

ORIGINAL ARTICLE

Assessment of the relationship between white mold (*Sclerotinia sclerotiorum* (Lib.) de Bary) infection levels and crop yield parameters in oilseed rape (*Brassica napus* L.) cultivation

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Abstract

White mold [*Sclerotinia sclerotiorum* (Lib.) de Bary] often results in substantial yield and quality losses in winter oilseed rape (*Brassica napus* L.; OSR). This study investigated the tolerance levels of four commonly cultivated OSR hybrids (Architect, Bluestar, PT271, and Umberto) to white mold infection and assessed the effects of fungal infection on yield. Artificial inoculation with mycelial disks of *S. sclerotiorum* was performed on the four OSR hybrids during the silique formation stage (BBCH 71–79) over three consecutive growing seasons (2020/21 to 2022/23). The levels of OSR plant infection and yield parameters (thousand-seed weight (TSW), moisture, protein, and oil content) were determined. The hybrids exhibited varying levels of tolerance to the pathogen, and these differences were affected by the growing season. The Architect hybrid proved to be the most susceptible in the 2020/21 season, while no differences were observed in the following growing seasons. Infection resulted in yield reductions of up to 93% and impacted protein and oil content, and TSW to varying extents, while moisture content remained unaffected. These results underscore the importance of selecting *S. sclerotiorum*-resistant oilseed rape hybrids to maintain yield quality and to inform integrated pest management (IPM) strategies tailored to the conditions of each growing season.

Keywords: *Brassica napus* L., cultivar tolerance, disease severity index, integrated pest management

Introduction

Winter oilseed rape (*Brassica napus* L.) (hereinafter referred to as OSR) is an important oil crop worldwide. In recent years, between 2014 and 2022, the cultivated area of OSR in the EU decreased by 152,000 hectares, while the yield increased by $0.19 \text{ t} \cdot \text{ha}^{-1}$ (AgriData 2024).

The symptoms caused by *Sclerotinia sclerotiorum* (Lib.) de Bary in OSR plants are characteristic water-soaked lesions, typically appearing on the middle part of the stem in the leaf axils (Fig. 1A) or at the stem base (Fig. 1B) (Saharan and Mehta 2008). These symptoms later develop into necrotic tissues, upon which the white mycelium of the pathogen appears,

along with the formation of the pathogen's sclerotia. The lesions caused by the pathogen eventually turn whitish, and as the tissues disintegrate, only the vascular tissues remain in the stem (Bolton *et al.* 2006). Since the pathogen largely destroys the plant's cellulose and hemicellulose content, the plant flowers early and wilts (Fig. 1C, D) (Bolton *et al.* 2006). Symptoms caused by the pathogen may also appear on the silique, resulting in whitening, and occasionally, sclerotia may be observed inside the silique (Li *et al.* 2006).

Infection by *S. sclerotiorum* may also result in significant yield losses in most host plants. In the case of OSR, it may cause yield reductions of 40–50%, and in



Fig. 1. Symptoms of white mould in OSR (oilseed rape) include lesions in the leaf axils of the branches (A) and at the stem base (B). As a result of the infection, the OSR plant wilts and dries out (C, D) (own images)

more severe cases of infection, even up to 80% (Pope *et al.* 1989; NCIPM 2010; Sharma *et al.* 2015). According to Del Rio *et al.* (2007), a 0.5% yield reduction (equivalent to 12.75 kg/ha) was observed for each percentage increase in *Sclerotinia* stem rot incidence. The decrease in yield depends on the severity and timing of the infection (Sharma *et al.* 2015). The pathogen infection may also reduce the number of siliquae per plant and the length of the silique (Zală *et al.* 2012). According to Zală *et al.* (2012), the thousand-seed weight (hereinafter: TSW) of infected seeds was 3.94 g, while that of non-infected plants was 5.45 g. In addition to quantitative yield losses, the pathogen also affects qualitative parameters (e.g., moisture content, oil content, protein content, glucosinolate content, and

TSW. In OSR, the oil content decreased by 9.1%, while in Indian mustard, the oil content of infected seeds decreased by 34.7% (Zală *et al.* 2012; Singh *et al.* 2022). In erucic acid-free varieties, the disease caused both qualitative and quantitative changes in the fatty acid composition of OSR yield (Hu *et al.* 1999). Severe infection may increase erucic acid and glucosinolate content (Alizadeh *et al.* 2006). Additionally, infected seeds have lower moisture content and lower thousand-seed weight compared to the yield of non-infected OSR plants (Singh *et al.* 2022).

Prevention and suppression are the basic strategies for integrated control of white mold. Multiple measures can minimize the risk of infection, including strategic hybrid selection – specifically growing hybrids

with greater resistance to reduce the severity and extent of damage caused by pathogen infection (Barzman *et al.* 2015). In addition, the hyperparasitic fungus *Paraphaeosphaeria minitans* and certain mycoviruses can be used as biological control agents to reduce pathogen infection level (Yu *et al.* 2013; Pálincás *et al.* 2018). Numerous synthetic fungicide active substances are available to control this pathogen, and these are typically applied before the OSR plant becomes infected (Barzman *et al.* 2015; Pálincás *et al.* 2018).

This study aimed to evaluate the tolerance of four popular and widely grown OSR hybrids to *S. sclerotiorum* in Hungary. Additionally, we aimed to determine the yield and quality losses caused by pathogen infection, including changes in moisture content, oil content, protein content, and thousand-seed weight.

Materials and Methods

The experiment was conducted under open-field conditions near the village of Hegyfalú (47°23'N 16°88'E) in western Hungary, over three growing seasons (2020/21, 2021/22, 2022/23). The experimental plots were located in three different fields within a 3 km radius over the three growing seasons to ensure consistent conditions (soil type, previous crop, nutrient availability, etc.) across the three-year study. The agronomic and plant protection interventions were similar and adhered to the principles of OSR cultivation throughout the study period (Balodis and Gaile 2011).

