EVALUATION OF PRODUCTION PERFORMANCE AND QUALITY PARAMETERS OF BARLEY VARIETIES AND LINES UNDER THE PEDO-CLIMATIC CONDITIONS OF NORTHWESTERN ROMANIA

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Abstract

Winter barley (*Hordeum vulgare* L.) is one of the most important cereal crops cultivated in Romania for its high productive potential, adaptability, and multiple end-uses. This study evaluated the agronomic performance, yield components, and grain quality of winter barley cultivars and breeding lines at ARDSLivada, northwestern Romania, over two contrasting growing seasons (2023/2024 and 2024/2025): 25 genotypes in 2023/2024 and 27 in 2024/2025. The seasons differed substantially in temperature and precipitation, with higher temperatures and abundant rainfall in 2023/2024 versus a significant precipitation deficit in 2024/2025providing an opportunity to assess genotype adaptability under contrasting conditions.

Significant genotype differences were found for grain yield, yield components, and grain quality. Grain yield ranged from 4153 to 7252 kg ha^{-1} in 2023/2024 (highest: Iulian, then F8-1-2020) and from 4250 to 9182 kg ha^{-1} in 2024/2025, with the new breeding lines FB-38-24 and FB-14-24 significantly outperforming the control and all other genotypes. F8-1-2020, Gabriela, Artemis, and Expert FD showed relatively stable performance across both years.

Substantial variability was also found for yield components and quality: Ileana had the highest protein content (17.0%), while FB-38-24 combined exceptional yield with the highest TKW (56.4 g) and a high hectoliter weight (64.2 kg/hl), reflecting considerable genetic diversity and the importance of jointly assessing productivity and quality in barley breeding.

The breeding lines FB-14-24 and especially FB-38-24 demonstrated superior agronomic performance and represent promising genetic resources for future cultivar development and variety registration. Further multi-year experiments will provide a more comprehensive assessment of genotype performance, stability, and adaptability, and will strengthen the identification of superior barley genotypes for breeding and registration.

Keywords: winter barley; breeding lines; grain yield; grain quality; genotype adaptability; climatic variability; northwestern Romania.

Introduction

Winter barley (*Hordeum vulgare* L.) is an economically important cereal crop in Romania and worldwide, valued for its adaptability to diverse pedo-climatic conditions and its multiple end-uses in animal feed, brewing, and human nutrition. Northwestern Romania has distinct soil and climatic features that can significantly influence the agronomic behavior and technological traits of the crop, making local multi-environmental testing essential for identifying genotypes that combine high yield with optimal industrial parameters (Boanta et al., 2020). The main objective of this study was therefore to evaluate the production performance and quality parameters of several winter barley varieties and lines under the pedo-climatic conditions of Northwestern Romania.

Literature review

Barley (*Hordeum vulgare* L.) is one of the most historically significant and ecologically resilient cereal crops globally, having sustained human civilizations for millennia by adapting to environments where other major grains fail (Zohary, Hopf, & Weiss, 2012). It ranks fourth among global cereal crops in production volume and area, after maize, rice, and wheat (Grando & Gómez-Macpherson, 2005; Ullrich, 2011), with a global cultivated area of approximately 46.84 million hectares and an annual production of 141.52 million metric tons (FAOSTAT, 2024). Romania allocates 531,050 hectares to barley cultivation, with an official annual production of 2,203,260 metric tons (FAOSTAT, 2024), reflecting its multi-purpose use as feed, in malting/brewing (Briggs, 2012), and increasingly in human nutrition due to its functional dietary compounds (Badea & Wijekoon, 2021).

Taxonomically, cultivated barley belongs to the family *Poaceae*, genus *Hordeum*, having evolved from its wild progenitor *Hordeum vulgare* ssp. *spontaneum* in the Fertile Crescent (von Bothmer & Komatsuda, 2011). Agronomically, two-rowed types produce larger, more uniform kernels preferred for malting, while six-rowed types yield more kernels per spike and are typically used for feed (von Bothmer & Komatsuda, 2011; Badr et al., 2000). Grain composition, approximately 65–75% starch and 9–14% protein (Ullrich, 2011), determines its industrial and nutritional value: the malting industry requires a strictly regulated protein window (Magliano et al., 2014), while beta-glucan contributes to cholesterol-regulating dietary fiber (AbuMweis et al., 2010; EFSA NDA Panel, 2011) and to wort viscosity challenges in brewing.

