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Hungarian University of Agriculture and Life Sciences

Analysis of interactions between biotic stressors (Turnip yellows virus and *Sclerotinia sclerotiorum* (Lib.) de Bary) and oilseed rape hybrids of different genetic backgrounds

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1. Introduction and objectives

Winter oilseed rape (*Brassica napus* L.) (hereinafter: oilseed rape) is the second most widely cultivated oilseed crop both globally and in Hungary, and a range of biotic and abiotic stressors challenge its production. Among the biotic factors, *Sclerotinia sclerotiorum* (Lib.) de Bary, the causal agent of white mold, and Turnip yellows virus (TuYV) are of particular importance, as they can induce substantial quantitative and qualitative yield losses. Infection with TuYV is not readily discernible through visual inspection, and therefore, laboratory diagnostics are required for accurate detection. TuYV infection in oilseed rape can lead to up to a 46% reduction in yield and may reduce oil content by up to 1%.

Symptoms caused by the broad-host-range pathogen *S. sclerotiorum* primarily develop at the stem base and along the stem, and less frequently on the pods. Infection may result in up to 70% yield loss, a reduction of more than 9% in oil content, and a decrease of up to 58% in thousand-seed weight, whereas glucosinolate and erucic acid content may increase.

Integrated pest management (IPM) against these pathogens relies primarily on preventive measures, including crop rotation, the use of resistant or tolerant hybrids, and vector control. A second principle of integrated pest management (IPM) is informed decision-making regarding interventions, whereby it is determined whether a given pest or pathogen requires treatment under specific conditions. For this purpose, precise knowledge of economic thresholds is essential, allowing growers to objectively evaluate the necessity of interventions relative to the expected yield loss. It is particularly important for producers to recognize whether a specific biotic stressor (*S. sclerotiorum* and/or TuYV) is causing quantitative or qualitative yield losses that exceed the economic threshold. Awareness of these factors enables growers to more effectively implement and adapt integrated pest management strategies, which in turn provides a foundation for the research objectives of the present study.

The objectives:

1. Morphological and aggressiveness characterization of *S. sclerotiorum* isolates originating from different oilseed rape growing regions in Hungary.
2. Evaluation of the tolerance levels of various oilseed rape hybrids (Architect, Bluestar, PT271, Umberto) to *S. sclerotiorum* and Turnip yellows virus (TuYV).
3. Assessment of the effects of *S. sclerotiorum* and Turnip yellows virus (TuYV) infection on key phenotypic and yield parameters of oilseed rape (plant height, pod number, branching, seed number, thousand-seed weight, oil content, protein content, and seed yield).

2. Materials and Method

2.1. Laboratóriumi kísérlet

Stems of oilseed rape infected by the pathogen *Sclerotinia sclerotiorum* were collected at full maturity (BBCH 89) from four oilseed rape–growing regions in Hungary (Vaskút, Olaszfalu, Jászapáti, Répceszentgyörgy) in 2020 (O20, V20, RSZ20, JSZ20) and 2021 (O21, V21, RSZ21, JSZ21). In the laboratory, sclerotia were extracted from the infected stems, and pure cultures were subsequently established from them. From these pure cultures, 5 mm-diameter plugs were cut and placed on 9 cm-diameter Petri dishes containing PDA (Potato Dextrose Agar) medium, which were then incubated at 20 °C (Clarkson et al., 2003), with three replicates per strain. Mycelial growth was recorded after 24 hours (Rathi et al., 2018), while the number and weight of sclerotia were determined after 240 hours.

The aggressiveness of different strains was tested on four hybrids (Architect, Bluestar, PT271, Umberto). Fungicide was removed from the seed surface, followed by surface sterilization (Nair and Chung, 2017). Seeds were germinated in the dark for the first 24 hours, and then under light conditions (2500 lux) at room temperature (23 ± 2 °C) for the next 48 hours (He et al., 2016). From strains cultured on PDA medium, 5 mm-diameter plugs were cut (Zamani-Noor and Jedryczka, 2025) and placed onto the surface of the seedlings, which were then incubated at room temperature until assessment. Aggressiveness tests were conducted with three replicates per strain, evaluating six seedlings per Petri dish on the 10th day after inoculation (Ordóñez-Valencia et al., 2015). Seedlings were rated using five infection categories: 0 – no visible symptoms; 1 – browning of the root tip; 2 – further plant wilting with mycelial growth; 3 – the mycelium completely covers the seedling; 4 – formation of resting structures (sclerotia) observed (Turóczi, 2020, personal communication).

2.2. Field experiment

Field experiments were conducted in Vas County, in the Hegyfalu region, during the 2020/21, 2021/22, and 2022/23 growing seasons, involving four oilseed rape hybrids (Architect, Bluestar, PT271, Umberto). The pathological characteristics of the hybrids differed according to the descriptions provided by the variety owners/seed companies. The experiments were established on areas of 6, 8,3, and 11,5 ha, with large plots of 24 × 200 m per hybrid. To reduce edge effects, the experimental fields were surrounded by border crops.

