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EVALUATION OF YIELD AND WINE QUALITATIVE PARAMETERS FROM GRAPEVINES EXPRESSING FOLIAR SYMPTOMS OF GRAPEVINE TRUNK DISEASES IN SLOVAK CLIMATIC CONDITIONS

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ABSTRACT

Grapevine trunk diseases represent a serious threat to viticulture, posing substantial challenges to the sustainability and productivity of vineyards. Fungal pathogens associated with the grapevine trunk diseases complex decompose the wood matter in grapevine trunks, leading to the disruption of vascular tissue integrity and the subsequent disruption of water and nutrient translocation within the plant. The aim of the work was to compare the yield and qualitative parameters of musts and wines from symptomatic and asymptomatic grapevines. The grape originated from the Nitra wine-growing district, from varieties Riesling Italico and Cabernet Sauvignon, aged 17 years, were used. Grapes from symptomatic and asymptomatic grapevines were processed into must and wines. The differences in yield quantity and physicochemical parameters of must and wine were analysed. Fourier transform infrared spectroscopy was used to analyse the physicochemical parameters. To test the statistical significance of the results, the Tukey's test ($p \leq 0.05$) was applied. Symptomatic grapevines of Cabernet Sauvignon exhibited significantly lower cluster weight and yield compared to asymptomatic grapevines, with a decrease of 504.71 g per bush. For Riesling Italico, no significant difference in yield was found. The must from symptomatic grapevines had significantly lower total sugar content, with Cabernet Sauvignon showing a decrease of 51.29 g/L and Riesling Italico a decrease of 23.72 g/L, along with higher acidity in Cabernet Sauvignon (+1.54 g/L). These findings confirm that grapevine trunk diseases exert a detrimental effect on both yield and must quality, with notable variability observed between grape varieties.

Keywords: grapevine trunk diseases, yield, wine quality, Cabernet Sauvignon, Riesling Italico

INTRODUCTION

Grapevine trunk diseases (GTDs) currently represent one of the greatest challenges for world viticulture **(Fontaine *et al.*, 2016)**. GTDs are caused by a complex of wood-destroying fungi that decompose the wood in grapevine trunks. The complex includes a spectrum of wood-destroying fungi belonging to the families *Botryosphaeriaceae*, *Celotheliaceae*, *Diaportaceae*, *Diatrypaceae*, *Hymenochaetaceae*, *Nectriaceae*, *Stereaceae*, *Togniniaceae*, and others **(Díaz and LaTorre, 2013; Úrbez-Torres *et al.*, 2013; Cloete *et al.*, 2014; Muntean *et al.*, 2022)**. Wood-destroying fungi co-occur with endosymbiotic fungi in grapevine wood, and fungal species richness can exceed 150 species in some locations **(Hofstetter *et al.*, 2012)**.
Foliar symptoms of GTDs are not manifested every growing season. Even asymptomatic grapevines can be heavily infected by wood-destroying fungi. The appearance of symptoms of GTDs is related to the course of meteorological elements during the growing season. Water stress of the grapevine is considered to be the initiating factor for the manifestation of symptoms **(Calvo-Garrido *et al.*, 2021)**. Other factors that influence the prevalence of GTDs include the vineyard's varietal composition, grapevine rootstock, and grapevine cultivation practice. The tools used during grapevine pruning can also be a vector of disease transmission **(Agustí-Brisach *et al.*, 2015)**. Varieties with a high incidence of GTDs symptoms include Sauvignon blanc, Rebo, Cabernet Sauvignon, Primitivo, Pinotage, and others **(Murolo and Romanazzi, 2014)**.
Symptomatic grapevines have lower photosynthetic intensity, disrupting the grape ripening process **(Petit *et al.*, 2007, Magnin-Robert *et al.*, 2011)**. On grape berries, GTDs appear as black, purple, or brown dots, also referred to as "black measles" **(Essakhi *et al.*, 2008)**. When grapevines are infected, the production quality of both wine and table grape varieties is significantly reduced **(Rolshausen and Kiyomoto, 2007; Bruno and Sparapano, 2007; Cloete *et al.*, 2014)**. There is insufficient sugar formation in the berries, and acid metabolism is reduced. Berry skins contain lower concentrations of catechin, epicatechin, and anthocyanins **(Lorrain *et al.*, 2012)**.
Protection against the spread of grapevine trunk diseases is complicated. The problem is the considerably wide range of pathogens involved in the wood decomposition process of grapevine trunks. Among the preventive measures, emphasis is placed on correct grapevine pruning technique to minimise the occurrence of large cutting wounds. Pruning should be carried out during periods without atmospheric precipitation **(Wunderlich *et al.*, 2017)**. Research shows that *Trichoderma harzianum* can be effective in suppressing infection caused by some wood-destroying fungi **(John *et al.*, 2005)**. *Trichoderma* improves plant vigour by increasing their resistance to biotic stressors **(Pozo *et al.*, 2002)**.
The aim of the present study was to compare the quantitative parameters of grapes and the qualitative parameters of grape must and wine from symptomatic and asymptomatic grapevines of the Cabernet Sauvignon and Riesling Italico wine grape varieties in the climatic conditions of Slovakia.