Barley's evolutionary success rests on wide genetic diversity, enabling it to thrive from sub-arctic to arid Mediterranean climates (Ullrich, 2011; Dawson et al., 2015). Modern breeding distinguishes winter/spring growth habits and hulled/hull-less types, with local programs continuously evaluating commercial varieties and advanced breeding lines for phenotypic stability, disease resistance, and technological quality under regional conditions (Zengin et al., 2008; Ullrich, 2011; Boanta et al., 2020; Vasilescu et al., 2019; Muntean et al., 2021; Kosztyuné Krajnyák et al., 2024; Györgyiné Kovács et al., 2025).

Materials and methods

The experiments were conducted over two consecutive growing seasons (2023/2024 and 2024/2025) at the Agricultural Research and Development Station (ARDS) Livada, Satu Mare County (lat. 47°51′ N, long. 23°08′ E, altitude 120–130 m), located in northwestern Romania.

The soil at the experimental site is a typical Luvisol (preluvosol tipic, brown luvic soil), with low humus content in the arable layer and an acidic pH. The profile comprises five horizons: Ap (0–18 cm, plowed surface layer), Ao (18–40 cm, light-colored and acidic), AB (40–55 cm, transitional), Bt1w (55–70 cm, clay accumulation with a yellowish-reddish color from Fe oxides under water stagnation), and Bt2w (70–110 cm, low pH and the highest clay content) (Table 1).

Table 1. Soil characteristics of the experimental field at ARDS Livada

Component	U.M.	Ap 0-18	Ao 18-40	AB 40-55	Bt1w 55-70	Bt2w 70-110
Humus (C x 1.72)	%	1.7				
N total	%	0.168	0.102	0.072	0.068	-
pH in water	-	5.19	6.24	6.65	6.53	5.28
Clay (<0.002 mm)	% g/g	20.9	21.1	27.0	32.4	33.1
Apparent density	g/cm3	1.35	1.54	1.48	-	1.48

U.M. = unit of measure; Ap, Ao, AB, Bt1w, Bt2w = soil horizons.

The climatic conditions recorded during the two experimental seasons differed considerably and strongly influenced the agronomic performance, yield components, and grain quality of the evaluated genotypes.

The 2023/2024 season was substantially warmer (+3.1 °C) and wetter (+165.5 mm) than the multiannual average, with pronounced excess rainfall in November–December that favored foliar pathogen development.

The 2024/2025 season was closer to the historical average in temperature (+1.1 °C) but recorded an overall precipitation deficit (−126.2 mm), with uneven monthly distribution and pronounced day-to-night temperature fluctuations in spring (Table 2).

Therefore, the interpretation of yield and grain quality results must be considered in the context of the substantial environmental differences observed between the two experimental seasons.

Table 2. Monthly and mean temperatures and rainfall during the two growing seasons (2023/2024 and 2024/2025), compared to the multi-year average, at ARDS Livada

Year	Climatic factor	Month									Mean temp. (°C)	The amount (mm/m^2)
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.		
2023/2024	Temp. (°C)	13,3	5,9	3,0	1,4	7,5	9,3	13,1	17,4	21,3	10,2	
	Multi-year average	9,8	4,8	0,1	-2,0	0,1	4,7	10,5	15,8	20,5	7,1	
	Difference ±	+3,5	+1,1	+2,9	+3,4	+7,4	+4,6	+2,6	+1,6	+0,8	+3,1	
	Rainfall (mm/m$^{2)}$	65,3	128,7	126,1	75,9	41,5	40,0	41,6	30,2	147,2		696,5
	Multi-year sum	54,4	57,4	62,8	49,3	44,2	45,7	50,9	75,5	90,8		531,0
	Difference ±	+10,9	+71,3	+63,3	+26,6	-2,7	-5,7	-9,3	-45,3	+56,4		+165,5
2024/2025	Temp. (°C)	10,8	3,0	1,9	2,5	0	7,8	12,1	13,3	21,6	8,1	
	Multi-year average	9,8	4,8	0,1	-1,9	0,2	4,8	10,5	15,8	19,0	7,0	
	Difference ±	+1,0	-1,8	+1,8	+4,4	-0,2	+3,0	+1,6	-2,5	+2,6	+1,1	
	Rainfall (mm/m$^{2)}$	56,1	49,5	34,8	40,2	17,8	94,0	23,2	68,5	20,4		404,5
	Multi-year sum	54,5	57,3	62,3	49,7	44,2	45,6	50,7	74,8	91,7		530,7
	Difference ±	+	-7,8	-27,5	-9,5	-26,4	+48,4	-27,5	-6,3	-71,3		126,2