The incidence of turnip yellows virus (TuYV) infection was assessed in all three experimental years at the stem elongation stage (BBCH 33). Leaf samples were collected from 10 randomly selected plants in three sampling areas per hybrid, and laboratory analysis was performed using an ELISA test (D’Arcy et al., 1989). In addition, the marked plants were visually assessed for symptomatic individuals based on the characteristic anthocyanin discoloration (Ricotta et al., 2007; Congdon et al., 2020).

Artificial inoculation with the pathogen *Sclerotinia sclerotiorum* was performed at the green bud stage (BBCH 51) and at the pod formation stage (BBCH 71–79) (Zamani-Noor and Jedryczka, 2025). For each hybrid, eight plants were inoculated in six sampling areas per inoculation time point. Disease severity was evaluated in all three growing seasons at the ripening phenological phase (BBCH 80–89) using a five-point scale:

00: uninfected control plants (hereafter referred to as 00-plants);

0: asymptomatic plants (hereafter referred to as 0-plants);

01: necrotic symptoms appearing on the stem up to 5 cm in length (hereafter referred to as 01-plants);

02: necrotic symptoms appearing on the stem up to 10 cm in length (hereafter referred to as 02-plants);

03: necrotic symptoms appearing on the stem at least 20 cm in length (hereafter referred to as 03-plants).

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

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

where DS is the disease severity (%), f is the frequency of each infection category, v is the number of plants in the given category, N is the total number of plants assessed, and X is the highest value of the rating scale.

The effects of TuYV and *S. sclerotiorum* infections on the phenotypic and yield parameters of oilseed rape were assessed on the previously individually marked plants. Prior to harvest, the stem diameter, plant height, and the number of branches and pods were recorded. After harvest, the yield per plant and thousand-seed weight were determined, and the seeds were analyzed under laboratory conditions for oil, protein, and moisture content. Germination vigor was determined according to the standard method (MSZ ISO 6354-3:1996).

2.3. Data Evaluation and Statistical Analysis

Laboratory experiment data were organized in MS Excel and statistically analyzed using the PAST software with one-way ANOVA. Tukey's test was applied for multiple comparisons: for colony growth, sclerotium number, and sclerotium weight, all strains were analyzed together, while aggressiveness was analyzed separately for each hybrid. Linear relationships among the examined parameters were assessed using Pearson's correlation coefficient (r) in SPSS 28.0.

Field experiment data were also processed in Excel. The effects of growing season, infection, hybrid, and their interactions were evaluated using multifactor ANOVA (IBM SPSS Statistics 29.0), whereas percentage infection, disease severity, and other parameters were analyzed in PAST using pairwise comparisons with Tukey's test. In the TuYV and *S. sclerotiorum* experiments, the relationships between infection/severity and the examined parameters were analyzed using Pearson correlation for each growing season.

Significance of differences was assessed at the 5% level ($p<0{,}05$) in all cases (Baráth et al., 1996). "No data" indicates cases in which measurements were not available for a given infection category or the available sample was insufficient to perform the measurement. The strength of correlations was determined based on the r value.

3. Results

3.1. Laboratory experiment

3.1.1. Morphological characteristics of the examined *Sclerotinia sclerotiorum* strains and their linear relationship with infection categories

Morphological examination of *Sclerotinia sclerotiorum* strains collected over two growing seasons revealed significant differences among the strains in colony growth, as well as in sclerotium number and weight. The V20 strain exhibited the largest colony growth, whereas the RSZ21 strain showed the smallest. Significant differences were also observed in both the number and weight of sclerotia.

Aggressiveness was assessed on four hybrids (Architect, Umberto, Bluestar, PT271), which differed significantly. In tests on the PT271 hybrid, all strains displayed high aggressiveness compared to the other hybrids, with the O20 strain showing the highest and the RSZ21 strain the lowest aggressiveness.

Pearson correlation analysis indicated a significant relationship between colony size measured 24 hours after inoculation and the infection categories. Very strong positive correlations were observed for the Architect, Umberto, and PT271 hybrids, while a strong positive correlation was observed for Bluestar, indicating that higher colony growth at 24 hours after inoculation was associated with increased aggressiveness.

A very strong negative correlation between sclerotium weight and infection categories was observed for the Architect, Umberto, and PT271 hybrids, and a strong negative correlation was observed for Bluestar. Across all examined hybrids, decreased sclerotium weight corresponded to increased aggressiveness of the strains (**Figure 1**).

