

THE EFFECT OF BLACK POINT DISEASE ON THE QUALITY OF WHEAT GROWING IN THE SOUTHERN PART OF ROMANIA

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Abstract

Black point is a disease that affects wheat production quality worldwide, affecting the chemical composition. The aim of the study was to evaluate the effect of black point disease on the quality of wheat grown in southern Romania during 2022-2024. The incidence and severity of black point were determined by classical laboratory analyses. Quality analyses were carried out using standard NIR spectroscopy to determine dry matter, hardness, gluten, crude protein, and starch. The incidence of caryopses with black points varied by year and climatic conditions. The year 2023 stands out, with the incidence of the attack ranging from 3.3% (Line 1) to 10.4% (Ursita). The gluten content was low across all 2022 samples, classified as satisfactory only in the Ursita and Miranda varieties (26.6% and 27.7%, respectively). In 2023, gluten exceeded 30% in Trivale, Line 1 and Line 2 being classified as very good. Statistical analysis (Tukey test) shows significant differences among experimental years and varieties, and when the two factors are combined.

Key words: wheat, black point, proteins, hardness, gluten.

INTRODUCTION

Black point is a major disease of wheat because it affects crop quality (Malaker et al., 2009). Unlike common wheat, durum wheat is the most susceptible to black point infection (Davis & Jackson, 2009; Fernandez et al., 2011). An incidence greater than 10% can negatively impact crop quality (Rees et al., 1984; Lorenz, 1986). Due to its effect on the quality and nutritional value of wheat, the selling price decreases, resulting in economic losses (Solanki et al., 2006; Vuckovic et al., 2012; Mishra & Srivstava, 2015; Patel & Minipara, 2015). In severe infections, seed germination, emergence, and weight are negatively affected (Rahman & Islam, 1998; Özer, 2005; Drasz et al., 2016). When incidence and severity are high, the flour will be of poor quality, with changes in dough colour, odour, and taste (King et al., 1981; Prescott et al., 1986). According to Kashem et al. (1999), black point negatively affects the biochemical composition of wheat, as pathogens involved in the disease reduce the levels of starch and soluble carbohydrates. Furthermore, the same authors show that prolamin, gluten,

and phenolic compounds increased in infected caryopses. "Black point" disease is caused by a complex of fungi and typically occurs when climatic conditions are characterised by high humidity and favourable temperatures, as well as rainfall during the flowering and grain-filling stages (Bhowmink, 1969). If the seed-filling period is characterised by low temperatures and heavy rainfall, the severity of the disease increases (Bhowmink, 1969; Williamson, 1997; Wang et al., 2002). Diseased caryopses are easily recognised by their brownish-black colour in the embryonic region as well as in other parts, depending on the severity of the disease. The blackening may be partial and, in severe cases, even total (Khulbe et al., 2011; Srivstava et al., 2014; Patel & Minipara, 2015). Research on the fungi involved in black point has shown that their composition can vary from one agricultural region to another. Most studies indicate that the most commonly isolated fungi are: *Alternaria* species (most frequently *Alternaria alternata* and *Alternaria trititica*), *Curvularia* spp., *Fusarium* spp., *Drechslera sorokiniana*, *Stemphylium* spp., and *Cladosporium* spp. (Adlakha & Joshi, 1974;

Hasan *et al.*, 2009; Srivastava *et al.*, 2014, cited by Patel & Minipara, 2015; Gafencu *et al.*, 2019). Fernandez *et al.* (1994b) highlight that the predominant fungi on black-pointed caryopses were *Alternaria alternata*, *Cochliobolus sativus*, and *Fusarium* spp. Furthermore, the incidence of caryopses infected with *Alternaria* spp. was higher than that of those infected with *Cochliobolus sativus*. Of the two fungi, *Cochliobolus sativus* is considered far more dangerous because it can reduce seed germination. In addition, it infects the roots, potentially killing seedlings immediately after emergence. *Alternaria* spp. does not affect germination (Kilpatrick, 1968; Huguélet *et al.*, 1973; Rees *et al.*, 1984; Fernandez & Conner, 2011).

