

YIELD STABILITY AND ADAPTIVE POTENTIAL OF THE TWO-ROW BARLEY VARIETY “GORAST” UNDER THE AGROCLIMATIC CONDITIONS IN BULGARIA

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Abstract. *Due to the complexity, labor intensity, and long duration of the breeding process duration, combined with constantly changing environmental conditions, the stability of yields over a long period of time in a variable environment is of paramount importance. Yield is increasingly determined by stress tolerance rather than maximum genetic potential by stress tolerance rather than by maximum genetic potential under ideal growing conditions is a key paradigm in modern breeding, especially in the context of climate change currently. The present study evaluates the productivity and adaptability of the Bulgarian malting barley variety “Gorast”. The experiment is based on data from the trials within the Executive Agency of Variety Testing Field Inspection and Seed Control system during the 2010 and 2011 growing seasons and the current agroecological conditions in Bulgaria in 2024 and 2025 vegetation years. Bulgaria has a long-standing tradition of conducting scientific and experimental research aimed at developing new cereal varieties, particularly barley. There is a rich collection of cultivars that form the country’s varietal structure, developed during various periods. Significant changes in environmental conditions on a global scale necessitate a reassessment of established varieties as a source of biodiversity, considering current growing conditions. The results of the current research confirm the relevance of the Gorast cultivar. Although it was recognized, zoned, and listed in Bulgaria’s variety register in 2012, trials conducted more than a decade later reveal that the studied cultivar retains its breeding significance and can be recommended for cultivation today in regions with variable agroecological conditions. The most recent experiments confirm that Gorast is characterized by a balanced combination of agronomic traits such as broader adaptation, delivering more stable yields (average 676 kg/dka) across a wider range of environmental conditions, less susceptible to lodging, consistent thousand-kernel weight (av. 50 g.), and favorable grain malting qualities (11% protein, 80% extract) compared to the standards.*

Keywords: *barley breeding, cultivar description, *Hordeum vulgare* L., re-evaluation, yield stability*

INTRODUCTION

Efforts in the field of cereal breeding cover a wide range of areas. Trends in the development of the variety model are determined primarily by economic conditions and market requirements, as well as soil and climatic conditions in the respective countries (ENCHEV, 1990; IVANOVA AND MISHEV, 2012). Despite global differences, the primary goal of breeding programs has been to increase yield levels and the stability of cultivars under optimal growing conditions (FALCONER, 1990; LOSKUTOV, 2021). In recent decades, however, drastic climate changes and increasingly frequent conditions conducive to abiotic stress have been observed (AL-TAWAHA ET AL., 2022; CURTIS AND HALFORD, 2014; NIKOLOVA, 2013). These changes manifest as more frequent droughts in key crop-growing regions, sharp temperature fluctuations, mild and warm winters, and significant diurnal temperature variations (ABEBAW, 2025). In this context, nowadays breeders’ efforts to achieve high and stable yields are focused on improving the genetic potential of plants to adapt to adverse environmental factors (ARAUS ET AL., 2008; BECKER AND LÉON, 1988; KYRYLCHUK ET AL., 2023).

Barley (*Hordeum vulgare L.*) is one of the oldest cultivated crops and remains of major global importance as feed, malting, and industrial raw material. Its wide adaptability and relatively short vegetation period make it particularly suitable for regions characterized by climatic variability and increasing frequency of abiotic stress factors (ARAUS ET AL., 2008). In Southeastern Europe, and especially in Bulgaria, winter barley plays a significant role in ensuring stable grain production under conditions of recurrent drought and temperature fluctuations. In 2024, the areas sown with barley in Bulgaria were 198,217 hectares, and the average barley grain yields were 5360 kg/ha (NECHEV ET AL., 2026, MAF, 2024).

Plant breeding in Bulgaria faces numerous challenges (TODOROVSKA ET AL., 2018). The country's territory is characterized by extremely diverse climatic conditions. For example, in Northern Bulgaria, soils have better moisture retention, unlike in the southern parts of the country, where droughts are a frequent occurrence. This leads to a strong dependence of a variety's genetic potential on growing conditions. A major drawback of modern varieties is that their high yields are seriously compromised under stressful conditions. In contrast, older, widely adapted varieties are often more resilient but have a lower yield potential. This, in turn, creates one of the main breeding dilemmas: high-yielding varieties or stable varieties.