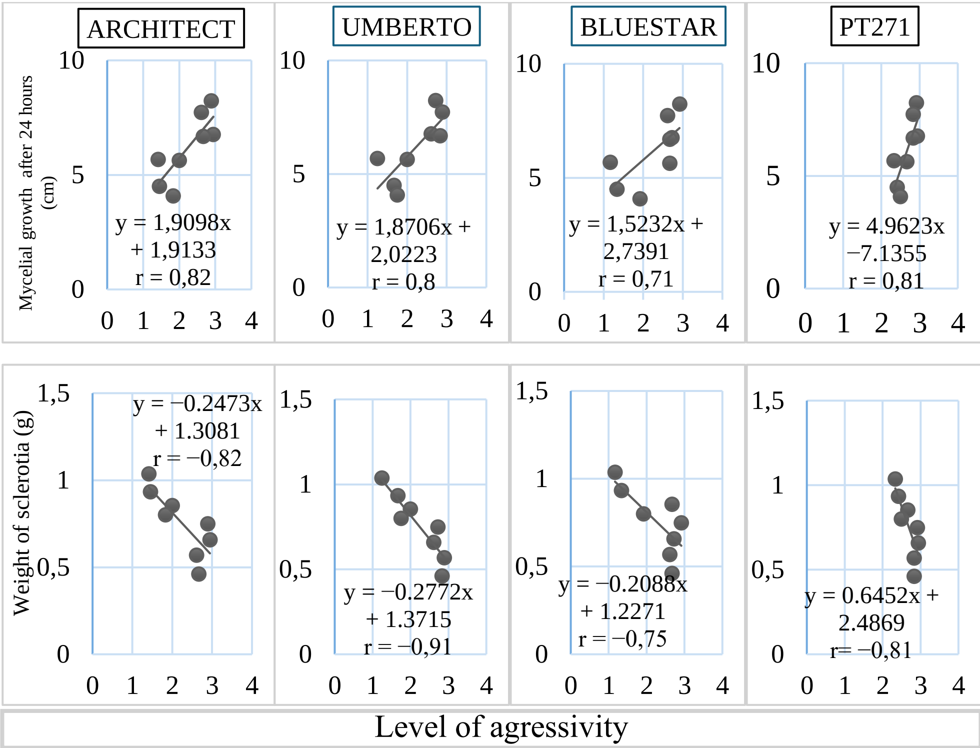

Figure *1:* Linear relationships between colony size measured 24 hours after inoculation, sclerotium weight, and infection categories of the examined *Sclerotinia sclerotiorum* strains

3.2. Field experiment

3.2.1. Incidence of Turnip Yellows Virus (TuYV) Infection

During the assessment of turnip yellows virus (TuYV) infection (confirmed by ELISA), in the 2020/21 growing season, the Bluestar hybrid exhibited significantly higher infection compared to the other three hybrids. In the 2021/22 growing season, the Umberto and Architect hybrids showed significantly lower infection than Bluestar. Based on visual assessment of symptomatic plants, TuYV infection (confirmed by ELISA) in the 2021/22 season was significantly higher in Bluestar than in PT271 and Architect. In the 2022/23 growing season, Architect and Umberto displayed significantly lower infection percentages compared to Bluestar and PT271 (**Figure 2**).

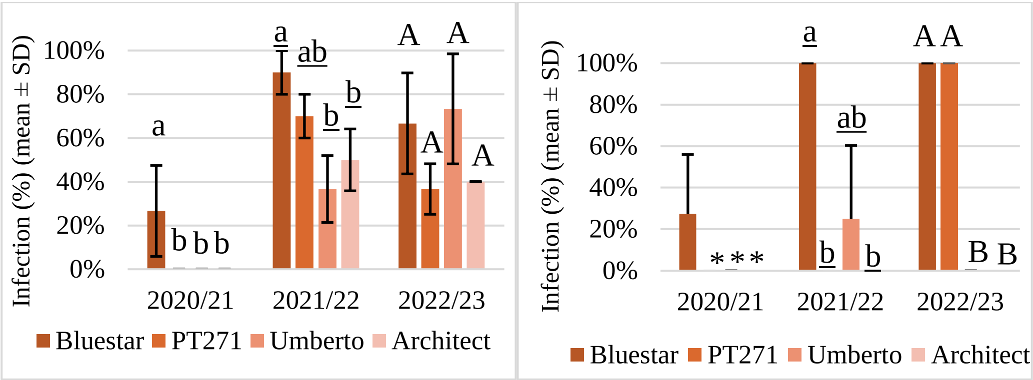

Figure 2: TuYV infection (%) (confirmed by ELISA) and the incidence of infection (confirmed by ELISA) based on visual assessment of symptomatic plants over three growing seasons in the four hybrids

3.2.2. Effect of turnip yellows virus infection on phenotypic and yield parameters of oilseed rape

Multifactor analysis of variance revealed that TuYV infection, as an independent factor, did not have a significant effect on stem base diameter, plant height, number of branches, number of pods, pod length, number of seeds, yield, moisture content, protein content, thousand-seed weight, or germination percentage. Based on the multifactor ANOVA, TuYV infection had a significant independent effect only on oil content.

When examined by growing season for individual hybrids, no significant differences were observed between TuYV-infected and non-infected plants in terms of stem base diameter, plant height, number of branches, number of pods, pod length, number of seeds, yield, moisture content, thousand-seed weight, or germination percentage. However, a significant difference between TuYV-infected and non-infected plants was detected for protein content in the 2020/21 growing season and for oil content in the 2022/23 growing season. Differences among treatments are illustrated in detail using yield as an example.

When yield was analyzed by growing season for individual hybrids, no significant differences were detected between TuYV-infected and non-infected plants. In the 2022/23 growing season, significantly higher yield was recorded for TuYV-infected plants of the PT271 hybrid compared to the Bluestar hybrid (p=0,042). For TuYV-non-infected plants, significantly higher yield was measured for the PT271 hybrid compared to the Bluestar (p=0,028) and Architect (p=0,015) hybrids in the 2022/23 growing season (**Figure 3**).