Diff ± = deviation from the multi-year average. Source: weather station, ARDS Livada.

The biological material consisted of 25 winter barley (*Hordeum vulgare* L.) genotypes common to both growing seasons: 14 registered commercial varieties (Cardinal FD, Ametist, Smarald, Lucian, Iulian, AGIL, Cadril, Expert FD, Azur FD, Artemis, Gabriela, Diana, and Ileana, together with the check cultivar Control) and 11 advanced breeding lines (F8-22-2018, F8-16-2018, DH 420-3, F8-1-2020, DH 461-1, F8-3-21, DH 425-4, DH 425-3; DH 417-12, F8-114-10, and DH 403-12) (Table 3). In 2024/2025, two additional breeding lines, FB-14-24 and FB-38-24, were introduced into the trial.

The experiment was laid out in a randomized complete block design (RCBD) with three replications, with the spatial allocation of genotypes within each replication established by randomization (Table 3). Each experimental plot had a total area of 10 m² (1 m width x 10 m length), with a row spacing of 12.5 cm.

Table 3. Randomization scheme showing the plot allocation of genotype codes across the three replications (R1, R2, R3) at ARDS Livada

Plot position	R1	R2	R3
1	1	15	10
2	2	19	13
3	3	14	7
4	4	3	9
5	5	10	24
6	6	18	21
7	7	11	25
8	8	5	6
9	9	25	2
10	10	20	5
11	11	13	15
12	12	24	12
13	13	8	18
14	14	23	4
15	15	7	23
16	16	16	11
17	17	21	17
18	18	4	19
19	19	6	20
20	20	1	8
21	21	17	14
22	22	22	1
23	23	12	3
24	24	2	16
25	25	9	22

**Numbers indicate the genotype code (Nr. crt., Table 3) allocated to each plot position within each replication. Plots corresponding to FB-14-24 and FB-38-24 (2024/2025 only) are not included*

Figure 1. Comparative field trials of barley cultivars at ARDS Livada.

The preceding crop in both growing seasons was forage pea (*Pisum sativum*, cv. Magistra Liv) (Cernay et al., 2018). Following harvest in July, crop residues were incorporated by disc harrowing, and plowing was carried out in September at a depth of 22–25 cm, followed by two passes of a disc harrow. Basic fertilization was applied using a complex N18P46K0 fertilizer at a rate of 150 kg/ha, incorporated into the soil during seedbed preparation with a field cultivator prior to sowing.

Sowing was performed during the second half of October (2023 and 2024) using a Wintersteiger experimental plot seeder, at a density of 350 germinable seeds/m² and a depth of 4–5 cm. Seedling emergence occurred approximately two weeks after sowing in both years.

In spring, supplementary fertilization was carried out with 300 kg/ha of calcium ammonium nitrate (CAN 27.5% N). Weed control was achieved by applying Sekator Progress OD herbicide at a rate of 0.15 L/ha in early spring. The same cultivation technology was applied in both growing seasons.