During each growing season, the same four hybrids widely cultivated in Hungary [Bluestar (Syngenta), PT271 (Corteva), Umberto (KWS), and Architect (Limagrain)] were sown in 6 m wide × 250 m long (1500 m²) mesoplots. The seeding rate was 2.5 kg · ha⁻¹, with a row spacing of 15 cm in each plot. A 6 m wide border crop [Feliciano (KWS)] was sown around the experimental area, and 40 cm wide channels were made between the plots for better separation. At the beginning of each growing season, 12 sample areas (2 m² each) were randomly marked 10 m apart within each plot, and at each sampling point, eight consecutive plants were selected.

The *S. sclerotiorum* strain used was isolated in Hungary from OSR and stored in the microbial strain collection of the Institute of Plant Protection, MATE. Subsequently, the pathogen isolation process was performed using the hyphal tip technique in the laboratory of the Department of Integrated Plant Protection at MATE, following the methods of Dhingra and Sinclair (1985). From the fastest-growing five-day-old culture, 0.5 cm diameter mycelial plugs were cut out and placed on tomato agar plates (9 cm in diameter).

These plugs were incubated in the dark at 25°C for five days until active mycelial growth was observed.

Artificial inoculation was performed with the pathogen's mycelial plugs (Bhuiyan *et al.* 2021; Zamani-Noor and Jedryczka 2025) in the field at the siliqua formation stage (Biologische Bundesanstalt Bundessortenamt und Chemical Industry, BBCH 71–79). The abbreviation BBCH derives from the names of the originally participating stakeholders: „Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie“ so we need to use UND of OSR plants based on the method of Gupta *et al.* (2020). Inoculation was carried out at every second sampling point per plot (6 sampling areas × 8 plants, a total of 48 plants per plot), while the remaining previously marked but untreated 48 plants per plot served as the untreated control. For inoculation, a 1 cm² plug of agar medium fully colonized by the fungus was placed at the base of the stem, and covered with parafilm for 4 days (Fig. 2).



Fig. 2. The OSR plants are infected by *Sclerotinia sclerotiorum* (the inoculum is marked with an arrow)

The assessment of disease severity of inoculated plants and its effect on seed yield and quality parameters (moisture content, oil content, protein content, TSW) was conducted at the ripening phenological stage (BBCH 80–89).

Disease severity was assessed using a 5-grade scale:

- scale 00 – non-infected, control (hereinafter: plants of 00);
- scale 0 – no symptoms (hereinafter: plants of 0);
- scale 01 – necrotic symptoms extending up to 5 cm on the stem (plants of 01);
- scale 02 – necrotic symptoms extending up to 10 cm on the stem (plants of 02);
- scale 03 – necrotic symptoms extending at least 20 cm on the stem (plants of 03).

To determine the severity of the infection, the following formula was applied (Bán *et al.* 2017):

$$DS = \frac{\sum(f \times v)}{N \times X} \times 100,$$

where: DS – disease severity; f – infection class frequencies; v – number of plants of each class; N – total number of observed plants; X – the highest value of the evaluation scale.

The entire plant was removed from the soil during manual harvesting and placed in a paper bag. Subsequently, the harvested OSR plants were threshed individually using a Minibatt sample harvester, and the yield per plant was measured with an analytical balance at a standard moisture content of 6%. The oil, protein, and moisture contents of the seeds were measured using an INSTALAB 600 laboratory device. To determine the TSW, one thousand seeds were selected per sample using a Pfeuffer Contador seed counter, and their weight was determined.

The weather conditions in the area were similar across the three growing seasons. In the 2021/22 growing season, the average monthly temperature was lower in almost every month compared to the other two seasons. August and September received more rainfall during the 2020/21 growing season than during the other two growing seasons (Fig. 3). In Central Europe, including Hungary, the sowing period for OSR ranges from mid-August to mid-September, while the harvesting time is from late June to early July.

For comparison of data based on OSR growth and hybrid, the PAST program was utilised, employing ANOVA and Tukey pairwise comparisons. The

significance level for differences was set at a 5% threshold (Baráth *et al.* 1996). To test the effects of the different factors, we used multifactor ANOVA in SPSS. Regression analysis was conducted using Microsoft Excel to determine the relationships between infection severity and the examined parameters.

In the results section, the comment “no data” indicates that the disease severity was very low and could not be assessed.

Results

Disease severity (DS) of oilseed rape hybrids

During the 2020/21 growing season, the Architect hybrid showed significantly higher tolerance to *S. sclerotiorum*-induced disease severity (DS) than the other three OSR hybrids examined (Bluestar, PT271, and Umberto). However, during the subsequent two growing seasons (2021/22, 2022/23), there was no statistically significant difference observed in plant disease infection severity caused by *S. sclerotiorum* (Fig. 4).