Figure 1 Chronic form of Grapevine trunk diseases on the red wine variety Cabernet Sauvignon..

MATERIAL AND METHODS

Experimental localities

The wine-growing village of Nitra is located in western Slovakia, in the Nitra wine-growing district, which is part of the Nitra wine-growing region. The geographical coordinates of the vineyard are 48.301220° N, 18.100772° E **(Geoportál, 2024)**. The training system in the vineyard is Rhine-Hessian. The grapevines are planted on rootstock SO4. The year of planting of the vineyard is 2007. The annual sum of temperatures above 10 °C is above 3000 °C. The average temperature for the growing season is 16–17 °C. Fluvisol is the predominant soil type at the site.

Experimental varieties

The CS plantation was damaged in 15% of the bushes, while the RI plantation was damaged in 5% of the bushes. We only used the chronic form, and the apoplectic form was not included in the experiment.
Riesling Italico (RI) is a white wine variety that probably originated in France. It is one of the most cultivated varieties in Slovak vineyards and covers an area of 1620.5 ha **(Meravá, 2021)**. It grows moderately vigorously with good maturation of grapevine shoots. The variety is resistant to winter and spring frosts. It produces regular and reliable yields. The coefficient of fertility is 0.6-1.1. RI is highly productive, with a yield per hectare normally exceeding 10 tons **(Pospíšilová *et al.*, 2005)**.
Cabernet Sauvignon (CS) is a French red wine variety with a cosmopolitan distribution. It is one of the most widespread varieties in Slovak vineyards. Its cultivated area in Slovakia covers an area of 639.2 ha **(Meravá, 2021)**. The size of the clusters and berries is small. Hectare yields average between 6 and 9 tons, with a fertility coefficient of 1.6. CS wines are valued for their specific varietal bouquet **(Pospíšilová *et al.*, 2005)**. It is a sensitive variety to attack by GTDs **(Sosnowski *et al.*, 2007)**.

Sample preparation

As part of the experimental procedure, grape samples of RI and CS wine varieties were harvested from symptomatic and asymptomatic grapevines on September 20, 2024. Grapes were harvested at 15 kg from each variant in 3 replications (Table 1) into plastic crates. Grapes were crushed and destemmed using a destemmer. The resulting grape mash was pressed on a hydro press, obtaining approximately 10 litres of must in each variant in 3 repetitions.
Samples of 50 mL were taken from the musts of each variant and used to determine basic physicochemical parameters. After sampling, static desilting was carried out. For this purpose, Seporit (Erbslöh, Germany) was used at a dose of 100 g/hL. After 12 hours of static desilting, the musts were decanted into 10 L bottles.
After desilting and decanting into clean bottles, a pure culture of the wine yeast Oenoferm PinoType (Erbslöh, Germany) was added to the must at a dose of 30 g/hL. Fermentation was carried out at a controlled temperature of 20 °C. After 21 days of fermentation, 50 mL wine samples were taken and used to determine the physicochemical parameters of the wine. This methodological procedure was applied to all the variants in order to evaluate the effect of GTDs on the qualitative parameters of the must and the wine.