Throughout the growing season, the following biometric and phenological observations were recorded for each genotype: seedling emergence density (plants/m²), winter survival, heading date, plant height (cm), and lodging resistance, each scored on a numerical scale. Resistance to foliar diseases was assessed under natural infection on a 1 (highly resistant) to 6 (highly susceptible) scale. Four pathogens were monitored consistently across both growing seasons: Powdery mildew (*Erysiphe hordei*), Net blotch (*Pyrenophora teres f. teres*), Leaf scald (*Rhynchosporium secalis*), and Ramularia leaf spot (*Ramularia collo-cygni*). A fifth disease, depending on natural infection pressure, differed between seasons: Leaf rust (*Puccinia hordei*) in 2023/2024, common root rot and spot blotch (*Helminthosporium sativum*) in 2024/2025. At harvest, the number of spikes per m², spike weight (g), and the number of kernels per spike were additionally determined.

Grain quality parameters, thousand-kernel weight (g), test weight (kg/hl), and protein content (%) were determined immediately after harvest using a Pfeuffer Granolyzer NIR grain analyzer (Pfeuffer GmbH, Kitzingen, Germany) (Ping, Wang, & Ren, 2013).

At physiological maturity, each experimental plot was harvested individually, and grain yield was recorded as the harvested mass per plot (kg/plot) for each of the three replications. Grain moisture content at harvest was determined separately for each replicate, and a correction coefficient was applied to standardize all yields to a moisture content of 14%. The corrected plot yields were subsequently converted to grain yield per hectare (kg/ha) for statistical analysis.

The harvested grain samples were analyzed for the key quality parameters described above using the NIR grain analyzer. Experimental data were processed by analysis of variance (ANOVA) using the PolyStat statistical software package to assess the significance of genotype effects on the studied traits (Gomez & Gomez, 1984). Means were compared using the least significant difference (LSD) test at significance thresholds of $p < 0.05$, $p < 0.01$, and $p < 0.001$ (Steel, Torrie, & Dickey, 1997).

Results and Discussion

Grain Yield Performance

Grain yield varied considerably among genotypes and between the two growing seasons. The experimental mean increased from 5421 kg/ha in 2023/2024 to 6048 kg/ha in 2024/2025, indicating a higher overall productivity in the second season despite the lower precipitation recorded during the growing period. The differences in grain yield among genotypes and their contrasting responses between seasons are illustrated in Figure 2.

As shown in Figure 2, in 2023/2024 grain yield ranged from 4153 kg/ha in DH 417-17 to 7252 kg/ha in Iulian, while the control (Martor) yielded 4828 kg/ha. Iulian recorded the highest yield, exceeding the control by 2424 kg/ha (150% of the control yield), with a statistically significant difference. F8-1-2020 also significantly exceeded the control, reaching 6530 kg/ha (135% of the control). Several other genotypes, including Expert FD, Gabriela, Ametist, Cardinal FD, and Artemis, produced higher yields than the control, although their differences were not statistically significant. In contrast, F8-22-2018, F8-16-2018, F8-114-10, and DH 417-17 were among the lowest-yielding genotypes.

In 2024/2025, as illustrated in Figure 2, grain yield ranged from 4250 kg/ha in Ametist to 9182 kg/ha in FB-38-24, compared with 5853 kg/ha for the control. The newly developed breeding lines showed particularly high productive potential, with FB-38-24 reaching 9182 kg/ha and FB-14-24 8149 kg/ha. These values exceeded the control by 3329 and 2296 kg/ha, respectively, and the differences were highly significant. Other genotypes, including F8-22-2018, Artemis, Gabriela, Cadril, F8-1-2020, Diana, and Expert FD, also exceeded the control, although without statistically significant differences.

The comparison between the two seasons highlights a pronounced genotype × environment interaction. Iulian, which was the highest-yielding genotype in 2023/2024, decreased from 7252 to 4421 kg/ha in 2024/2025. In contrast, Artemis, Gabriela, and Expert FD maintained relatively high yields in both seasons, while F8-1-2020 consistently exceeded 6500 kg/ha. These results suggest comparatively greater yield stability for these genotypes under contrasting environmental conditions. This pattern of contrasting genotype responses across seasons illustrates the practical importance of genotype-by-environment interaction (GEI) analysis in barley breeding, as emphasized by Pour-Aboughadareh et al. (2022), and is consistent with previous multi-environment evaluations of Romanian winter barley germplasm, which similarly reported substantial genotype-dependent variability in yield traits (Boanta et al., 2020).