Another long-standing trend, particularly since the year 2000, has been the widespread introduction of Western European varieties into the country's crop structure. These varieties often yield high harvests under intensive farming conditions, rendering domestically bred varieties uncompetitive (<https://iasas.government.bg/>). This gap is widening due to limited breeding resources, a lack of relevant funding, and restricted access to new genomic technologies. Consequently, this leads to a significantly slower and less effective breeding process.

All the factors listed so far highlight the need to re-evaluate certain varieties developed through national breeding programs, which were created during different time periods and for different growing conditions. In this context, the current study presents a re-evaluation of the Bulgarian malting barley variety - Gorast.

MATERIAL AND METHODS

Field experiments conducted as part of the Executive Agency of Variety Testing Field Inspection and Seed Control (IASAS) system during the 2009-2010 and 2010-2011 growing seasons were carried out at six stations located in different ecogeographic regions of Bulgaria (Chepintsi, Selanovtsi, Pordim, Radnevo, General Toshevo, Burgas).

Re-evaluation of Gorast cultivar for the period 2023-2024 and 2024-2025 for the north part of the country, was conducted at the seed production fields of "Agrodimex" Ltd. For the south part - at the experimental field of the Department of Crop production at the Agricultural University - Plovdiv (Figure 1).

The experimental sites covered a wide range of soil and climatic conditions, including leached and carbonate chernozems, alluvial-meadow soils, and gray forest soils, differing in nutrient availability and physical properties. Northern regions were characterized by more favorable moisture conditions and stable winter regimes, while southern locations experienced higher temperature stress and irregular precipitation. The Chepintsi site reflected cooler conditions due to higher altitude, whereas the Plovdiv and Dragoevo trials were marked by increased climatic variability, particularly in rainfall distribution during critical growth stages. These contrasting environments provided suitable conditions for evaluating the adaptability and stability of the studied cultivar (Table 1).

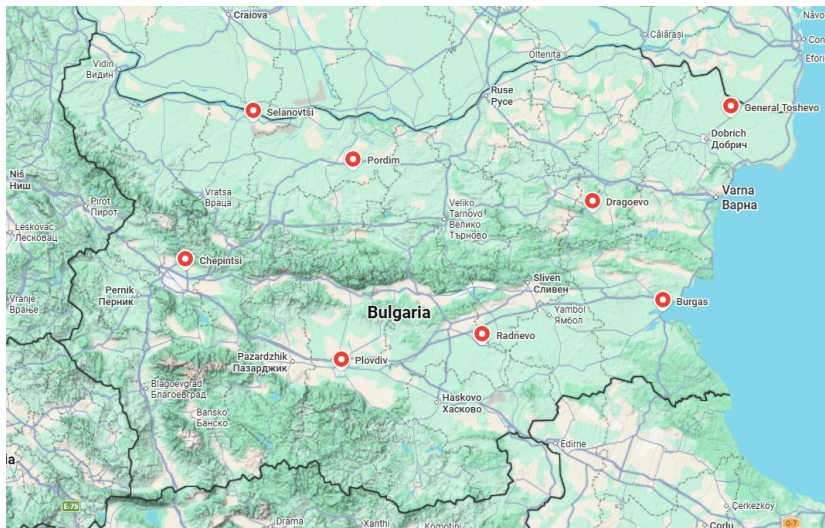


Figure 1. Field trials' locations in the territory of Bulgaria

Table 1

Average monthly climate parameters for barley vegetation periods during experiments in Bulgaria

Years/ Months	Precipitation		min t	max t	min t	max t
	2023/ 2024	2024/ 2025	2023/ 2024	2023/ 2024	2024/ 2025	2024/ 2025
October	4.2	2.3	8.6	26.5	5.3	23.9
November	22.7	52.8	3.9	15.8	-0.4	14.1
December	150.1	51.1	3.2	12.1	2.1	9.7
January	22.6	47.8	-1.9	9.9	-1.9	10.9
February	25.3	6.8	2.6	17.4	-3.2	8.3
March	67.2	39.3	4.9	17.7	3.3	19.3
April	72.8	37.3	8.4	25.8	5.6	20.0
May	55.1	74.5	11.2	24.3	10.6	25.2
June	11.5	5.3	17.5	35.1	15.4	34.9