In western Romania, Cotuna *et al.* (2020) isolated fungi of the genera *Alternaria* and *Fusarium* from black-pointed wheat grains. In the south, in a study of barley and two-row barley, Cristea *et al.* (2024) isolated fungi from the genera *Alternaria*, *Fusarium*, and *Drechslera*. The authors show that the incidence of seeds infected with *Alternaria* spp. was approximately 47% in the analysed varieties. Gafencu *et al.* (2019) isolated the following fungi from black-point wheat in northern Romania: *Alternaria* spp., *Cladosporium* spp., *Fusarium* spp., and *Cochliobolus* spp. The incidence of kernels infected with *Alternaria* spp. did not exceed 14%.

Black point is a disease associated with reduced grain quality, not with reduced wheat yield. Research shows that wheat seeds with black point have a thousand-kernel weight (TKW) that is 10–30% higher than that of seeds without symptoms. Furthermore, the fungus *Alternaria* spp. was predominantly isolated from the microflora growing on seeds with black point. This fungus does not affect plant vigour or yield, unlike the fungi *Fusarium* spp. and *Cochliobolus sativus* (Golosna *et al.*, 2026).

The incidence of the fungus *Cochliobolus sativus* (syn. *Bipolaris sorokiniana*) in European wheat is lower than in Africa and Asia (Hudec *et al.*, 2008; Draz *et al.*, 2016; Sharma *et al.*, 2021).

The aim of this study was to assess black point disease and its impact on the quality of wheat grown in southern Romania. To this end, several

Romanian wheat varieties were monitored over three experimental years.

MATERIALS AND METHODS

In this study, five wheat genotypes developed in Romania (three varieties and two lines) were evaluated for black point disease and grown at the Albota-Pitești Agricultural Research and Development Station in Argeş County. The evaluation of the disease and its effects on wheat quality was conducted between 2022 and 2024. Samples were collected after harvest from each variety (Trivale, Miranda, Ursita) and each line (Line 1 and Line 2). The composite sample consisted of 1 kg for each genotype. From each sample, 50 g seed samples were weighed in three replicates, from which impurities were removed. Over 1,000 caryopses were analysed in each sample to obtain the most accurate result possible.

The incidence was determined by counting the caryopses in each replicate and separating diseased from healthy. All seeds were examined visually and under a stereomicroscope (where necessary) to accurately quantify the diseased seeds. The incidence was determined using the classic formula in plant pathology by dividing the number of caryopses with black spots by the total number of caryopses examined, then multiplying the result by 100.

Severity was classified on a scale of 0-5 (Gilchrist, 1985). Analyses regarding incidence and severity were conducted at the plant pathology laboratory of the Faculty of Agriculture in Timișoara. The quality features (protein, gluten, dry matter, starch, hardness) were determined using near-infrared (NIR) spectroscopy (Norris *et al.*, 1989). These analyses were performed at the Research Platform of the University of Life Sciences “King Mihai I” from Timișoara.



Photo 1. Symptoms caused by black point in the wheat analysed caryopses (discolouration located mainly on the germ end) - original

Climatic data (average temperatures, precipitation) were obtained from the SCDA Albota-Pitești meteorological station and are presented in Figures 1-6.

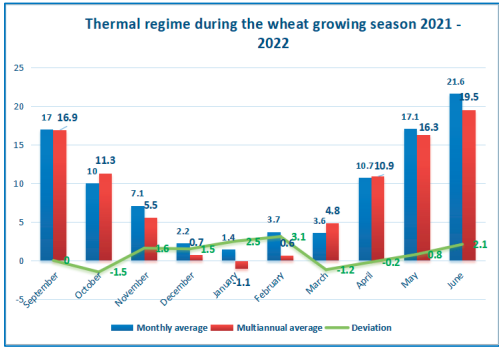


Figure 1. Graphical presentation of the thermal regime from the wheat growing season 2021-2022 from Albota- Pitești (Ghiorghe et al., 2026)