Table 1 Identification of experimental variants.

Variant designation	Variant characteristics
CS ASYM	Grapes from grapevines without foliar symptoms of GTDs. In variant was used red wine variety Cabernet Sauvignon.
CS GTDS	Grapes from grapevines showing symptoms of chronic form of GTDs. In variant was used red wine variety Cabernet Sauvignon.
RI ASYM	Grapes from grapevines without foliar symptoms of GTDs. In variant was used white wine variety Riesling Italico.
RI GTDS	Grapes from grapevines showing symptoms of chronic form of GTDs. In variant was used white wine variety Riesling Italico.

Laboratory methods

Average berry weight (g): The average weight of the 30 grape berries from different grape clusters from each experimental variant and repetition. It was measured using laboratory scales EMB 6000-1 (Kern, Germany).
Average cluster weight (g): The average weight of the 30 grape clusters, randomly selected from the crate from each experimental variant and repetition. It was measured using laboratory scales EMB 6000-1 (Kern, Germany).
Average grape yield per grapevine (g): The average grape yield per 10 grapevines from each experimental variant and repetition. It was measured using laboratory scales EMB 6000-1 (Kern, Germany).
Average yield per hectare (t): The average yield per hectare was measured by multiplying the average yield per grapevine and the number of grapevines in the area of 1 ha (5000 pcs).
Estimated yield (EUR): The estimated yield was calculated by multiplying the average yield per hectare and grape realisation price in Slovakia (0.80 EUR/kg).
The physicochemical parameters of musts and wines: Total sugars, fructose and glucose, , sugar free extract, total soluble solids (TSS), malic acid, lactic acid, tartaric acid, pH value, and total acids were measured using the Fourier Infrared Spectroscopy (FT-IR) ALPHA Bruker Optik GMBH analyser (Bruker Optik, Darmstadt, Germany).

Data analysis

For obtained data analyses, the statistical program XLSTAT v.2021.4.1 (Addinsoft, France) was used. The distribution of data was tested by the Shapiro-Wilk test. To test statistical significance of data, ANOVA-Tukey test was used ($p \leq 0.05$).

RESULTS AND DISCUSSION

Average berry and cluster weight

Berry weight in all evaluated variants was higher in the RI variety compared to the CS variety, which is in contradiction with the ampelographic characteristics presented by **Pospíšilová *et al.* (2005)**. For both varieties, no statistically significant differences in berry weight were found between grapes from asymptomatic and symptomatic grapevines. Grape clusters from asymptomatic grapevines had a higher average berry weight. In the case of the CS variety, the chronic form of GTDs led to a 6.25 % reduction in berry weight compared to asymptomatic grapevines. For the variety RI, this difference was higher, with the chronic form of GTDs causing a 10.00 % decrease in berry weight compared to asymptomatic grapevines. A comparison of berry weights is shown in Table 2. The hypothesis that the chronic form of GTDs syndrome significantly reduces berry weight was not supported.

Table 2 Comparison of berry weights between asymptomatic and symptomatic grapevines.

Variant	Mean +- SD (g)	Min (g)	Max (g)	CV (%)
CS ASYM	1.26±0.25a	0.74	1.80	19.48
CS GTDS	1.16±0.82a	0.63	1.74	24.01
RI ASYM	1.32±0.27a	0.71	2.11	20.29
RI GTDS	1.20±0.20a	0.72	1.56	17.04

Legend: RI – Riesling Italico, CS – Cabernet Sauvignon, ASYM – asymptomatic grapevines, GTDS – symptomatic grapevines, min – minimum, max – maximum, cv – coefficient of variation. a, b means rows with different letter are statistically different (Tukey test, $p < 0.05$).