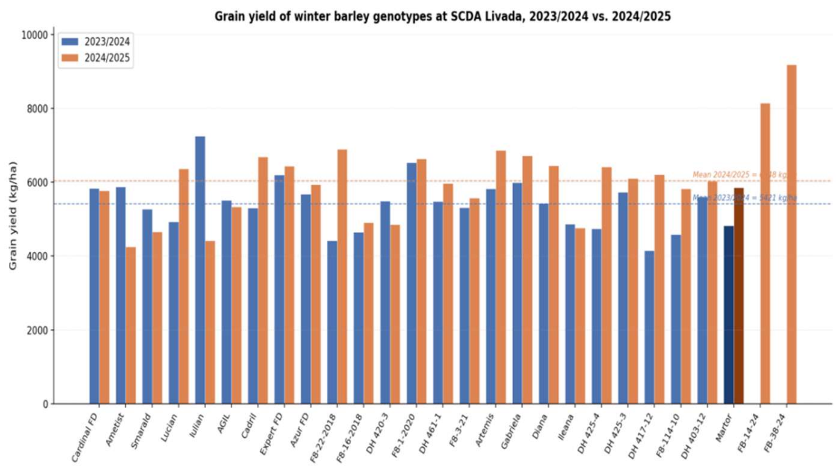

Figure 2. Grain yield (kg/ha) of winter barley genotypes at ARDS Livada, 2023/2024 vs. 2024/2025. Dashed lines indicate the experimental mean for each season.

Overall, grain yield was strongly influenced by both genotype and growing season. The newly developed breeding lines FB-14-24 and FB-38-24 showed the highest productive potential, particularly in 2024/2025, while several previously tested genotypes demonstrated comparatively stable performance across seasons. These results highlight the importance of multi-year testing for identifying winter barley genotypes combining high yield potential with good environmental adaptability.

Grain Quality Characteristics

Grain physical quality was evaluated using thousand-kernel weight (TKW) and hectoliter weight (HW). These parameters provide relevant information on kernel size, grain filling, density, and overall physical grain quality. Considerable variation was observed among genotypes and between the two growing seasons, indicating differences in their capacity to form and fill grains under contrasting environmental conditions.

In 2023/2024, TKW ranged from 38.4 g in AGIL to 50.0 g in Iulian. High values were also recorded in DH 425-4 (48.0 g), F8-114-10 (48.0 g), F8-3-21 (47.2 g), and the control (47.2 g). These results indicate favorable grain filling for several genotypes under the environmental conditions of the first season.

In 2024/2025, TKW ranged from 36.8 g in AGIL to 56.4 g in FB-38-24. The highest values were recorded in FB-38-24 (56.4 g), DH 425-4 (53.2 g), the control (52.8 g), DH 417-12 (52.4 g), DH 425-3 (52.4 g), and Gabriela (52.0 g). The high TKW values recorded by several genotypes despite the lower precipitation indicate good grain-filling capacity under the conditions of the second season. Particularly noteworthy was FB-38-24, which combined the highest grain yield with the highest TKW among the evaluated genotypes.

HW also varied considerably among genotypes. In 2023/2024, values ranged from 50.3 kg/hl in Expert FD to 62.0 kg/hl in F8-114-10. Other genotypes with relatively high HW included Gabriela (60.5 kg/hl), Lucian (60.4 kg/hl), DH 425-4 (59.6 kg/hl), and Ileana (59.5 kg/hl). These values indicate good grain density and favorable physical quality.

In 2024/2025, HW ranged from 53.2 kg/hl in Ametist to 70.6 kg/hl in Ileana. High values were also recorded for FB-38-24 (64.2 kg/hl), DH 417-12 (63.6 kg/hl), Gabriela (62.8 kg/hl), the control (62.8 kg/hl), DH 425-3 (62.5 kg/hl), and DH 425-4 (62.4 kg/hl). Thus, several genotypes combined favorable grain density with good productive performance, although the relationship between yield and individual quality parameters varied among genotypes.