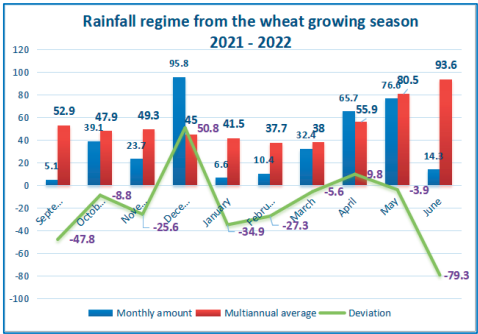


Figure 2. Graphical presentation of the rainfall regime from the wheat growing season 2021-2022 from Albota- Pitești (Ghiorghe et al., 2026)

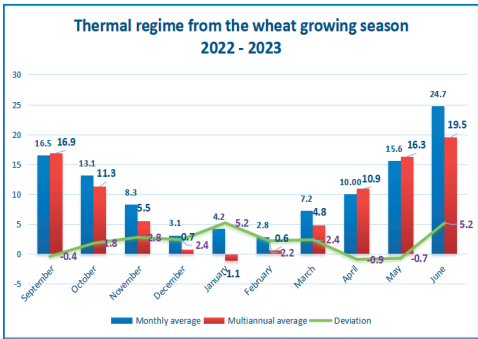


Figure 3. Graphical presentation of the thermal regime from the wheat growing season 2022-2023 from Albota- Pitești (Ghiorghe et al., 2026)

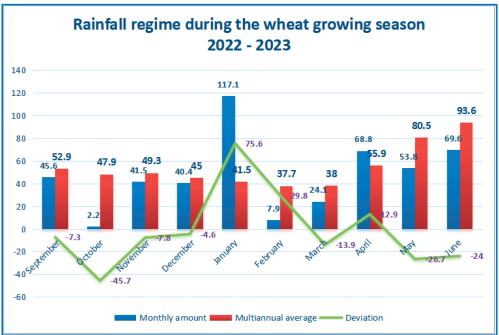


Figure 4. Graphical presentation of the thermal regime from the wheat growing season 2022-2023 from Albota- Pitești (Ghiorghe et al., 2026)

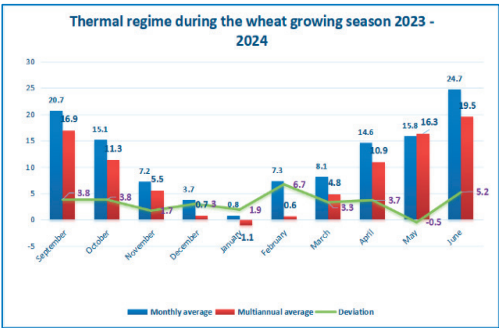


Figure 5. Graphical presentation of the thermal regime from the wheat growing season 2023-2024 from Albota- Pitești (Ghiorghe et al., 2026)

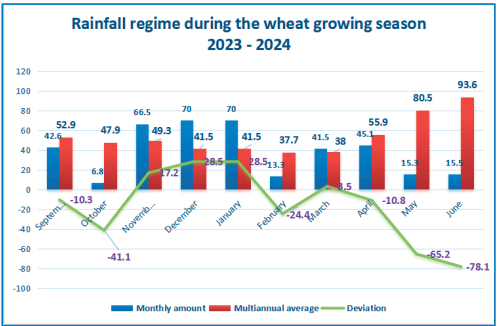


Figure 6. Graphical presentation of the rainfall regime from the wheat growing season 2023-2024 from Albota- Pitești (Ghiorghe et al., 2026)

The statistical analysis was performed with the software JASP (Version 0.95.4) (2025).

RESULTS AND DISCUSSIONS

Assessment of black point disease

The results regarding the incidence of black point disease between 2021 and 2024 for the analysed genotypes are presented in Figure 7.

Analysis of the results shows differences between years and genotypes. The year 2023 stands out, with a higher incidence across all genotypes than in 2022 and 2024. The highest incidence was recorded in the Ursita variety (10.4%), followed by Miranda (8.1%) and Line 2 (6%).