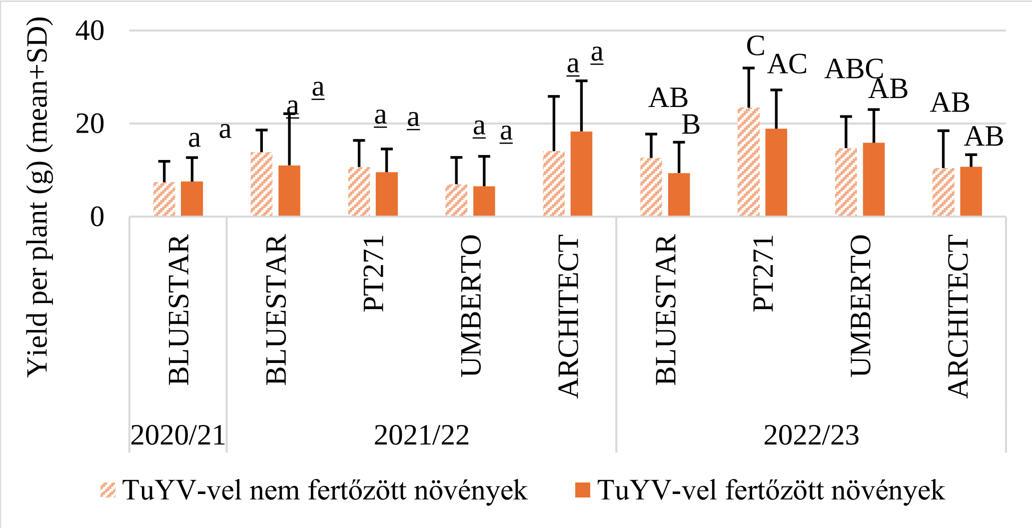

Figure 3: Yield of TuYV-infected and non-infected plants of the examined oilseed rape hybrids across three growing seasons

Based on Pearson correlation analysis, significant relationships were identified between TuYV infection and the number of branches, number of pods, pod length, number of seeds, yield, and oil content in the 2022/23 growing season. Significant correlations were also observed between TuYV infection and moisture content in the 2021/22 and 2022/23 growing seasons, as well as between TuYV infection and protein content in the 2020/21 and 2022/23 growing seasons.

3.2.3. Disease severity resulting from artificial inoculation with *Sclerotinia sclerotiorum*

In the 2020/21 growing season, when disease severity was evaluated for the four examined hybrids, artificial inoculation performed at the pod formation stage (BBCH 71–79) resulted in significantly higher disease severity in the

Architect hybrid compared to the other hybrids. When comparing disease severity resulting from artificial inoculation at the two phenological stages, inoculation at the pod formation stage caused significantly higher disease severity than inoculation at the green bud stage (BBCH 51) in the first growing season for the Architect hybrid, in the second growing season for the Bluestar hybrid, and in the third growing season for the Architect, Bluestar, and PT271 hybrids (**Figure 4**).

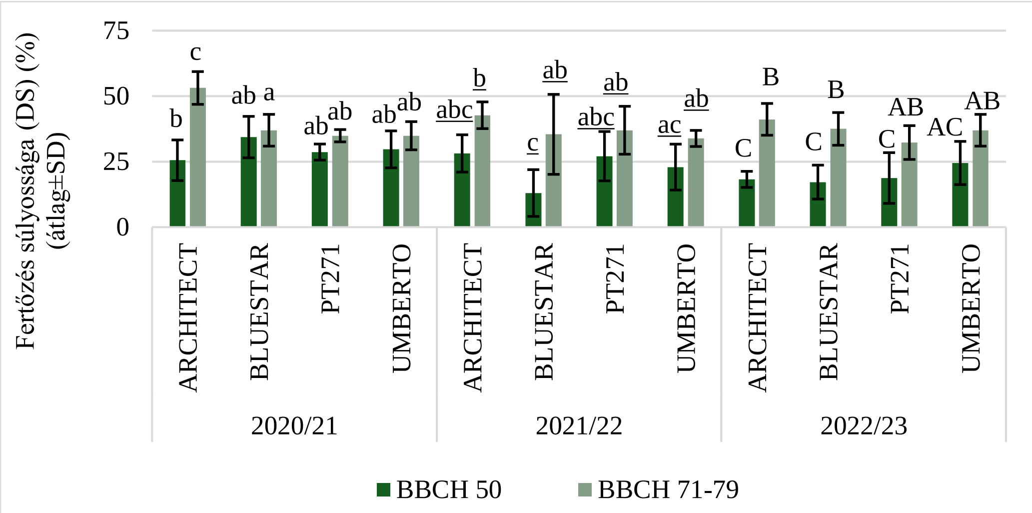

Figure 4: Disease severity resulting from artificial inoculation with S. sclerotiorum at the green bud (BBCH 51) and pod formation (BBCH 71–79) phenological stages in the examined oilseed rape hybrids across three growing seasons

Factorial analysis of variance indicated that inoculation timing and infection category, as independent factors, had significant effects on plant height, pod length, number of seeds, yield, and germination percentage. In contrast, inoculation timing had no detectable significant effect on stem base diameter, number of pods, number of branches, protein content, oil content, or thousand-seed weight; however, infection category had a significant effect on all examined parameters.