The cluster weight was higher in the RI variety compared to the CS variety, which is contrary to the data presented by **Pospíšilová *et al.* (2005)**. In the CS variety, a statistically significant lower weight of grape clusters was measured between grapevines with and without foliar symptoms of GTDs. The cluster weight was 18.20 % lower in grapes from symptomatic grapevines of the CS variety compared to grapes from asymptomatic grapevines. This difference in cluster weight was statistically significant, indicating that the presence of GTDs symptoms has a significant negative effect on the cluster size of this variety. In the case of the variety RI, there were not statistically demonstrable differences in cluster weight between symptomatic and asymptomatic grapevines. The average cluster weight from symptomatic grapevines was 10.52 % lower compared to grapes from asymptomatic grapevines. Based on the results, the negative effect of the chronic form of GTDs on cluster weight was confirmed to be variety-specific.

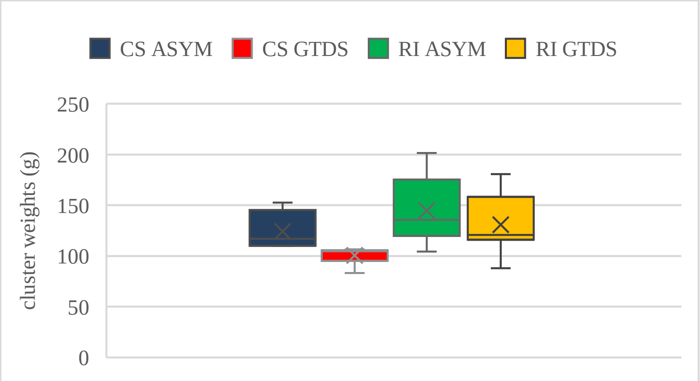

Figure 2 Comparison of cluster weights between asymptomatic and symptomatic grapevines. **Legend:** RI – Riesling Italico, CS – Cabernet Sauvignon, ASYM – asymptomatic grapevines, GTDS – symptomatic grapevines.

Average grape yield

Comparison of grape yields between asymptomatic and symptomatic grapevines provides information on the effect of GTDs on grape production. For both varieties, a decrease in grape yield was observed in symptomatic grapevines. Statistically significant differences in grape yield were found only in the CS variety (Table 3). Symptomatic grapevines of the CS variety had an average yield of 2773.24 g. Grape yield from symptomatic grapevines was significantly lower compared to asymptomatic grapevines. In the RI variety, the differences in yield between symptomatic and asymptomatic grapevines were not statistically significant. Asymptomatic grapevines of the RI variety achieved a yield of 2700.38 g. Symptomatic grapevines of this variety had a yield of 2683.27 g. The reduction in yield is related to the disruption of nutrient and water transport to the above-ground organs of the grapevine. This disruption leads to a reduction in the intensity of photosynthesis. RI showed better ability to compensate for the negative effects of the chronic form of GTDs than the CS variety. We hypothesize that a possible cause of differences between grape varieties is the different defence mechanisms during infection by fungi from the GTDs complex. These differences are the result of genetic variability in grapevine varieties.

Table 3 Comparison of grape yields per grapevine between asymptomatic and symptomatic grapevines.

Variant	Mean ± SD (g)	Min (g)	Max (g)	CV (%)
CS ASYM	2773.24±71.69a	2731.85	2856.03	18.20
CS GTDS	2268.53±58.64b	2234.67	2336	2.59
RI ASYM	2700.38±547.69a	2314.61	3327.25	20.28
RI GTDS	2683.27±92.55a	2617.82	2748.71	3.45

Legend: RI – Riesling Italico, CS – Cabernet Sauvignon, ASYM – asymptomatic grapevines, GTDS – symptomatic grapevines, min – minimum, max – maximum, cv – coefficient of variation. a, b means rows with different letter are statistically different (Tukey test, $p < 0.05$).

In the CS variety, there was a statistically significant difference in hectare yields between asymptomatic and symptomatic grapevines (Figure 3). Hectare yields of the CS variety were 13.87 t for asymptomatic grapevines and 11.34 t for symptomatic grapevines. After taking into account the grape market price of €0.8 per kilogram, this difference in estimated yields represents 2 024 EUR. In the case of RI variety, no statistically significant differences in hectare yields were observed between asymptomatic and symptomatic grapevines. Grape yields of both variants were similar, indicating that the chronic form of GTDs had no demonstrable effect on the yield of the RI variety. The difference in hectare yields between symptomatic and asymptomatic grapevines of the RI variety was 0.08 t. The hectare yields confirm that the manifestations of the chronic form of GTDs are variety specific. These results underscore the importance of selecting grape varieties with higher tolerance to GTDs, especially in vineyards with the previous occurrence of wood-destroying fungi.