When the two quality parameters are considered together, FB-38-24 was particularly noteworthy, combining a very high grain yield (9182 kg/ha) with high TKW (56.4 g) and HW (64.2 kg/hl). This combination indicates favorable grain filling and high physical grain quality under the environmental conditions of 2024/2025. Other genotypes showed specific advantages, such as Iulian, which recorded the highest TKW in 2023/2024, F8-114-10, which recorded the highest HW in the first season, and Ileana, which recorded the highest HW in the second season.

Overall, the results demonstrate substantial genotype-dependent variation in grain physical quality. While some genotypes were characterized by high TKW, others showed superior HW, and only a limited number combined favorable values for both parameters with high productivity. Among the evaluated material, FB-38-24 showed the most favorable combination of productivity and grain physical quality, supporting its potential for further evaluation in breeding and cultivation programs. Notably, the grain protein content recorded across genotypes in 2024/2025 (12.6-17.0%, Table 6) extended beyond the typical range reported for barley grain (approximately 9-14%; Ullrich, 2011) and confirmed a strong genotype effect on this trait, consistent with earlier findings on Romanian barley germplasm (Vasilescu et al., 2019). Furthermore, the combination of high TKW and comparatively low protein content observed in FB-38-24 agrees with the inverse relationship generally reported between kernel size and grain protein concentration in barley (Magliano et al., 2014).

Table 5. Grain yield, thousand-kernel weight (TKW), and hectoliter weight (HW) of winter barley genotypes, ARDS Livada, 2023/2024

Nr.crt.	Genotype	Grain yield (kg/ha)	Diff. vs control (kg/ha)	Relative yield (%)	Signif.	TKW (g)	HW (kg/hl)
1	Cardinal FD	5837	1009	121	-	45,2	55.3
2	Ametist	5877	1049	122	-	44,4	56.0
3	Smarald	5277	449	109	-	39,2	55.1
4	Lucian	4931	103	102	-	41,0	60.4
5	Iulian	7252	2424	150	XX	50,0	52.3
6	AGIL	5514	686	114	-	38,4	52.4
7	Cadril	5301	473	110	-	41,6	52.8
8	Expert FD	6198	1370	128	-	40,0	50.3
9	Azur FD	5682	854	118	-	40,0	51.3
10	F8-22-2018	4416	-412	91	-	41,6	56.3
11	F8-16-2018	4652	-176	96	-	43,6	56.7
12	DH 420-3	5496	668	114	-	43,2	54.2
13	F8-1-2020	6530	1702	135	X	46,4	55.3
14	DH 461-1	5479	651	113	-	43,6	58.1
15	F8-3-21	5316	488	110	-	47,2	55.0
16	Artemis	5828	1000	121	-	46,0	55.7
17	Gabriela	5991	1163	124	-	46,4	60.5
18	Diana	5434	606	113	-	41,6	55.8

19	Ileana	4869	41	101	-	44,4	59.5
20	DH 425-4	4743	-85	98	-	48,0	59.6
21	DH 425-3	5730	902	119	-	46,0	56.7
22	DH 417-17	4153	-675	86	-	44,0	57.0
23	F8-114-10	4583	-245	95	-	48,0	62.0
24	DH 403-12	5602	774	116	-	43,2	53.5
25	Control	4828	Ct	100	-	47,2	54.6
	Experimental mean	**5421**					
	LSD 5%	**1664**					
	LSD 1%	**2219**					
	LSD 0.1%	**2890**					

Signif. = statistical significance of the difference vs. control (Martor): X = significant positive difference at p<0.05; XX = significant positive difference at p<0.01; - = not significant. LSD = least significant difference.

Table 6. Grain yield, thousand-kernel weight (TKW), hectoliter weight (HW), and protein content of winter barley genotypes, ARDS Livada, 2024/2025