The following main characteristics were examined: Yield, kg/dka

Growing season, days

Earing date

1000-grain weight, g

Hectoliter weight, kg/hl

Lodging before harvest, score

Resistance to ear breakage at the ear neck, score

Density at harvest, number of ear-bearing stems per 1 m²

Overwintered plants, %

The response of the varieties (Gorast and stadarts) to pathogens causing brown rust, powdery mildew, black rust, stripe rust, and fusarium head blight was determined under natural

infection conditions and controlled conditions according to UPOV methodology (<https://www.upov.int/en/>).

Laboratory analyses were conducted in laboratories authorized by the IASAS (<https://iasas.government.bg/>). The cold tolerance assessment was performed at the abiotic stress laboratory at Dobrudzha Agricultural Institute in G. Toshevo. The brewing and technological parameters were analyzed anonymously in the independent laboratories of and the Institute of Agriculture - Karnobat, Bulgaria.

The results were statistically analyzed, and the significance of the differences was determined using Duncan's test.

RESULTS AND DISCUSSIONS

"GORAST" cultivar - breeding line 557D003

/Winter two-rowed, *Hordeum vulgare* L. sensu lato. Subs. *distichum* (L.) Korn covar. *Distichon* (L.) Alef. S.i./ (Figure 2.)



Figure 2. Gorast

List "A" also includes varieties pursuant to Article 16(2) of the Plant Variety Protection Act of March 4, 2003, which meet the requirements for biological and agronomic qualities suited to the country's soil and climate conditions, if, when compared to standard varieties, they demonstrate better results in terms of yield and/or product quality across functional categories. If a variety exhibits an exceptional characteristic, the other characteristics may be disregarded when assessing the variety's biological and agronomic qualities.

Recognized pursuant to Article 16(2) of the Law on the Protection of New Plant Varieties and Animal Breeds, with the distinctive characteristic: technological qualities. The variety was registered since 2012 in list "A" of The Official Variety List of Bulgaria by the company "Agrodimex" Ltd., main department - Dobrich, Bulgaria (<https://agrodimex.com/>).

The variety was tested for biological and agronomic characteristics over a two-year period (2010, 2011 vegetation years) by IASAS, using an average standard based on the varieties "Obzor," "Emon," and "Kaskador 3."

ORIGIN: Gorast was developed by sexual hybridization through the crossing of Krazy 2 × Hor1677 in 1985. It was grown in experimental plots in 1986, in demonstration plots from 1987 to 1997, in commercial plots in 1998, and studied in commercial trials from 2000 to 2003.

AGRONOMIC CHARACTERISTICS:

The average grain yield for the testing period was 656.1 kg/dka, compared to 650.3 kg/dka for the average standard.

In terms of the length of the growing season, the variety is on par with the average standard-217 days.

Plant density is 818 ear-bearing stems per m², compared to 841 for the average standard.

The average weight of 1,000 seeds for the trial period is 41.48 g, compared to 41.51 g for the average standard. The hectoliter weight is 67 kg, compared to 66.7 kg for the average standard.

Under natural infection conditions in the field, it is resistant to powdery mildew and black rust, and susceptible to brown rust.

Under artificial infection conditions, it showed moderate resistance to brown rust and susceptibility to black rust. It is comparable to the standard varieties in terms of resistance to *Fusarium* across all classes and in all three forms-showing strong susceptibility to *Fusarium culmorum*, moderate resistance to *Fusarium graminearum*, and resistance to *Fusarium oxysporum*.

The extract content is average, comparable to that of the standard varieties “Obzor” and “Kaskadior 3,” and higher than that of the standard variety “Emon.” The soluble nitrogen content is higher than that observed for the “Obzor” and “Kaskadior 3” varieties and lower than that for the “Emon” variety. In terms of total protein content in the malt, the variety is on par with the standard varieties. The crude protein content (Stage I) averaged 12.32% on a dry matter basis across all testing sites during the trial period, compared to 12.50% on a dry matter basis for the average standard.