The effect of *Sclerotinia sclerotiorum* infection on yield

In Table 1, in terms of disease severity, there was a significant difference between categories 00, 0, and 01, and between categories 02 and 03 ($p < 0.02$), while no significant difference was observed between categories 02 and 03. In terms of yield, only the main effect

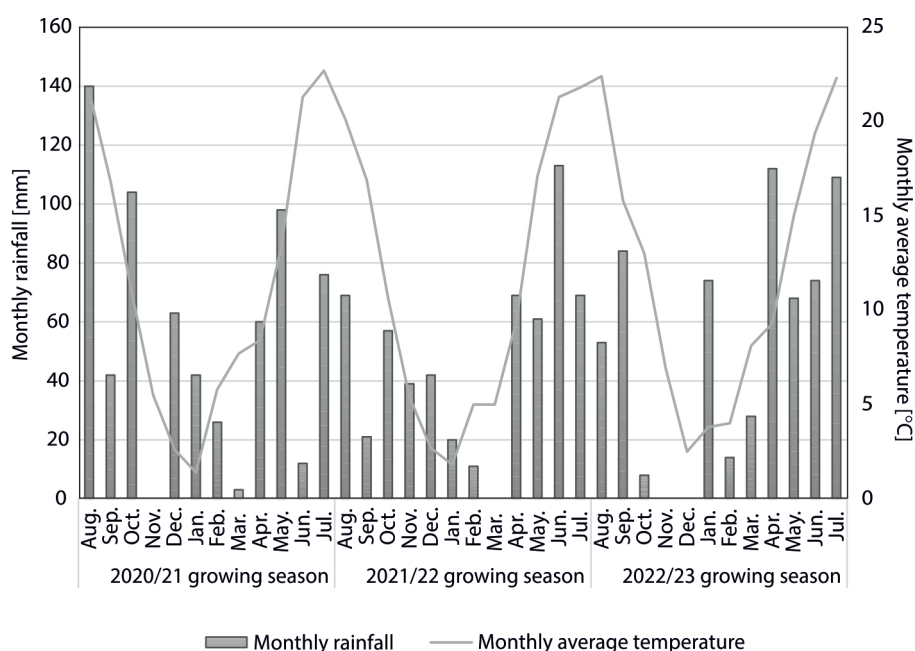


Fig. 3. Monthly rainfall data and average monthly temperature for the three growing seasons (rainfall data from our records, average monthly temperature data from (Metnet 2024))

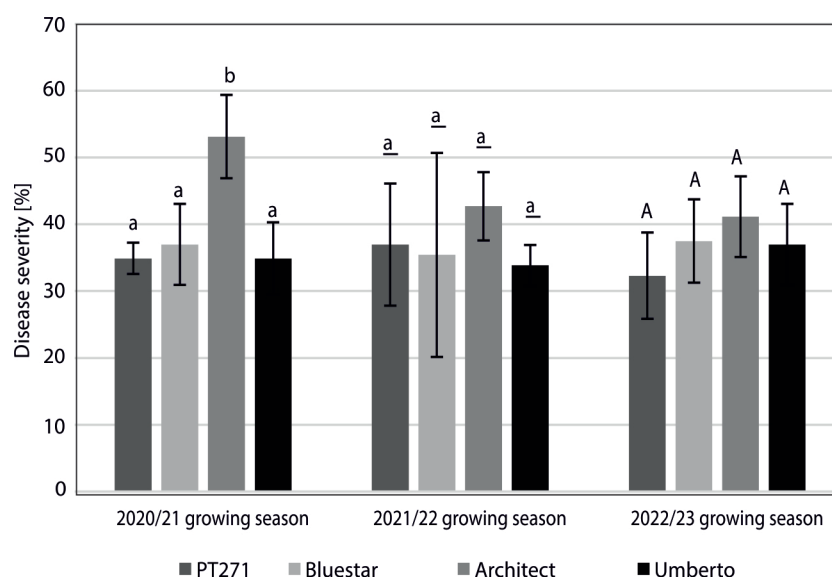


Fig. 4. The disease severity (DS) of *Sclerotinia sclerotiorum* infection between hybrids within the growing season. Bars with different letters indicate significant differences by hybrid and growing season

Table 1. Multi-factor ANOVA for yield taking into account different factors (hybrid, growing season, infection)

	Yield				
	ANOVA		Tukey Comparison		
	F	p-value	group	sign. class	avg. val. [g]
Growing season	1.315	0.25	2020/21		12.443
			2021/22		17.157
			2022/23		11.295
Hybrid	1.395	0.27	PT271		11.625
			Bluestar		12.514
			Architect		14.184
			Umberto		16.203
Infection	21.643	< 0.001	00	d	16.99
			0	c	23.971
			1	b	12.711
			2	a	7.585
			3	a	3.862
Growing season x Hybrid	1.622	0.142			
Growing season x Infection	0.658	0.791			
Hybrid x Infection	0.539	0.826			
Growing season x Hybrid x Infection	0.423	0.982			

of infection was significant ($p < 0.001$), but neither the hybrid, growing season, nor any interactions affected the yield significantly (Table 1).

Figure 5 shows that, for hybrid PT271, there were significant differences in seed yield of plants due to white mold infection during the 2021/22 growing season, with plants of disease severity 0 showing significantly higher yields than plants of categories 02 and 03. During the 2021/22 growing season, Bluestar hybrid plants with disease severity 02 had significantly lower seed yields compared to category 00 plants. During the 2021/22 growing season, Architect hybrid plants of category 0 had significantly higher seed yields compared to plants of categories 02 and 03. In addition, during the 2022/23 growing season, there was a significant difference between plants of categories 00 and 02 (Fig. 5).

The effect of *Sclerotinia sclerotiorum* infection on moisture content

For moisture content, there was a significant difference between growing seasons, with results obtained during the 2020/21 growing season having lower moisture content ($p < 0.001$). Regarding moisture content, only the main effect of growing season was significant ($p < 0.001$), but neither the hybrid, infection, nor any interactions affected the seed moisture significantly (Table 2).

There was no significant difference in moisture content between the hybrids tested in any of the years, but in almost all years, the highest values were obtained for all hybrids in the 00 or 0 categories (Fig. 6).