In 2022, the incidence of black point was higher in the genotypes Line 2 (8.8%) and Ursita (7.1%). In the other genotypes, the disease did not exceed a 2.8% incidence. The year 2024 was not conducive to black point disease; consequently, the recorded incidence did not exceed 1% (Figure 7).

The severity of the disease was rated 1 (on a scale of 0-5) because all analysed caryopses showed that only the tip of the embryo was coloured brown.

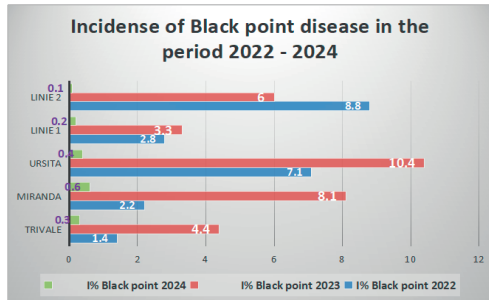


Figure 7. Graphical presentation of the incidence of black point disease in the period 2022-2024 from Albota-Pitești (Ghiorghe et al., 2026)

The data obtained were statistically analysed using analysis of variance (ANOVA). The F-test indicates significant differences among varieties, among experimental years, and between the two factors combined (Table 1).

Table 1. ANOVA for the black point attack frequency (F%) on winter wheat caryopses

Cases	Sum of Squares	df	Mean Square	F	P
Genotype	109.055	4	27.264	28.824	< 0.001
Year	293.534	2	146.767	155.167	< 0.001
Genotype * Year	117.033	8	14.629	15.466	< 0.001
Residuals	28.376	30	0.946		

The coefficient of variation was generally low (Miranda, Trivale and Ursita), indicating a normal distribution of the data, with the exception of two lines: Line 1, 2024 (CV = 0.903) and Line 2, also in 2024 (CV = 0.708) - Table 2. Levene's test rejects the null hypothesis, indicating significant differences among the variants in the incidence of black spots ($p = 0.003$).

Table 2. Descriptive statistics for the black point attack frequency (F%) on winter wheat caryopses

Genotyp c	Year	N	Mean	SD	SE	Coefficient of variation
Linie 1	2022	3	2.773	0.360	0.208	0.130
	2023	3	3.247	0.386	0.223	0.119
	2024	3	0.157	0.142	0.082	0.903
Linie 2	2022	3	8.737	2.182	1.260	0.250
	2023	3	6.020	1.441	0.832	0.239
	2024	3	0.127	0.090	0.052	0.708
Miranda	2022	3	2.193	0.570	0.329	0.260
	2023	3	8.110	0.975	0.563	0.120
	2024	3	0.567	0.163	0.094	0.287
Trivale	2022	3	1.407	0.136	0.079	0.097
	2023	3	4.400	0.493	0.285	0.112
	2024	3	0.267	0.090	0.052	0.338
Ursita	2022	3	7.087	0.722	0.417	0.102
	2023	3	10.367	2.222	1.283	0.214
	2024	3	0.370	0.104	0.060	0.282

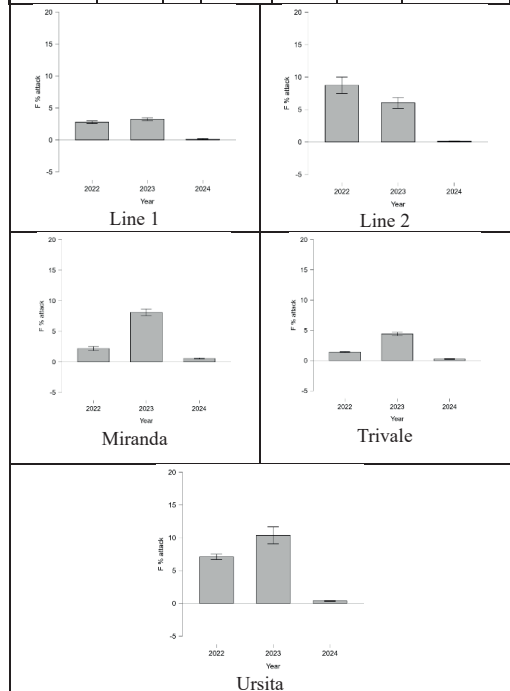


Figure 8. Black point attack frequency (F%) on Line 1, Line 2, Miranda, Trivale and Ursita, during 2022-2024 (SE displayed)