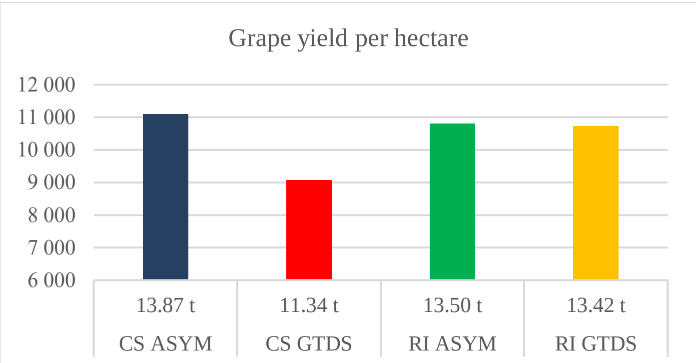

Figure 3 Comparison of grape yields (t) and estimated yields (EUR) per hectare between asymptomatic and symptomatic grapevines, in conversion at a price of 0.80 EUR per kilogram of grapes.
Legend: RI – Riesling Italico, CS – Cabernet Sauvignon, ASYM – asymptomatic grapevines, -GTDS – symptomatic grapevines.

The decrease in photosynthetic intensity of symptomatic grapevines is one of the factors for the insufficient sugar content of grapes. **Dewasme *et al.* (2024)** found that the quality of CS grapes produced from symptomatic grapevines was similar to grapes from asymptomatic grapevines. The authors report that yield losses rarely exceed 1 hL/ha. We found statistically significant differences in all quality parameters of must from symptomatic grapevines compared to asymptomatic grapevines for the CS variety. We also found a statistically significant decrease in hectare yield between asymptomatic and symptomatic grapevines of the CS variety. One factor causing our results to differ from those of **Dewasme *et al.* (2024)** may be the density of grapevines planted in the vineyard. The authors observed vineyards with a number of grapevines per hectare ranging from 6 667 to 10 000. In our experimental vineyard, there were 5 000 grapevines per hectare. A lower number of grapevines in vineyards is associated with a higher crop load on the grapevines. High crop load may act as a stress factor for the grapevines. Symptomatic grapevines with a lower crop load may be less vulnerable to a decrease in the quantity and quality of the grape production. **Murolo & Romanazzi (2014)** found that grapevine rootstock can influence the occurrence of the chronic form of GTDs. Grapevines grafted on SO4 rootstock had a higher incidence of symptomatic grapevines compared to 1103P rootstock. This is a result of water stress in the grapevines caused by the low drought tolerance of the SO_4 rootstock. The grapes used in our experiment came from grapevines grafted on the SO4 rootstock. SO_4 rootstock could have led to an increase in plant water stress and may have been one of the factors behind the statistically significant differences in the observed quantitative and qualitative parameters of grapes and must between asymptomatic and symptomatic grapevines.

Physicochemical parameters of musts and wines

The must from symptomatic grapevines of both grape varieties had statistically significantly lower content of total sugars compared to the asymptomatic variant (Table 4). The CS variety had 51.29 g/L lower sugar content in symptomatic grapevines compared to asymptomatic grapevines. In the RI variety, the total sugar content was 23.72 g/L lower in symptomatic grapevines compared to asymptomatic grapevines. The lower sugar content was also confirmed by lower fructose, glucose, and total soluble solids. Fructose and glucose are the main monosaccharides metabolized by yeasts during alcoholic fermentation. Lower sugar content may limit the fermentation process and alcohol production. This decrease may be mainly due to a weakening of plant function, leading to reduced photosynthetic activity and reduced transport of sugars into the grape berries (**Ďurčanská *et al.*, 2019**). In the case of the CS variety, the content of total acids in the must from symptomatic grapevines was demonstrably higher compared with the asymptomatic variant. The differences in total acid content between musts from asymptomatic and symptomatic grapevines of the RI variety were not statistically significant. The must produced from symptomatic grapevines had a statistically significantly higher malic acid content, which is the result of limited acid metabolism in the grape berries.