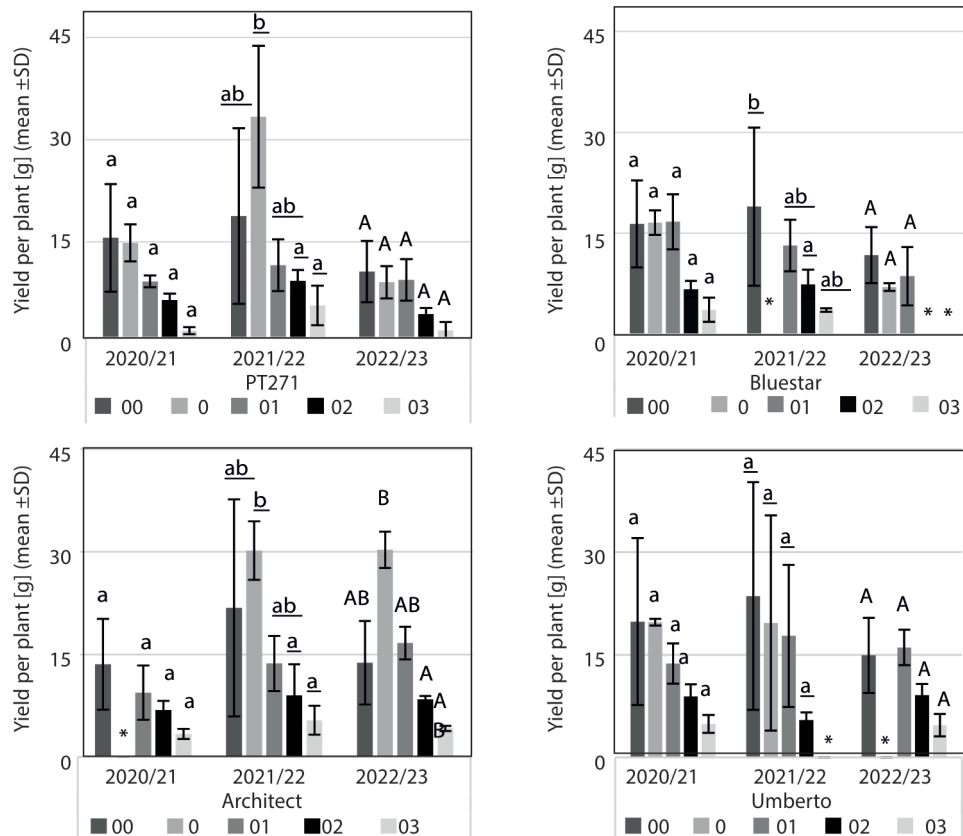


Fig. 5. The effect of *Sclerotinia sclerotiorum* infection severity on the yield between hybrids within the growing season (* no data). Bars with different letters indicate significant differences by hybrid and growing season

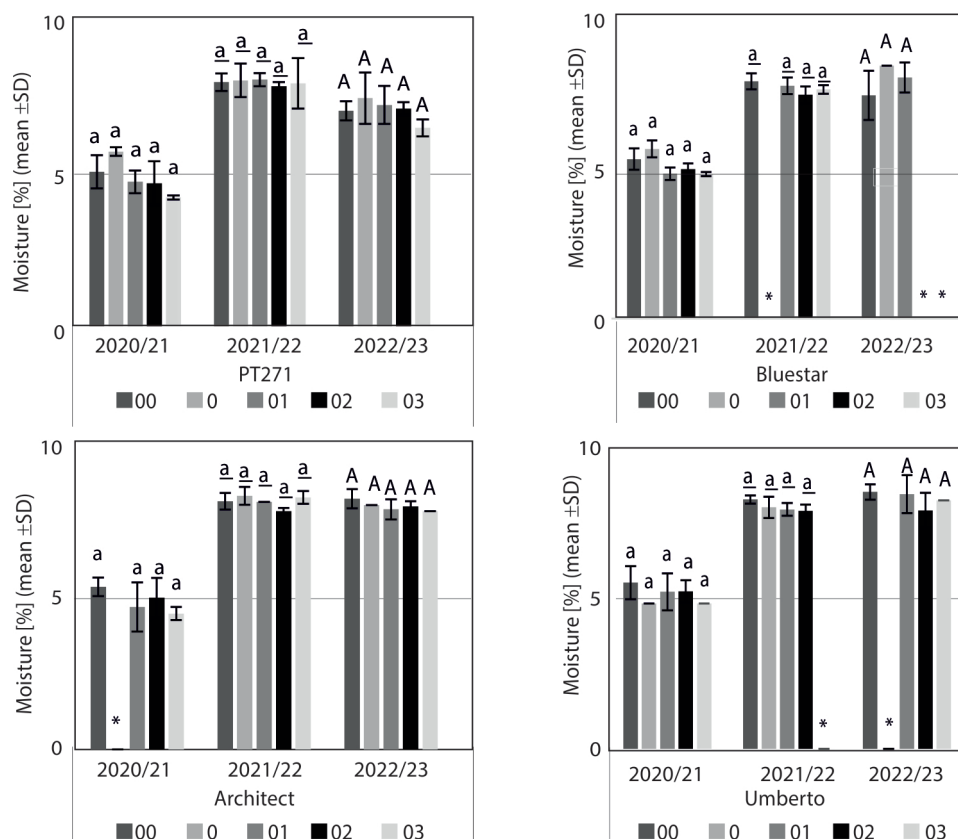


Fig. 6. The effect of *Sclerotinia sclerotiorum* infection severity on the moisture content between hybrids within the growing season (* no data). Bars with different letters indicate significant differences by hybrid and growing season

Table 2. Multi-factor ANOVA for moisture content taking into account different factors (hybrid, growing season, infection)

	Moisture content				
	ANOVA		Tukey Comparison		
	F	p-value	group	sign. class	avg. val. [%]
Growing season	156.718	<0.001	2020/21	b	5.118
			2021/22	a	8.064
			2022/23	a	7.9
Hybrid	0.027	0.994	PT271		6.904
			Bluestar		6.951
			Architect		7.114
			Umberto		7.268
Infection	0.434	0.783	00		7.198
			0		7.48
			1		7.26
			2		6.671
			3		6.716
Growing season x Hybrid	0.084	0.994			
Growing season x Infection	0.186	0.995			
Hybrid x Infection	0.157	0.987			
Growing season x Hybrid x Infection	0.106	0.746			