During the analyses, post hoc tests were applied for all phenotypic and yield parameters by growing season and by hybrid, based on the results of inoculations performed at both phenological stages. Differences among treatments are illustrated in detail using yield as an example.

When analyzing the effect of artificial inoculation at the green bud stage (BBCH 51), in the 2020/21 growing season, the Architect hybrid showed significantly higher yield in the 00-category plants compared to the 02- and 03-category plants, and in the 01-category plants compared to the 03-category plants. In the 2022/23 growing season, the Architect hybrid exhibited significantly higher yield in the 00-, 0-, and 01-category plants compared to the 03-category plants. For the Bluestar hybrid, in the 2020/21 season, the 00-category plants had significantly higher yield than the 01-, 02-, and 03-category plants. In addition, the 0-category plants had significantly higher yield than the 02- and 03-category plants. In the 2022/23 season, the 00-category plants of Bluestar had significantly higher yield than the 02- and 03-category plants, and the 01-category plants also showed significantly higher yield than the 03-category plants. For the PT271 hybrid, in the 2020/21 season, the 02- and 03-category plants had significantly lower yield than the 00-category plants. In the 2021/22 season, the 00-category plants, and in the 2022/23 season, the 0-category plants had significantly higher yield than the 03-category plants. For the Umberto hybrid, in the 2020/21 season, the 00-category plants had significantly higher yield than the 02- and 03-category plants, and in the 2021/22 season, higher yield than the 03-category plants. In the third growing season, the 00-category plants had significantly higher yield than the 01-, 02-, and 03-category plants, while the 03-category plants had significantly lower yield than the 0-category plants for Umberto (***Figure 5*).**

When analyzing the effect of artificial inoculation at the pod formation stage (BBCH 71–79), for the Architect hybrid in the 2022/23 season, the 0-category plants had significantly higher yield than plants in all other infection categories. Additionally, in the third growing season, the 03-category plants of Architect had significantly lower yield than the 01-category plants.

For the Bluestar hybrid, the 00-category plants had significantly higher yield than the 02- and 03-category plants. For the PT271 hybrid, in both the 2020/21 and 2022/23 seasons, the 03-category plants showed significantly lower yield than the 00-category plants. In the Umberto hybrid, in the 2022/23 season, the 00- and 0-category plants had significantly higher yield than the 03-category plants (***Figure 6***).

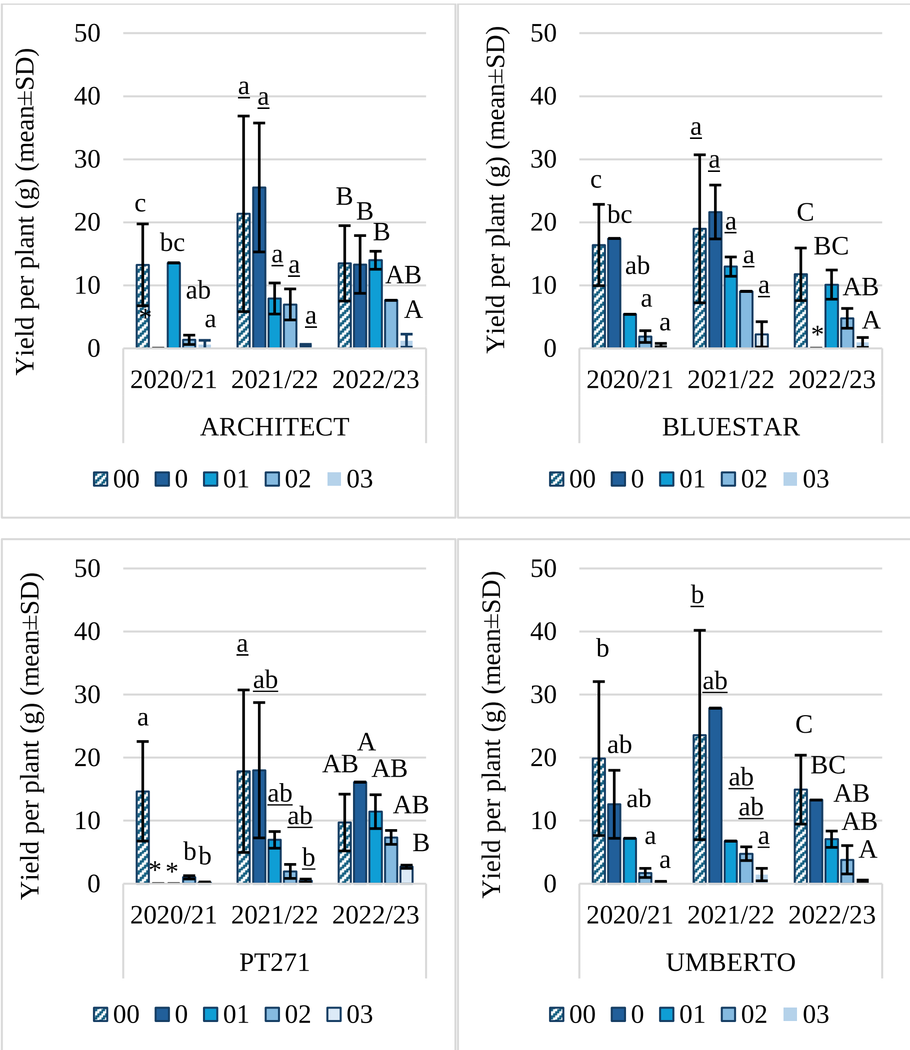

Figure 5: Yield in the examined hybrids across three growing seasons in relation to infection categories resulting from artificial inoculation with *S. sclerotiorum* at the green bud phenological stage. Bars in different colors represent the different infection categories.