Post hoc comparisons (Tukey's test) regarding the influence of genotype on the incidence of black spot revealed statistically significant differences ($p < 0.001^{***}$) between Line 1 and Line 2, Line 1 and Ursita, Line 2 and Trivale, Miranda and Ursita, and Trivale and Ursita. Significant differences were recorded between Line 1 and Miranda, Line 2 and Miranda, and Miranda and Trivale (Table 3).

Table 3. Post Hoc Comparisons (Tukey test) - Influence of genotype on the black point attack frequency (F%) on winter wheat caryopses

Variety	Variety	Mean Diff.	95% CI for Mean Difference		t	Ptukey
			Lower	Upper		
Linie 1	Linie 2	-2.902	-4.232	-1.572	-6.330	< 0.001***
	Miranda	-1.564	-2.894	-0.235	-3.412	0.015*
	Trivale	0.034	-1.295	1.364	0.075	1.000
	Ursita	-3.882	-5.212	-2.552	-8.468	< 0.001***
Linie 2	Miranda	1.338	0.008	2.668	2.918	0.048*
	Trivale	2.937	1.607	4.267	6.405	< 0.001***
	Ursita	-0.980	-2.310	0.350	-2.138	0.231
	Trivale	1.599	0.269	2.929	3.487	0.012*
Miranda	Ursita	-2.318	-3.648	-0.988	-5.055	< 0.001***
	Trivale	-3.917	-5.247	-2.587	-8.543	< 0.001***

* $p < .05$, *** $p < .001$

Post hoc comparisons (Tukey's test) regarding the effect of year on the incidence of black spot show that the differences are significant ($*** p < 0.001$) across all experimental years (Table 4).

Table 4. Post Hoc Comparisons (Tukey test) - Influence of year on the black point attack frequency (F%) on winter wheat caryopses

Year	Year	Mean Diff.	95% CI for Mean Difference		t	Ptukey
			Lower	Upper		
2022	2023	-1.989	-2.865	-1.114	-5.602	< 0.001***
	2024	4.142	3.267	5.017	11.663	< 0.001***
2023	2024	6.131	5.256	7.007	17.265	< 0.001***

*** $p < 0.001$

Between 2022 and 2024, climatic conditions (precipitation and temperature) varied from year to year. Precipitation was below average in all experimental years during the wheat growing season (Figure 9). In the 2021–2022 and 2023–2024 seasons, the deficit ranged from 172.6 to 155.7 mm, much higher than that of the 2022–2023 season (63.3 mm). In May and June (2022-2024), when grains were forming and developing, precipitation was below average. The highest deficits were recorded in June of 2022 and 2024 (79.3 mm and 78.1 mm, respectively). In June 2023, the deficit was 24 mm (Figure 10), the incidence of black point disease being highest that year (Figure 7).

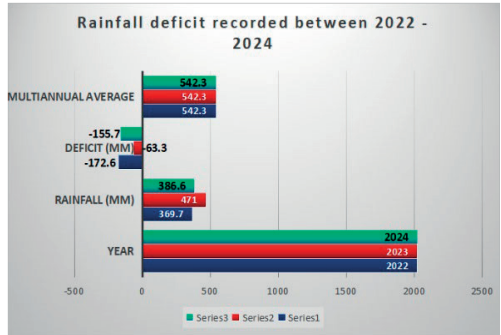


Figure 9. The rainfall deficit from 2022 to 2024 from Albota-Pitești (Ghiorghe et al., 2026)