As a result of re-evaluation in recent years, the winter two-row barley cultivar Gorast demonstrated stable performance across contrasting environments during the 2024 and 2025 growing seasons. Grain yield varied between locations and years. The highest yields, exceeding the standard mean, were recorded in Dragoevo during both growing seasons. In 2024, Gorast exceeded the standards by 16%, while the variety maximum yield was 755 kg/dka, recorded in Dragoevo, 2025 (Table 2). This trend is associated with more favorable moisture conditions and enhanced tillering capacity, as reflected in higher numbers of productive stems per unit area (Table 3). Across both environments, Gorast maintained optimal plant height (84-92 cm) and exhibited no lodging, indicating good suitability for mechanized harvesting.

Climatic conditions during the experimental period did not impose significant abiotic stress. No winter damage or drought-induced yield penalties were observed, allowing full expression of the genetic potential of the cultivar.

Table 2.

Grain yield obtained from variety trials of two-row winter barley during the 2024 and 2025 growing seasons, kg/dka.

Location/ year	Plovdiv 2023/2024			Dragoevo 2023/2024			Plovdiv 2024/2025			Dragoevo 2024/2025		
	kg/dka	GD	%	kg/dka	GD	%	kg/dka	GD	%	kg/dka	GD	%
Av. St	669		100	639		100,0	707,8		100,0	704		100
Obzor	726	+	109	656	-	103,1	701	-	97,54	651	000	92,2
Emon	624	o	93	601	-	94,09	741	-	103,3	748	+++	106
Kaskadior 3	656	-	98	654	-	102,8	712	-	99,16	704	-	101
Gorast	656	-	98	739	+++	116	597	ooo	82,63	755	+++	107

GD	5%	43,29		6,69	36,8		5,98	24,34		3,50	6,11		1,19	13,7		2,01	13,44		2,04
GD	1%	58,29		9,01	49,6		8,06	32,80		4,71	8,23		1,61	18,4		2,70	18,09		2,75
GD	0.1%	77,29		12	65,7		10,68	43,46		6,25	10,9		2,13	24,4		3,58	23,99		3,64
Accuracy of the experiment, %			2,1			1,9			1,2			0,4			0,7				0,7

Table 3.

Assessment of crop density and lodging severity during the study period

Variety, year	Number of class-sized stems /m ² /		Stem height /cm/		Lodging* /score/	
	Plovdiv	Dragoevo	Plovdiv	Dragoevo	Plovdiv	Dragoevo
2023-2024						
Obzor, 24	785	1100	100	98	8	9
Emon, 24	778	930	89	99	8	9
Kaskadior 3, 24	737	889	78	87	9	9
Gorast, 24	792	910	84	85	9	9
2024-2025						
Obzor, 25	797	811	102	97	8	9
Emon, 25	744	784	97	95	8	9
Kaskadior 3, 25	752	790	84	88	9	9
Gorast, 25	883	889	92	87	9	9

* - Score 1: Everything is lying on the ground; Score 2: More than 50% of the straw is touching the ground, with the exception of the top of the stalk, which is upright; Score 3-Less than 50% of the straw touches the ground; the rest is upright; Score 4-Stems are bent more than 60°, but do not touch the soil surface except at their base; Score 5-Stems are bent between 45° and 60°; Score 6-Stems are tilted between 30-45°; Score 7-Stems are tilted between 15-30°; Score 8-Stems are slightly tilted (<15°); Score 9-Stems are upright, vertical

The disease assessment revealed moderately susceptible to highly susceptible to major foliar pathogens, particularly net blotch (*Pyrenophora teres*), powdery mildew (*Erysiphe graminis f. sp. hordei*), and rusts (*Puccinia hordei*), with scores predominantly in the range of 7–9 (Table 4). These results indicate that, despite its agronomic stability and yield performance, ‘Gorast’ requires appropriate disease management under conditions favorable for pathogen development. Compared with earlier evaluations reporting higher levels of resistance, the present findings suggest a shift toward increased susceptibility under current agroecological conditions, likely associated with changes in pathogen populations and environmental factors.

Table 4.