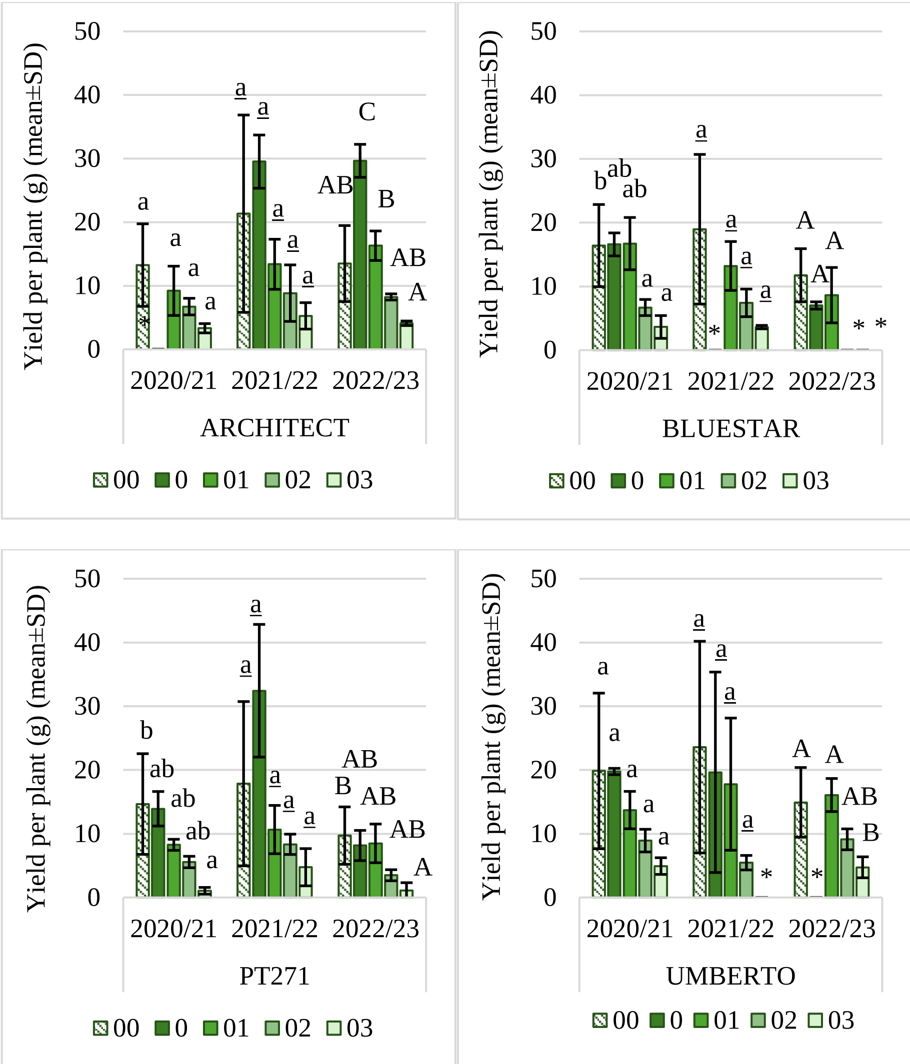

Figure 6: Yield development in the studied hybrids across three growing seasons under artificially inoculated infection categories with S. sclerotiorum at the pod formation phenological stage. Bars in different colors represent the di*fferent* infection categories.

A Based on Pearson correlation analysis, it was determined that, in all three growing seasons, the infection categories resulting from artificial inoculation at the green bud (BBCH 51) phenological stage were significantly associated with most of the measured traits. The infection category showed a significant relationship with stem diameter at the base, plant height, number of branches, number and length of pods, number of seeds, yield, oil content, thousand-seed weight, and germination percentage, whereas significant correlations with moisture content and protein content were observed in two growing seasons.

In the case of artificial inoculation at the pod formation (BBCH 71–79) phenological stage, significant correlations were observed across all three growing seasons between the infection category and the number of pods, pod length, yield, oil content, thousand-seed weight, and germination percentage. Significant relationships were detected in two growing seasons for stem diameter at the base, moisture content, and protein content, and in one growing season for the number of branches and number of seeds.

4. Conclusions and outlook

4.1. Analysis of the morphological and aggressiveness strains of the examined *Sclerotinia sclerotiorum* strains in vitro

The *Sclerotinia sclerotiorum* strains were collected from four rapeseed-growing regions in Hungary, and their morphological and aggressiveness traits were examined. The strains exhibited significant differences in colony growth measured 24 hours after inoculation, consistent with observations reported by Garg et al. (2010).