Calzarano *et al.* (2001) compared grape and must quality parameters between healthy grapevines, symptomatic grapevines, and grapevines that were not showing foliar symptoms of GTDs at the time of the study but were symptomatic in the past. Grapes from symptomatic grapevines had statistically significantly lower reducing sugar content compared to the other variants, resulting in lower alcohol content in wine from symptomatic grapevines. The statistically significantly lower content of reducing sugars in grapes from symptomatic grapevines of our experimental grape varieties confirms the findings of **Calzarano *et al.* (2001)**. **Girardello *et al.* (2023)** analyzed the sugar and acid content in must from grapes of both symptomatic and asymptomatic grapevines. He observed a 10% reduction in sugar content in the must from symptomatic grapevines, along with an increase in acidity. **Calzarano *et al.* (2004)** investigated the effect of GTDs on qualitative changes in must and wine. The authors of the study found a significant reduction in must sugar content and a significantly higher malic acid content. In our study, an analogous decrease in sugars and higher malic acid content was found in the must from grapes of symptomatic grapevines. Based on our results, we confirmed the hypothesis of the influence of varietal variability on the acid content in musts from grapevines with symptoms of the chronic form of GTDs.

Table 4 Comparison of grape must qualitative parameters between asymptomatic and symptomatic grapevines.

Variant	Fructose (g/L)	Glucose (g/L)	TSS (°Bx)	Total sugars (g/L)	Malic acid (g/L)	pH value	Total acids (g/L)
CS ASYM	112.33±0.64a	105.74±0.29a	21.40±0.02a	214.65±0.10a	3.15±0.08a	3.23±0.00a	5.66±0.05a
CS GTDS	91.67±1.33b	85.20±0.47b	17.96±0.11b	163.36±0.50b	3.90±0.06b	3.16±0.00b	7.20±0.08b
RI ASYM	106.38±2.13a	98.65±2.30a	20.75±0.10a	201.60±1.50a	2.04±0.05a	3.15±0.01a	5.16±0.04a
RI GTDS	86.12±0.31b	75.83±0.18b	16.68±0.03b	177.88±0.10b	2.21±0.03b	3.13±0.01a	5.20±0.09a

Legend: RI – Riesling Italico, CS – Cabernet Sauvignon, ASYM – asymptomatic grapevines, GTDS – symptomatic grapevines, TSS – total soluble solids. a, b means rows with different letter are statistically different (Tukey test, $p < 0.05$).

Girardello *et al.* (2020) research shows that grapes from infected vines had a lower ethanol content compared to grapes from healthy vines, which was attributed to a lower content of total soluble sugars in the infected grapes due to delayed ripening at harvest. The fermentation efficiency is directly influenced by the sugar levels, as yeasts primarily metabolize fructose and glucose during alcoholic fermentation **(Girardello *et al.*, 2019; Alabi *et al.*, 2016; Lecourieux *et al.*, 2013)**. The diminished sugar content in symptomatic grapevines can be attributed to impaired plant functions, which lead to reduced photosynthetic activity and consequently lower sugar transport into the grape berries **(Salo *et al.*, 2024)**.
Comparison of the acid profile of the wines showed significant differences in the concentration of organic acids, which affect the quality and sensory characteristics of the wine (Table 5). The pH value was not statistically different between the variants. Wines from symptomatic grapevines had higher malic and tartaric acid content compared to asymptomatic grapevines. The higher malic acid content is a consequence of the disturbed metabolism of the plant. The increased tartaric acid content of grapes from symptomatic grapevines affects the acidity structure of the wine and may contribute to the higher perceived acidity. In wines from symptomatic grapevines, the total acid content was statistically significantly higher in the CS variety by 1.32 g/L compared to asymptomatic grapevines. The sugar-free extract, which includes all solids such as organic acids, minerals, and aromatic compounds, was lower in wines from symptomatic grapevines of the RI variety. A lower sugar-free extract may have a negative effect on the sensory characteristics of the wine. In the case of the RI variety, the content of total acids was similar between the variants. Total acid content was also higher in wines from symptomatic grapevines, suggesting that GTDs affect plant metabolism. Despite the higher acid concentrations in the grapes, wine pH was not statistically different between healthy and symptomatic grapevines. These findings suggest that GTDs affect acid metabolism, which may influence the flavour profile of wine. The study indicates that the CS variety's must from symptomatic grapevines had a significantly higher total acid content compared to its asymptomatic counterparts. This observation aligns with findings from other studies that have documented increased acidity in grapevines affected by infections, which can disrupt normal metabolic processes **(Girardello *et al.*, 2019; Salo *et al*., 2024)**. Specifically, the symptomatic grapevines exhibited elevated malic acid levels, a result of limited acid metabolism within the berries. This phenomenon has been previously reported, where infections led to alterations in organic acid profiles, thereby affecting the overall quality of the grape must **(Petrişor and Chireceanu, 2019)**.