Table 3. Multi-factor ANOVA for protein content taking into account different factors (hybrid, growing season, infection)

	Protein content				
	ANOVA		Tukey Comparison		
	F	p-value	group	sign. class	avg. val. [%]
Growing season	22.081	<0.001	2020/21	b	19.069
			2021/22	a	18.077
			2022/23	a	18.293
Hybrid	14.917	<0.001	PT271	ab	18.419
			Bluestar	c	19.044
			Architect	b	17.994
			Umberto	a	18.487
Infection	7.986	<0.001	00	b	18.232
			0	b	17.745
			1	a	18.717
			2	a	19.074
			3	a	19.025
Growing season x Hybrid	0.676	0.669			
Growing season x Infection	1.55	0.141			
Hybrid x Infection	1.577	0.099			
Growing season x Hybrid x Infection	1.555	0.073			

The effect of *Sclerotinia sclerotiorum* infection on protein content

Regarding protein content, there were significant differences between disease severity levels, growing seasons, and hybrids. During the 2020/21 growing season, the plants showed significantly higher protein content compared to the other two growing seasons ($p < 0.001$). Significant differences were observed between Bluestar, Architect, and Umberto ($p < 0.001$) (Table 3). In terms of seed protein content, during the 2020/21 growing season, seeds from plants in category 00 of the OSR hybrid Architect had significantly lower protein content compared to the seed yield from plants of category 02. During the 2021/22 growing season, plants with disease severity level 0 had significantly lower protein content compared to plants in categories 00, 02, and 03. In the case of the Umberto hybrid, during the 2020/21 growing season, plants in category 00 had significantly lower protein content than those in categories 01 and 02 (Fig. 7).

The effect of *Sclerotinia sclerotiorum* infection on oil content

Regarding oil content, a significant difference was observed among the hybrids, with the Bluestar hybrid showing higher oil content than the Architect and Umberto hybrids ($p < 0.02$). Regarding the disease severity, plants in categories 00 and 0 had significantly higher oil content than those in category 03 ($p < 0.001$). Additionally, the two-way interactions between growing season and infection ($p = 0.003$), as well as between hybrid and infection ($p = 0.021$), had significant effects on oil content (Table 4).

In terms of oil content, among the examined hybrids, the Bluestar hybrid showed significantly higher oil content in the plants in category 00 compared to the plants of category 01 during the 2022/23 growing season. For the Architect hybrid, during both the 2020/21 and 2022/23 growing seasons, the plants in category 00 had significantly higher oil content than the category 02 plants (Fig. 8).

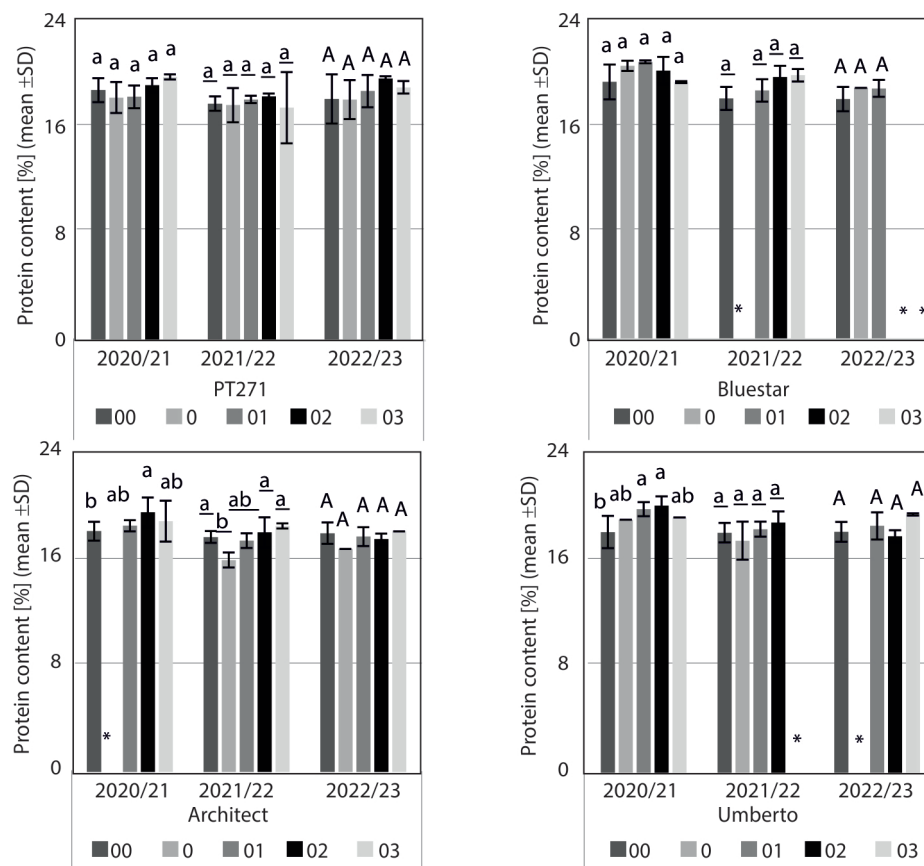


Fig. 7. The effect of *Sclerotinia sclerotiorum* infection severity on the protein content between hybrids within the growing season (* no data). Bars with different letters indicate significant differences by hybrid and growing season