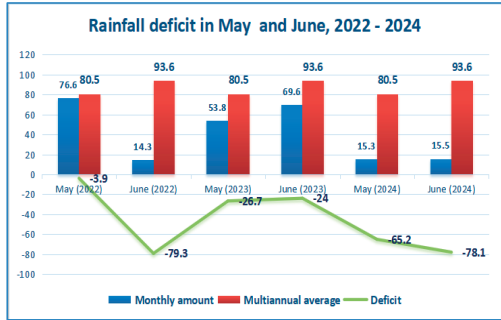


Figure 10. The rainfall deficit in May and June, 2022-2024 from Albota-Pitești (Ghiorghe et al., 2026)

Temperature conditions during the grain-filling stage were characterised by deviations from the long-term monthly averages. June stands out with higher positive deviations from the monthly average, as follows: 2.1 °C in 2022, 5.2 °C in 2023 and 2024 (Figures 1, 3 and 5). Regarding temperature, studies show that wheat exhibited black point symptoms under high-temperature conditions (30°C) in the absence of fungal infection, compared to wheat exposed to temperatures of 10°C. The authors conclude that abiotic stress can cause physiological changes (Ellis et al., 1996). Climatic conditions are decisive in triggering black point disease. It is known that the disease is initiated by both biotic and abiotic factors. In general, rainfall and high humidity during grain development favour the disease, but the most critical period for wheat is considered to be the milk-waxy ripening stage (Petr & Capouchova, 2001; Wang et al., 2002; Moschini et al., 2006).

The effect of black point on wheat quality

Several quality indices of the wheat analysed between 2022 and 2024 were determined in the laboratory: crude protein, gluten, dry matter, starch, hardness, bulk density, and moisture content. The results are presented in Figures 11 and 12.

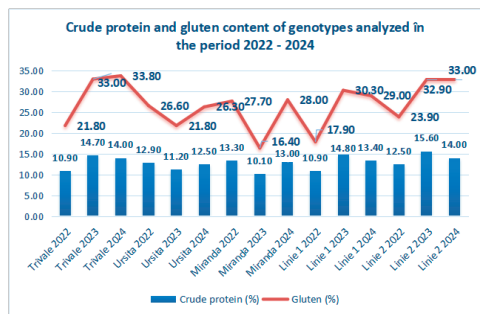


Figure 11. The amount of crude protein and gluten in the wheat genotypes analysed during the period 2022 - 2024 from Albota - Pitești (Ghiorghe *et al.*, 2026)

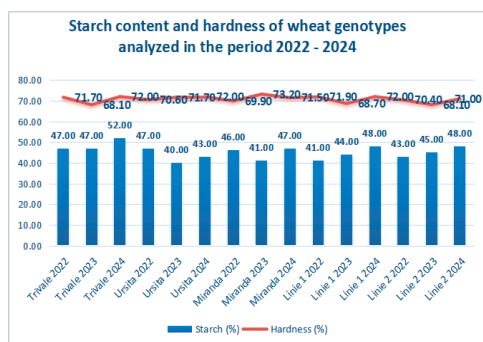


Figure 12. The amount of starch content and hardness in the wheat genotypes analysed during the period 2022- 2024 from Albota-Pitești (Ghiorghe *et al.*, 2026)

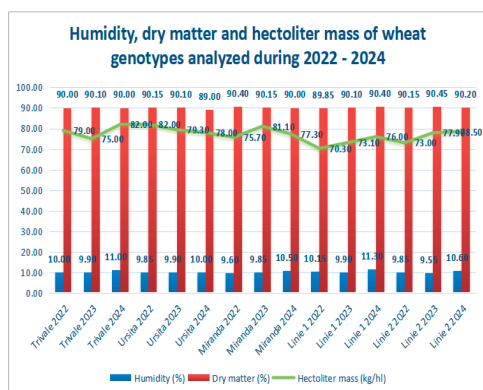


Figure 13. The humidity, dry matter and hectolitre mass in the wheat genotypes analysed during the period 2022- 2024 from Albota-Pitești (Ghiorghe *et al.*, 2026)

The crude protein content ranged from 10.10% to 14.80%, with variations observed between genotypes and years. Higher crude protein levels were observed in the following varieties: Trivale (14.00% in 2023 and 14.70% in 2024), Line 1 (14.80% in 2023 and 13.40% in 2024), and Line 2 (15.60% in 2023 and 14.00% in 2024). In 2022, the crude protein content was lower across nearly all genotypes, ranging from 10.90% (Trivale) to 13.30% (Miranda) - see Figure 11. Generally, the crude protein content in wheat should be between 9% and 14%.