The number of sclerotia varied between strains, in agreement with previous studies (Li et al., 2008; Ghasolia & Shivpuri, 2011; Pawan et al., 2016), indicating morphological variability of the pathogen (Morrall et al., 1972). Taylor et al. (2015) also observed differences in both the number and weight of sclerotia on PDA medium. Among the three strains investigated, L6 produced many small sclerotia, L44 produced few but larger sclerotia, and L17 showed intermediate values. The strain collected from Répceszentgyörgy (RSZ21) formed the highest number of sclerotia. Similarly, Elgorban et al. (2013) reported the highest sclerotia number and mycelial growth on PDA medium. In my experiments, sclerotia weight ranged from 0.46 to 1.04 g per Petri dish, whereas Kyryk et al. (2021) reported lower values.

Consistent with the findings of Pratt and Rowe (1995) and Alavi and Dalili (2016), host susceptibility in my experiments depended on both the cultivar and the pathogen strain. Taylor et al. (2015) and Li et al. (2008) found no correlation between sclerotia characteristics and aggressiveness.

4.2. Infection by Turnip Yellows Virus

In the three growing seasons examined (2020/21, 2021/22, and 2022/23), the infection caused by turnip yellows virus (TuYV) was assessed in four oilseed rape hybrids (Architect, Bluestar, PT271, Umberto) under field conditions. The highest infection levels were observed in the 2021/22 growing season (36.7–90% depending on the hybrid, based on ELISA tests), likely due to the moderately warm weather from August to October. These temperatures (10–25 °C) favored early appearance and population buildup of aphids, which are closely associated with TuYV infection (Asare-Bediako et al., 2020). Similar results were reported by Puthanveed et al. (2023), who observed an average TuYV infection of 75%, reaching 100% in some regions. Milošević et al. (2016) detected TuYV in 70% of the examined plants in Serbia using ELISA tests.

In several cases, the presence of TuYV symptoms described in the literature (Stevens et al., 2008; Coutts et al., 2010) did not correlate with virus detection by ELISA. It was observed that infected plants often remained asymptomatic, whereas plants showing symptoms sometimes tested negative for the virus. Similar findings were reported by Nancarrow et al. (2022), who detected TuYV in peas and lentils across multiple growing seasons without visible symptoms. These results indicate that visual symptoms alone are not reliable for accurately determining the presence of the virus.

Among the hybrids examined, Bluestar was the most susceptible to TuYV, showing the highest infection levels in all growing seasons. In the Architect hybrid, which carries the "R54" resistance gene, infection was detected in two growing seasons. Environmental factors may influence this outcome, as higher temperatures can reduce the effectiveness of resistance or even render it inactive (Dreyer et al., 2001; Hackenberg et al., 2020). Since the "R54" resistance gene is currently the only one available in commercial cultivation, its incomplete effectiveness may compromise the durability of resistance.

4.3. Analysis of the effects of turnip yellows virus infection on the phenotypic and yield parameters of oilseed rape

When examining the effect of TuYV infection on various phenotypic and yield parameters, multi-factor ANOVA indicated that the infection influenced oil content; however, based on the Tukey test, no consistent effect could be detected for any parameter in any of the hybrids. These findings are not fully consistent with several previous studies. According to Jay et al. (1999) and Jones et al. (2007), TuYV infection resulted in reduced plant height, number of branches, and dry matter content of leaves, stems, and pods. Moreover, yield was reported to decrease by up to 41.5% (Jay et al., 1999), while seed weight and protein content increased (Jones et al., 2007). Oil content reduction was reported at 1.1% (Jay et al., 1999) and 3% (Jones et al., 2007).

Despite these findings, monitoring TuYV infection remains crucial, as the presence of the virus can affect certain phenotypic and yield parameters depending on the growing season and hybrid, potentially causing significant economic losses in sensitive seasons and susceptible hybrids. Accordingly, monitoring aphid populations and implementing integrated pest management strategies are key to preventing quantitative and qualitative yield reductions caused by the virus.

4.4. Analysis of the severity of infection caused by *Sclerotinia sclerotiorum*

Based on my field experiments conducted over three growing seasons, no consistent differences in infection severity were observed among the studied oilseed rape hybrids following artificial inoculation with *Sclerotinia sclerotiorum* at either the green bud (BBCH 51) or pod formation (BBCH 71–79) phenological stages. Sun et al. (2005), however, reported significant differences among cultivars when inoculation was performed at the flowering stage.

Comparing inoculation timings, in two growing seasons, artificial infection at the pod formation stage resulted in greater disease severity than inoculation at the green bud stage in the Architect and Bluestar hybrids. These results partially differ from publications suggesting that the most critical period for *S. sclerotiorum* infection in oilseed rape is flowering (Kutcher et al., 2001; Zhao et al., 2004). The development of infection is influenced by fallen petals and the favorable microclimatic conditions occurring during pod formation (Turkington & Morrall, 1993). Based on these findings, it is recommended that when assessing hybrid tolerance to *S. sclerotiorum*, artificial inoculation at the pod formation stage should be included, and inoculations should be performed across multiple phenological stages.