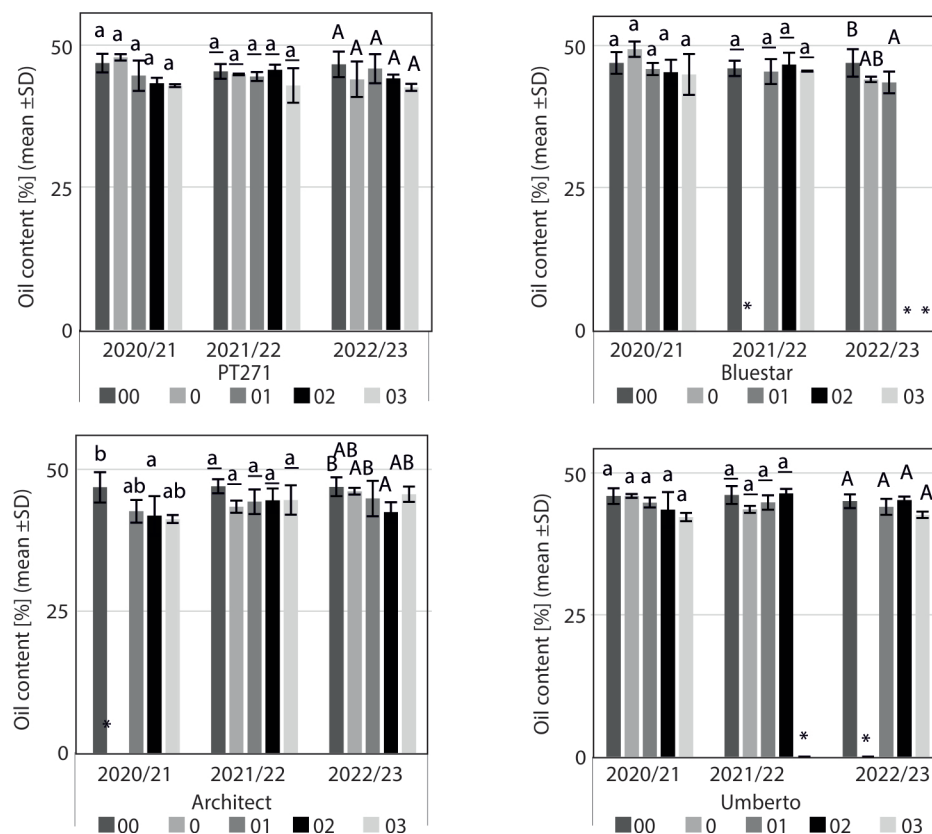


Fig. 8. The effect of *Sclerotinia sclerotiorum* infection severity on the oil content between hybrids within the growing season (* no data). Bars with different letters indicate significant differences by hybrid and growing season

Table 4. Multi-factor ANOVA for oil content taking into account different factors (hybrid, growing season, infection)

	Oil content				
	ANOVA		Tukey Comparison		
	F	p-value	group	sign. class	avg. val. [%]
Growing season	0.166	0.847	2020/21		45.573
			2021/22		45.592
			2022/23		44.931
Hybrid	2.806	0.04	PT271	ab	45.668
			Bluestar	b	46.085
			Architect	a	45.218
			Umberto	a	44.47
Infection	17.409	< 0.001	00	c	46.192
			0	bc	45.15
			1	ab	44.678
			2	ab	44.337
			3	a	43.658
Growing season x Hybrid	1.852	0.09			
Growing season x Infection	3.034	0.003			
Hybrid x Infection	2.058	0.021			
Growing season x Hybrid x Infection	0.974	0.49			

Table 5. Multi-factor ANOVA for thousand-seed weight (TSW) taking into account different factors (hybrid, growing season, infection)

	TSW				
	ANOVA		Tukey Comparison		
	F	p-value	group	sign. class	avg. val. [g]
Growing season	42.43	< 0.001	2020/21	b	3
			2021/22	a	3.697
			2022/23	a	3.999
Hybrid	0.037	0.991	PT271		3.662
			Bluestar		3.533
			Architect		3.581
			Umberto		3.545
Infection	29.266	< 0.001	00	b	3.983
			0	a	3.437
			1	a	3.312
			2	a	2.961
			3	a	2.905
Growing season x Hybrid	1.938	0.076			
Growing season x Infection	2.623	0.009			
Hybrid x Infection	0.732	0.719			
Growing season x Hybrid x Infection	0.859	0.629			

The effect of *Sclerotinia sclerotiorum* infection on TSW

Differences in TSW were also observed between growing seasons, with the values obtained during the 2020/21 growing season being significantly lower than those obtained in the other two growing seasons ($p < 0.001$). In addition, a significant difference was observed among the disease severity categories, with the 00 category plants having a significantly higher TSW compared to the other categories ($p < 0.001$). Regarding TSW, the effects of the independent variables were not significant, and among the two-way interactions, only the interaction between growing season and infection was significant ($p = 0.009$) (Table 5).

TSW results revealed that Bluestar hybrid plants in category 00 exhibited higher TSW values during the first growing season compared to those in categories 0, 02, and 03. Similarly, during the 2022/23 growing season, Bluestar hybrid plants of category 01 had lower TSW compared to plants in category 00. For the Architect hybrid, significantly higher TSW was observed for plants in category 00 than for plants of categories 01, 02, and 03 during the 2020/21 growing season. For the Umberto hybrid, during the 2020/21 growing season,

plants in category 00 had significantly higher TSW compared to plants in categories 02 and 03. During the second growing season, plants in category 00 had significantly higher TSW compared to plants in category 01 (Fig. 9).

Regression analysis between disease severity (DS) and the examined parameters

Regression analysis revealed significant correlations for the Architect and PT271 hybrids across all three growing seasons. For the Bluestar hybrid, significant correlations were found during the 2020/21 and 2021/22 growing seasons. For the Umberto hybrid, a significant correlation was observed only during the 2020/21 growing season. In each case, as the scale of infection increased, there was a significant decrease in yield (Fig. 10).

