficient resource utilization during the grain-filling stage, even under water deficit.

– Phytosanitary balance: Weed infestation remains the primary limiting factors in organic production, showing 40–70% higher density than conventional fields. However, the identical species composition of pests and beneficial entomofauna in both systems suggests that organic farming supports natural regulation mechanisms without increasing the risk of pest outbreaks.

– Practical value: For drought-prone regions, the Sitara barley demonstrates

excellent adaptability to organic practices, providing a reliable alternative for sustainable agricultural production in the face of climate uncertainty.

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Institute of Agriculture – Karnobat, 1 Industrialna St, 8400 Karnobat, Bulgaria
Agricultural Academy, Sofia, Bulgaria
e-mails: dinadadar@gmail.com, https://orcid.org/0009-0000-2013-3810
maneva_ento@abv.bg, https://orcid.org/0000-0002-8192-7216