4.5. Effects of *Sclerotinia sclerotiorum* infection on the phenotypic and yield parameters of oilseed rape

With increasing infection severity, stem base diameter consistently decreased (8.69–27.6%). Based on inoculation at the green bud phenological stage, the PT271 hybrid exhibited reduced plant height in two growing seasons on plants showing symptoms on at least 20 cm of the stem compared to non-infected plants. This likely reflects pathogen-induced stress and reduced photosynthetic surface

(Attaran et al., 2014). These findings are consistent with other studies (Li et al., 2006; Roy et al., 2021; Khan et al., 2023), which suggest that a larger stem base diameter may be associated with increased resistance, possibly due to higher lignin content (Malinovsky et al., 2014). Cao et al. (2022) further supported this by reporting enhanced resistance linked to modifications in lignin composition.

According to multi-factor ANOVA, infection also affected plant height (7.37–16.83% reduction), which was confirmed by pairwise comparisons in several hybrids (Architect, PT271, and Umberto), consistent with observations in sunflower by Asadabadi et al. (2022). Infection reduced the number of branches (2.06–28.58%), and pairwise comparisons showed that Architect and Umberto hybrids had fewer branches on symptomatic plants in two growing seasons, again highlighting that reduced vegetative growth is associated with decreased generative traits.

Pod number decreased by 12.26–77.54% depending on infection severity. For inoculation at the green bud stage, this was consistently observed across all four hybrids, whereas for inoculation at the pod formation stage, consistent reductions were noted in the PT271 hybrid on plants showing symptoms on at least 20 cm of the stem. These results align with findings reported by Danielson et al. (2004) and Ză et al. (2012). Pod length and seeds per pod consistently decreased linearly (11.23–39.82% and 16.1–49.24%, respectively), which was detectable for most hybrids in pairwise comparisons following green bud inoculation. Previous studies also confirmed that infection reduces pod length and seed number (Danielson et al., 2004; Zală et al., 2012).

Yield showed a strong negative correlation with infection severity, decreasing by 29.8–90.62%, with inoculation at the green bud stage causing greater losses. This is consistent with findings by Del Río et al. (2007), Kirkegaard et al. (2006), and Danielson et al. (2004) for soybean. Infection increased seed protein content (2.57–4.2%) while oil content decreased linearly (4.35–4.91%). Similar results were reported by Zală et al. (2012), who observed a 9.1% reduction in oil content due to infection. Infection had no consistent effect on seed moisture.

Multi-factor ANOVA further indicated that infection reduced thousand-seed weight (13.07–33.17%) and germination percentage (8.35–23.38%), which was confirmed by Tukey tests across multiple hybrids and growing seasons. These results are consistent with Zală et al. (2012), who observed a 27.7% reduction in thousand-seed weight in infected plants compared to non-infected controls.

5. New scientific results

During laboratory analyses of the morphological and aggressiveness traits of *Sclerotinia sclerotiorum* isolates collected over two years (2020 and 2021) from various oilseed rape growing regions in Hungary (Vaskút, Olaszfalu, Jászapáti, Répceszentgyörgy), I determined the following:

1. 24 hours after inoculation, the isolates differed in colony growth, number of sclerotia, and sclerotial weight. The isolate collected from Vaskút in 2020 exhibited the highest colony growth and aggressiveness, whereas the greatest number of sclerotia was observed in the isolate from Répceszentgyörgy in 2021, and the highest sclerotial weight in the isolate from Jászapáti in 2021. Isolates with higher colony growth generally exhibited greater aggressiveness but lower sclerotial weight.

Based on my three-season (2020/21, 2021/22, and 2022/23) field experiments conducted in western Hungary on four oilseed rape hybrids (Architect, Bluestar, PT271, Umberto), I established the following:

2. Regarding susceptibility to turnip yellows virus (TuYV), the Bluestar hybrid was the most susceptible (infection levels ranging from 27% to 90%, depending on the growing season). The Architect hybrid, carrying

resistance to TuYV, exhibited the highest tolerance, although infection was still detectable (0–50%, depending on the growing season).

3. No differences were observed among the hybrids in susceptibility to *S. sclerotiorum*. Artificial inoculation at the pod formation stage (BBCH 71–79) resulted in higher infection levels (depending on the hybrid) compared to inoculation at the green bud stage (BBCH 51).
4. Infection with TuYV did not exert a detrimental effect on the evaluated phenotypic and yield parameters (stem base diameter, plant height, number of branches, number of pods, pod length, yield, seed moisture and protein content, thousand-seed weight, germination percentage).
5. Infection with *S. sclerotiorum* had a predominantly negative effect on the evaluated phenotypic and yield parameters of oilseed rape—except for seed moisture—including stem base diameter, plant height, number of branches, number of pods, pod length, seeds per pod, yield, oil content, thousand-seed weight, germination percentage, and protein content, while in some cases a positive effect on protein content was observed (depending on the hybrid).

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7. Publications from this work

Peer-reviewed papers:

Vizi R., Kiss J, Turóczi Gy., Dobra N., Pálinkás Z. (2022): Őszi káposztarepce hibridek termésének mennyiségi és minőségi változása fehérpenészes betegség hatására *Növényvédelem.* 82 (57), 12. 521-529.

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Posters and abstracts:

Vizi R., Kiss J., Turóczi Gy., Pálinkás Z. (2021): A fehérpenészes rothadás (*Sclerotinia slcerotiorum* (Lib.) de Bary) által okozott szártő fertőzés hatása az őszi káposztarepce egyes paramétereire. 67. Növényvédelmi Tudományos Napok,

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