During the 2020/21 growing season, a significant correlation was found between seed oil content and the scale of infection for the PT271 hybrid. During the 2020/21 season, seed weight significantly decreased with increasing scale of infection in the Umberto hybrid, and during the 2021/22 season in the Architect

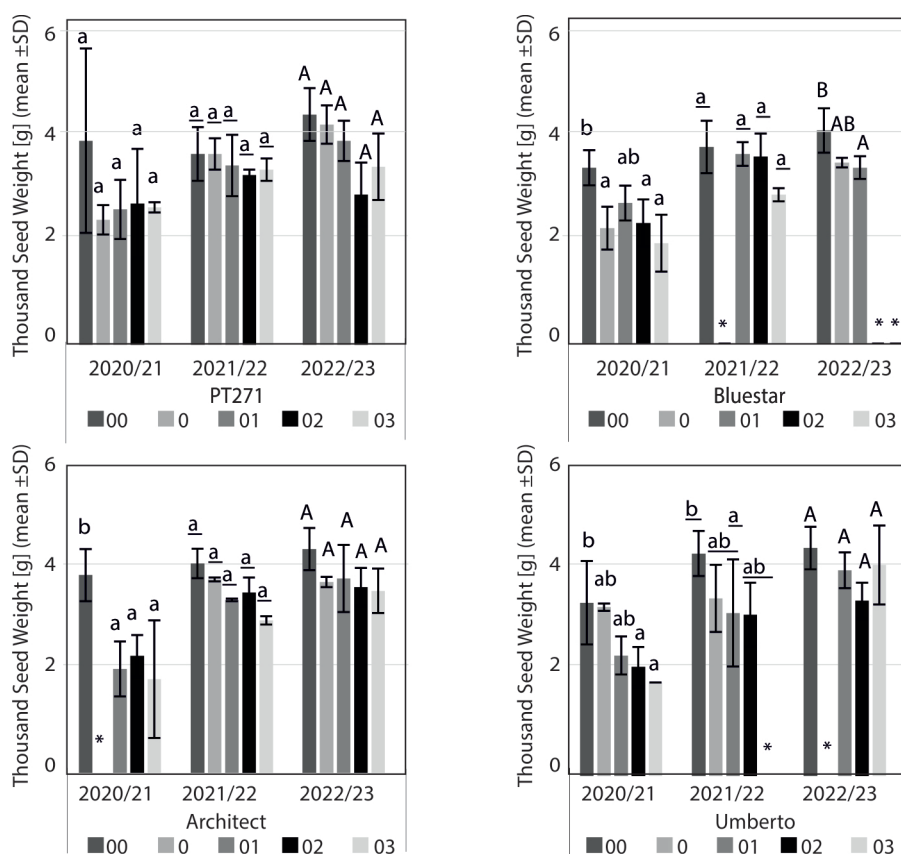


Fig. 9. The effect of *Sclerotinia sclerotiorum* infection severity on the thousand-seed weight (TSW) content between hybrids within the growing season (* no data). Bars with different letters indicate significant differences by hybrid and growing season

hybrid. A significant relationship was observed between protein content and the scale of infection during the 2021/22 growing season for the Architect hybrid (Table 6).

Discussion

This study investigated four widely grown OSR hybrids in Hungary across three growing seasons in field experiments. The objective was to assess their susceptibility to *S. sclerotiorum* and to quantify the quality

and yield losses that farmers could experience based on the severity of the infection. All four hybrids tested showed susceptibility to artificial inoculation, albeit with varying responses. However, significant differences were not consistently observed across the years (2020/21 to 2022/23 growing seasons). Architect exhibited the highest disease severity during all three growing seasons, although significant differences were only observed in the 2020/21 growing season. A previous study by Zawieja *et al.* (2023) also reported differing susceptibility among hybrids, possibly linked to their sensitivity to oxalic acid. Furthermore, the differences between the hybrids were attributed to their varying physical stem characteristics. Singh *et al.* (2023) concluded that resistant lines exhibited reduced stem lesion length, stem diameter, and stem water content, along with increased stem dry matter content, stem-specific density, stem breaking force, stem breaking strength, and lignin content.

Significant yield reduction due to pathogen infection was consistently observed across all three growing seasons. In the Bluestar and PT271 hybrids, yield losses associated with disease severity (DS) were evident during the first two growing seasons. For the Architect hybrid, this effect was consistent across all three

Table 6. The significant relationships (R-squared and p-value) between oil content, thousand-seed weight (TSW), protein content, and *Sclerotinia sclerotiorum* infection.

Crop yield parameter	Hybrid	Growing season	Infection scale	
			p-value	R-squared
Oil content	PT271	2020/21	0.02	0.4083
Thousand-seed weight (TSW)	Umberto	2020/21	0.01	0.4913
	Architect	2021/22	0.00	0.6588
Protein content	Architect	2021/22	0.00	0.7222