Table 5 Comparison of wine acid content and pH value between asymptomatic and symptomatic grapevines.

Variant	Lactic acid (g/L)	Malic acid (g/L)	Tartaric acid (g/L)	pH	Total acids (g/L)	Sugar free extract (g/L)
CS ASYM	0.06±0.02a	2.40±0.10a	4.09±0.01a	3.18±0.02a	5.92±0.10a	25.50±1.70a
CS GTDS	0.00±0.00b	2.70±0.08b	4.65±0.01b	3.03±0.02b	7.24±0.10b	28.20±0.50a
RI ASYM	0.00±0.00a	2.10±0.30a	3.41±0.03a	2.94±0.01a	6.02±0.20a	33.5±4.00a
RI GTDS	0.00±0.00a	2.20±0.20a	3.25±0.02b	2.97±0.03a	5.89±0.20a	24.00±1.20b

Legend: RI – Riesling Italico, CS – Cabernet Sauvignon, ASYM – asymptomatic grapevines, GTDS – symptomatic grapevines. a, b means rows with different letter are statistically different (Tukey test, $p < 0.05$).

Lorrain *et al.* (2012) report that chemical and sensory differences between wines may also be related to delayed ripening of fruit from grapevines affected by grapevine trunk diseases. They consider physiological changes in symptomatic grapevines to be the cause of the deterioration of wine quality parameters. Disrupted xylem vessels lead to a deficient supply of water and nutrients and the subsequent decline in overall grapevine health. Deficient water and nutrient intake affects the formation of sugars and reduces acid metabolism in grape berries. Based on our results, we confirmed the negative effect of the chronic form of GTDs on the must and wine quality parameters. We assume that the reason for the deteriorated grape and wine parameters is the lower intensity of photosynthesis **(Petit *et al.*, 2007)**. Reduced photosynthetic activity not only impacts sugar accumulation but also hinders the development of aromatic compounds, ultimately leading to wines with less complexity and character.

CONCLUSION

Based on the findings of this study, it is evident that grapevine trunk diseases (GTDs) represent a significant threat to both grapevine yield and the quality of musts and wines. Symptomatic Cabernet Sauvignon grapevines showed a substantial reduction in cluster weight and yield compared to asymptomatic vines, with a decrease of 504.71 g per vine. The must from these symptomatic grapevines also displayed a notable decrease in total sugar content by 51.29 g/L, along with a significant increase in acidity (+1.54 g/L). Riesling Italico exhibited a reduction in sugar content of 23.72 g/L No significant difference in yield was observed between symptomatic and asymptomatic vines. These findings underline the detrimental impact of GTDs on both the quantity and quality of grape production. The results further emphasize the importance of maintaining healthy grapevines, as the chronic effects of GTDs lead to considerable variability in both yield and quality parameters across different grapevine conditions. Symptomatic vines suffer from reduced photosynthetic activity, which results in lower sugar accumulation and diminished wine quality. This study highlights the need for effective management strategies to control and prevent the spread of these diseases. Implementing improved pathogen management techniques, such as the use of resistant grapevine varieties and better vineyard practices, is crucial. Additionally, focusing on the selection of varieties that show greater resistance to GTDs can help ensure the long-term sustainability of vineyards and the production of high-quality wines.

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