Response of the studied varieties to economically significant pathogens in Bulgaria

Variety, yea	<i>Pyrenophora teres</i> /score 1-9/		<i>Erysiphe graminis f. sp. hordei</i> /score 1-9/		<i>Puccinia hordei</i> /score 1-9/	
	Plovdiv	Dragoevo	Plovdiv	Dragoevo	Plovdiv	Dragoevo
2023-2024						
Obzor, 24	6	7	9	9	8	8
Emon, 24	6	7	9	9	8	8
Kaskadior 3, 24	6	7	9	9	9	9
Gorast, 24	7	9	9	9	9	9
2024-2025						
Obzor, 25	6	7	9	9	8	9
Emon, 25	6	6	9	9	5	7
Kaskadior 3, 25	6	7	9	9	6	6
Gorast, 25	8	8	9	9	9	7

In this scale values were 1: R (Resistant), 2: R - MR (Resistant - Moderately Resistant), 3: MR (Moderately Resistant), 4: MR - MS (Moderately Resistant - Moderately Susceptible), 5: MR - MS (Moderately Resistant - Moderately Susceptible), 6: MR - MS (Moderately Resistant - Moderately Susceptible), 7: MS (Moderately Susceptible), 8: MS - S (Moderately Susceptible - Susceptible), 9: S - VS (Susceptible - Very Susceptible).

Grain quality analysis revealed that ‘Gorast’ meets the requirements for malting barley. The cultivar was characterized by high extract content (up to 82.3%), high germination capacity (up to 98%), and thousand kernel weight of approximately 49-50 g (Table 5). Protein content remained within the optimal range for malting purposes (~11.3-11.4%), lower than or comparable to standard cultivars (Table 6), indicating suitability for brewing applications.

Table 5.

Average data on the brewing qualities of the genotypes studied during the study period

Variety	Weight of 1,000 grains/g/		Uniformity: Class 1		Extract %/		Moisture %/		Germination %/	
	Plovdiv	Dragoevo	Plovdiv	Dragoevo	Plovdiv	Dragoevo	Plovdiv	Dragoevo	Plovdiv	Dragoevo
Obzor	50.5	52.0	98.4	99.1	76.6	78.0	12.1	12.3	92	93
Emon	49.5	51.8	99.8	89.3	75.9	77.5	12.3	12.2	94	92
Kaskadior 3	46.7	48.9	96.7	92.2	76.1	78.2	12.1	12.8	92	90
Gorast	49.3	50.3	91.1	96.3	77.8	82.3	11.7	11.9	98	93

Table 6.

Variety	nitrogen /%		carbon /%		grain protein /%	
	Plovdiv	Dragoevo	Plovdiv	Dragoevo	Plovdiv	Dragoevo
Obzor	2.70	2.05	44.72	45.33	16.88	12.8
Emon	2.45	1.90	44.29	44.98	15.30	11.7
Kaskadior 3	2.00	2.00	44.41	45.01	12.51	12.5
Gorast	1.82	1.81	44.30	44.55	11.39	11.3

A comparative analysis between official IASAS trials (2010, 2011) and subsequent experiments (2024, 2025) demonstrates that the winter barley cultivar ‘Gorast’ has maintained stable agronomic performance over time. The cultivar achieved yields of **656.1 kg/dka** during state testing and up to **755 kg/dka** in recent trials, with advantages of up to **+16% over standard cultivars**. Key agronomic traits, including **thousand kernel weight (~49-50 g)** and **lodging resistance**, remained stable across environments and periods. ‘Gorast’ also exhibited consistent adaptability and disease tolerance under contrasting agro-climatic conditions. Grain quality parameters, including **high extract content (up to 82.3%)** and **optimal protein levels (~11.3-11.4%)**, confirm its suitability for malting and support its renewed use in agricultural practice.

From a practical perspective, Gorast can be recommended to farmers as a reliable cultivar for stable yields and consistent grain quality, particularly in regions with variable climatic conditions.

CONCLUSIONS

The results of the present study demonstrate that the winter two-row barley cultivar ‘Gorast’ maintains stable productivity and good adaptability under diverse agro-climatic conditions in Bulgaria. Based on the analysis of data from official state variety trials (2010, 2011) and subsequent experimental evaluations (2024, 2025), the cultivar shows no significant decline in yield performance over time, indicating preservation of its genetic potential. Overall, the cultivar can be recommended for continued use in Bulgarian agricultural practice, contributing to sustainable and risk-resilient barley production.