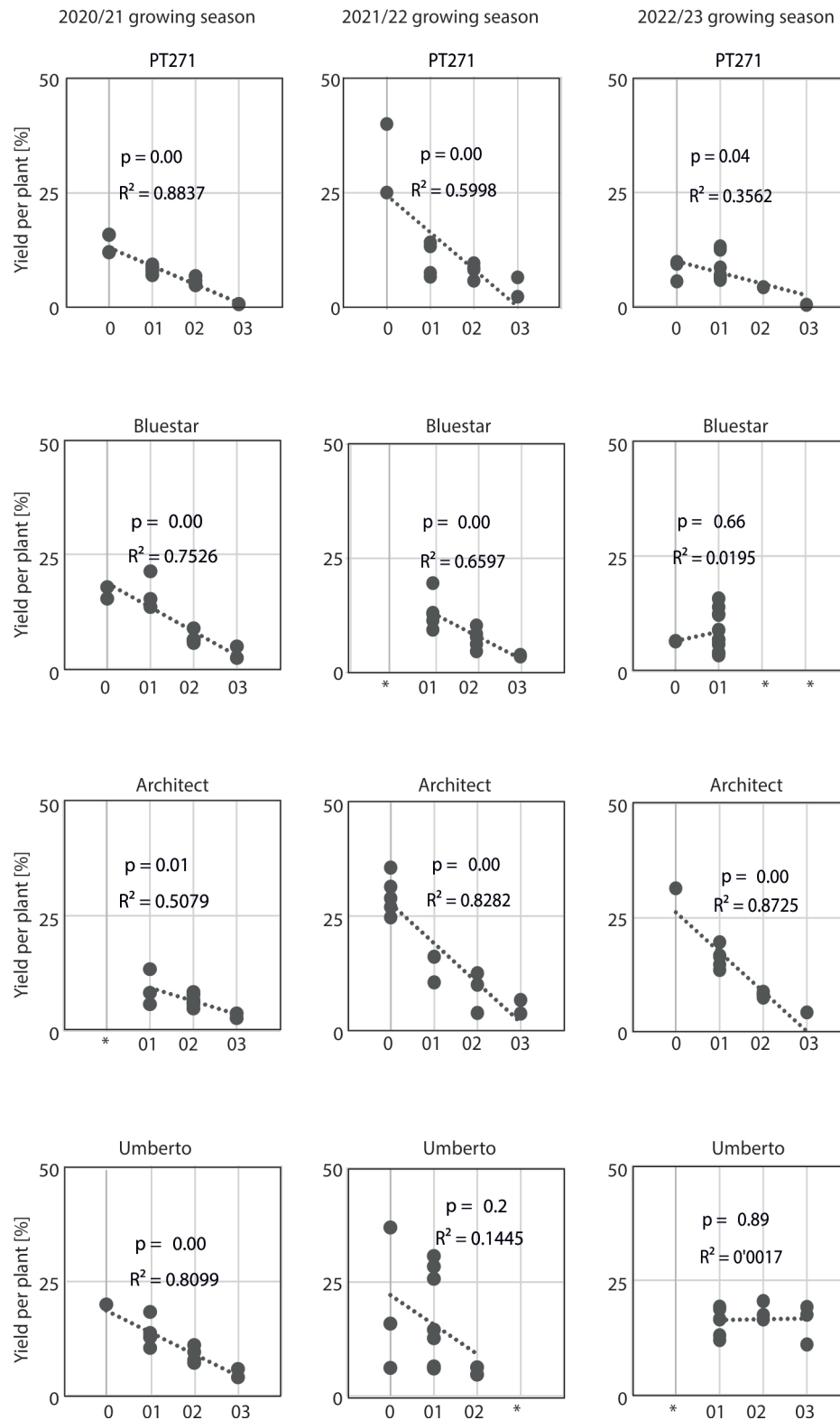


Fig. 10. Significant correlations between the severity of *Sclerotinia sclerotiorum* infection and yield for the individual OSR hybrids during the examined growing season (* no data)

seasons. In contrast, the Umberto hybrid exhibited a yield response to DS in only one growing season. These results align with the findings of Fall *et al.* (2018), who reported that increasing severity of *S. sclerotiorum* infection correlates with greater yield reductions.

Across all three growing seasons and for all hybrids studied, the severity of infection had a significant impact on yield quantity. The yield of the Architect hybrid was affected consistently in the second and third growing seasons. In contrast, for the hybrids Bluestar

and PT271, the effect of infection on yield was only observed in one growing season. This may be explained by varying growth durations among the hybrids, where some hybrids exhibited more advanced crop development. Consequently, early hybrids showed less quantitative and qualitative damage from the pathogen. Shukla (2005) also reported higher yield losses from infections occurring in earlier growth stages compared to later stages. The severity of pathogen infection consistently affects the oil content, protein content, and TSW during the 2020/21 to 2022/23 growing seasons for each of the hybrids tested. This is consistent with the findings of Rashid and Dedio (1992) and Zală *et al.* (2012), as they also reported that oil content decreased by 4–9% and 9.1% for OSR under infection. In addition, among the hybrids tested, the Architect hybrid had a consistent effect of infection on oil content in two growing seasons. In terms of protein content, Dorrell and Huang (1978) showed an increase in protein content of sunflowers as a result of pathogen infection. Similar to the results in this study, they found an increase in the protein content of OSR plants as a result of infection. In terms of protein content, only the Architect hybrid had a consistent effect of infection among the hybrids tested. In their studies, Danielson *et al.* (2004) and Zală *et al.* (2012) showed a significant decrease in TSW with increasing levels of infection. This is consistent with the present results, as the results showed that TSW decreased with infection. Among these hybrids, the Umberto and Bluestar hybrids showed a consistent decrease in TSW in two growing seasons due to infection. Regarding moisture content, the level of infection did not affect the moisture content of OSR plants. Zală *et al.* (2012) reported similar results, as they also did not find a consistent and strong relationship between infection severity and moisture content.

Moreover, these results indicate that the extent of infection by the pathogen *S. sclerotiorum* depends on the hybrids' response and the specific growing season conditions (e.g. rainfall, temperature). Therefore, considering the genetic background of the OSR hybrids, it is therefore crucial when implementing an IPM cropping system. While these hybrids do not guarantee complete control by preventing *S. sclerotiorum* infection, arising among the four OSR hybrids, the study highlights the importance of selecting OSR hybrids resistant to *S. sclerotiorum*, thereby preserving the yield and quality of OSR and contributing to integrated pest management (IPM) implementation.

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