Nr.crt.	**Genotype**	**Grain yield (kg/ha)**	**Diff. vs control (kg/ha)**	**Relative yield (%)**	**Signif.**	**TKW (g)**	**HW (kg/hl)**	**Protein (%)**
1	Cardinal FD	5777	-76	99	-	50,8	57,3	13,3
2	Ametist	4250	-1603	73	00	46,8	53,2	15,9
3	Smarald	4656	-1197	80	00	50,4	55,8	14,7
4	Lucian	6363	510	109	-	40,0	58,6	14,9
5	Iulian	4421	-1432	76	0	41,2	55,8	15,6
6	AGIL	5336	-517	91	-	36,8	57,8	16,0
7	Cadril	6689	836	114	-	37,6	54,2	14,4
8	Expert FD	6443	590	110	-	42,0	60,3	14,7
9	Azur FD	5935	82	101	-	42,8	53,6	14,8
10	F8-22-2018	6899	1046	118	-	44,4	55,8	14,7
11	F8-16-2018	4905	-948	84	-	44,4	56,0	15,3
12	DH 420-3	4862	-991	83	-	43,2	58,6	14,9
13	F8-1-2020	6642	789	113	-	47,2	56,8	13,5
14	DH 461-1	5967	114	102	-	46,0	59,8	14,2
15	F8-3-21	5577	-276	95	-	45,2	55,0	15,6
16	Artemis	6865	1012	117	-	50,4	61,3	15,0
17	Gabriela	6719	866	115	-	52,0	62,8	13,9
18	Diana	6449	596	110	-	41,6	59,5	15,7
19	Ileana	4766	-1087	81	-	46,0	70,6	17,0
20	DH 425-4	6420	567	110	-	53,2	62,4	15,5
21	DH 425-3	6105	252	104	-	52,4	62,5	14,9
22	DH 417-12	6213	360	106	-	52,4	63,6	15,7
23	F8-114-10	5820	-33	99	-	45,2	62,2	15,3
24	DH 403-12	6033	180	103	-	52,0	57,6	13,9
25	Control	5853	Mt	100	Ct	52,8	62,8	14,4
26	FB-14-24	8149	2296	139	***	51,2	60,7	13,5
27	FB-38-24	9182	3329	157	***	56,4	64,2	12,6
	Experimental mean	**6048**						
	LSD 5%	**1174**						
	LSD 1%	**1565**						
	LSD 0.1%	**2038**						

*Signif. = statistical significance of the difference vs. control (Martor): *** = significant positive difference at p<0.001; X = significant positive difference at p<0.05; 0 = significant negative difference at p<0.05; 00 = significant negative difference at p<0.01; - = not significant; Mt = control (Martor). LSD = least significant difference.*

Conclusions

The objective of this study was to evaluate the agronomic performance, yield components, and grain quality traits of winter barley cultivars and breeding lines under the environmental conditions of northwestern Romania and to identify genotypes with superior productivity, stability, and adaptability across contrasting growing seasons.

The newly developed breeding lines FB-14-24 and especially FB-38-24 demonstrated superior agronomic performance and represent valuable genetic resources for future breeding and variety registration programmes.

Regarding grain yield, the cultivar Iulian was the top performer in the 2023/2024 season (7252 kg ha^{-1}), while in 2024/2025 the newly introduced breeding lines FB-38-24 (9182 kg ha^{-1}) and FB-14-24 (8149 kg ha^{-1}) clearly outyielded all other genotypes, confirming their superior productive potential under the pedo-climatic conditions of northwestern Romania.

Among the genotypes common to both growing seasons, F8-1-2020, Gabriela, Artemis, and Expert FD combined above-average yields with consistent performance across the contrasting climatic conditions of 2023/2024 and 2024/2025, recommending them as stable and reliable genetic sources for further breeding work.

In contrast, the weakest yielding genotypes were DH 417-17, F8-22-2018, F8-114-10, and F8-16-2018 in 2023/2024, and Ametist, Iulian, Smarald, and Ileana in 2024/2025, indicating a lower adaptability of these entries to the specific environmental conditions of each season, particularly to water deficit and temperature fluctuations.

In terms of grain quality, the cultivar Ileana stood out with the highest protein content (17.0%) and the highest hectoliter weight (70.6 kg/hl), while FB-38-24 combined the highest thousand-kernel weight (56.4 g) with a high hectoliter weight (64.2 kg/hl), confirming the inverse relationship generally observed between grain yield and protein content in cereals.

These results should be further supported by additional experiments in future growing seasons to monitor the studied parameters over a longer period and obtain a more comprehensive assessment of genotype performance, stability, and adaptability.

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