BIBLIOGRAPHY

- ABEBAW, S.E., 2025 - A Global Review of the Impacts of Climate Change and Variability on Agricultural Productivity and Farmers’ Adaptation Strategies. *Food Sci. Nutr.* 13, e70260. <https://doi.org/10.1002/fsn3.70260>
- AL-TAWAHA, A.R.M.S., KHANUM, S., BENKEBLIA, N., AMANULLAH, IMRAN, KHALID, S., AL-TAWAHA, A.R., MONDAL, M., ODAT, N., DEY, A., ALIMAD, N., THANGADURAI, D., SANGEETHA, J., ISLAM, S., SHATNAWI, M., 2022 - Adapting Crops to Climate Change, in: Benkeblia, N. (Ed.), *Climate Change and Agriculture*. Wiley, pp. 53-77. <https://doi.org/10.1002/9781119789789.ch3>
- ARAUS, J.L., SLAFER, G.A., ROYO, C., SERRET, M.D., 2008 - Breeding for Yield Potential and Stress Adaptation in Cereals. *Crit. Rev. Plant Sci.* 27, 377-412. <https://doi.org/10.1080/07352680802467736>
- BECKER, H.C., LÉON, J., 1988 - Stability Analysis in Plant Breeding. *Plant Breed.* 101, 1-23. <https://doi.org/10.1111/j.1439-0523.1988.tb00261.x>

- CURTIS, T., HALFORD, N.G., 2014 - Food security: the challenge of increasing wheat yield and the importance of not compromising food safety. *Ann. Appl. Biol.* 164, 354-372. <https://doi.org/10.1111/aab.12108>
- ENCHEV, Q., 1990 - Plant breeding., Zemizdat, Sofia.
- FALCONER, D.S., 1990 - Selection in different environments: effects on environmental sensitivity (reaction norm) and on mean performance. *Genet. Res.* 56, 57-70. <https://doi.org/10.1017/S0016672300028883>
- IVANOVA, N., MISHEV, P., 2012 - Climate Changes and Its Impact on Agriculture - The Case Study of Bulgaria, in: *Human and Social Dimensions of Climate Change*. IntechOpen. <https://doi.org/10.5772/50861>
- KYRYLCHUK, A.M., SHCHERBYNINA, N.P., CHUKHLEB, C.L., 2023 - Barley - status and ways of increase grain production. *Taurian Sci. Her.* 90-103. <https://doi.org/10.32782/2226-0099.2023.131.11>
- LOSKUTOV, I.G., 2021 - Advances in Cereal Crops Breeding. *Plants* 10, 1705. <https://doi.org/10.3390/plants10081705>
- MAF, 2024. Ministry of Agriculture and Food (Министерство на земеделието и храните) http://mzh.government.bg/bg/media/filer_public/2025/09/16/ra460_public/ (accessed 4.27.26).
- NECHEV, N., YANEV, M., MITKOV, A., ZHELYAZKOV, I., MOSKOVA, C., DIMITROV, G., 2026 - Influence of the grass, broadleaf, and mixed weed infestation on some agronomic traits of barley (*Hordeum vulgare* L.), *Scientific Works. Presented at the Anniversary Scientific Conference "80 Years Agricultural University - Plovdiv: Traditions Meet Innovations"* Agricultural University, pp. 29-37. <https://doi.org/10.22620/sciworks.2025.01.003>
- NIKOLOVA, N., 2013 - The impact of the drought on the main crops cultivated in Northeastern Bulgaria. *Forum Geogr.* XII, 16-24. <https://doi.org/10.5775/fg.2067-4635.2013.016.i>
- TODOROVSKA, E., MHADI, N.A., CHRISTOV, N., BOZHANOVA, V., ATANASSOV, A., 2018 - Cereal genetics and genomics in bulgaria - challenges and perspectives, 71.
- IASAS - <https://iasas.government.bg/>
- UPOV - <https://www.upov.int/en/>
<https://bgsia.eu/wp-content/uploads/2021/01/Law-on-the-Protection-of-New-Plant-Varieties-and-Animal-Breeds12.pdf>