Black point can influence the crude protein content of wheat kernels, along with other factors. Studies show that a severe black point infection (5 on a 0-5 scale) positively influences crude protein accumulation. Malaker *et al.* (2009) show that, in wheat with an infection level rated at 5, the crude protein content was 16.8%, whereas in healthy wheat it was 12.5%.

In the present study, the severity of black point disease was rated as 1, indicating that the embryo tip was brownish-black across all genotypes. The low severity was attributed to unfavourable climatic conditions during the wheat ripening period.

Protein content correlates very well with gluten content. A high protein content generally indicates higher gluten content (Wieser *et al.*, 2023).

The amount of gluten in wheat is an important characteristic for baking and is influenced by several factors: genetic (genotype), climatic (precipitation, temperature), technological, insect infestation (cereal bugs), and fungal pathogens (Torbica *et al.*, 2007).

Based on gluten content, the analysed genotypes were classified as follows: Ursita - satisfactory in 2022 and 2024 and below the minimum threshold in 2023 (below 26%); Trivale and Line 2 - very good quality in 2023 and 2024; Miranda - good quality in 2024, satisfactory in 2022, and below the limit in 2023; Line 1 - very good quality in 2023, good in 2024, and satisfactory in 2022 - Figure 11.

The starch content ranged from 40.00% in the Ursita variety in 2023 to 52.00% in Trivale in 2024. The Ursita variety had a higher incidence of black point in 2022 and 2023 and a lower incidence in 2024. The lower starch content may be correlated with the 10.4% incidence of black point in 2023. The differences between

genotypes and years are very small. Studies show that black point disease affects the composition of wheat kernels, potentially reducing starch content. Seeds with black points have lower starch and protein content than healthy ones (Kashem et al., 1999). Other studies show that a low incidence of black point (up to 5%) has no visible effect on starch content. An incidence greater than 10% negatively affects baking quality (Grădinaru et al., 2017) (Figure 12).

The results obtained regarding the hardness of wheat caryopses show that all genotypes can be classified as hard according to the relative hardness scale measured by the NIR method (Norris et al., 1989) (Figure 12). There are many studies on the influence of black point on hardness, some of which are contradictory. A recent study shows that the disease does not affect hardness as much as other diseases. In general, the effect on caryopsis texture is influenced by the severity of the disease. In severe infections, baking and milling quality may be affected (Golosna et al., 2026). Given that the climatic conditions during the years analysed did not favour the disease, we conclude that these qualities were unaffected in the genotypes studied.

The measured hectolitre weight showed differences between years and genotypes, as follows: high quality - Trivale (2022 and 2024), Ursita (in all years), Miranda (2023 and 2024), Line 2 (2023 and 2024); medium quality - Trivale (2023), Miranda (2022), Line 1 (2024); low quality - Line 1 (2022 and 2023), Line 2 (2022).

The influence of black point on hectolitre weight and dry matter content has been reported in several studies (Malaker et al., 2009; Golosna et al., 2026).

CONCLUSIONS

In this study, the incidence of black point disease in the analysed genotypes was low, as was its effect on the quality indices measured. Identifying more tolerant genotypes was difficult under water-stress conditions, given that the disease is favoured by wet weather during wheat maturation. Statistical analysis revealed significant differences among the

analysed genotypes, experimental years, and between the combined factors (genotype $\times$ year). In terms of hectolitre weight, the Ursita variety exhibited high quality in all experimental years. In contrast, Line 2 had lower quality for two consecutive years (2022 and 2023). The lowest crude protein content was recorded in 2022 for all genotypes. For starch, the content did not exceed 52.00%.

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