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The Influence of Climatic Conditions on Downy Mildew and Powdery Mildew in Târnave Vineyard

Maria COMȘA[1]*, Liliana Lucia TOMOIAGĂ[1], Vlad BOTEA[1], Maria Doinița MUNTEAN[1], Alexandra Doina SÎRBU[1], Horia Silviu RĂCOARE[1], Veronica Sanda CHEDEA[1], Anamaria CĂLUGĂR[2]

[1]*Research Station for Viticulture and Enology Blaj (SCDVV Blaj), 515400 Blaj, Romania*

[2]*University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Romania, 3-5 Mănăștur St., 400372, Cluj-Napoca, Romania*

Corresponding author M. Comșa, e-mail: comsa_m@yahoo.com

RESEARCH ARTICLE

Abstract

The main diseases that affect the vineyards in the Târnave vineyard are: grapevine downy mildew caused by *Plasmopara viticola* and grapevine powdery mildew caused by *Uncinula necator*. The present study aimed to address the relationship between grapevine cultivars and the main diseases, downy mildew and powdery mildew, according to climatic variability and treatments applied. The analysis was carried out over two consecutive years 2021 and 2022 on five new cultivars, the creation of SCDVV Blaj: Selena, Blasius, Rubin, Radames and Brumăriu. Disease attack was determined during the vegetation period, until harvest. Cultivar susceptibility varied, some cultivars were relatively tolerant and no cultivar was highly resistant to both diseases. In addition, a difference between foliar and grape berry susceptibility to the two diseases was observed for several cultivars. This data provide a basis for developing low-treatment disease management strategies for specific grapevine cultivars based on downy mildew and powdery mildew susceptibility/tolerance.

Keywords: climatic conditions, downy mildew, powdery mildew, grapevines, cultivars, Târnave vineyards

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INTRODUCTION

The vineyards from the wine-growing Târnave (Romania) benefit from a specific, climate, due to the geographical location between the Târnave and Mureș rivers (Răcoare et al.; 2022, Călugăr et al., 2018). In viticulture, the climatic conditions represent the most important factor in modulation, growth and development of grapevine in all viticultural regions (Gülbasar et al., 2022). The research strategies carried out over time at the Research Station for Viticulture and Enology Blaj (SCDVV Blaj) included the development of new grapevine cultivars, some of them with high tolerance to diseases and pests, able to capitalize on the existing climatic and pedological conditions in the Târnave vineyards (www.scvblaj.ro). The main diseases that affect the grapevines from Târnave vineyards are: grapevine downy mildew caused by *Plasmopara viticola* and grapevine powdery mildew caused by *Uncinula necator* (Tomoiagă, 2013; Mihai-Oroian et al., 2010). In favorable weather conditions and the lack of phytosanitary measures, downy mildew and powdery mildew can cause significant production losses and the deterioration of grape quality. The climate is the most important determinant in the start, development, and evolution of these diseases. Pathogens do not develop on grapevines if the climatic conditions are unfavorable (Colonnec et al., 2004; Chakraborty et al., 2000). *Plasmopara viticola* (Berc. & Curtis) Berl. & De Toni, responsible for downy mildew is a fungus from the Oomycetes class, which overwinters as oospores on plant debris at ground level (Rodrighuez et al., 2020). The disease develops on all the green organs of the vine, causing direct losses to the inflorescences and grapes and indirectly by decreasing the activity of photosynthesis due to the attack on the leaves. In the case of severe attacks, it can cause the weakening of the vine through the premature fall of the leaves and the drying of the shoots. The fungus *Uncinula necator* [syn. *Erysiphe necator* (Schwein) Burr.] is an obligate parasite of the Erysiphaceae family and is responsible for the production of powdery mildew on grapevines. Powdery mildew, like downy mildew, attacks all the green organs of the grapevine, with negative consequences for the production and quality of grapes and must (Gadoury et al., 2003). The presence of the pathogen as surface mycelial structures created by conidiophores and conidia of fungus on the infected host organ causes the disease's symptoms (Marimuthu et al., 2019). Climate monitoring is essential for effective grapevine disease control. Worldwide, an average of 35% of all pesticides produced are used in viticulture (Essling et al., 2021). The cultivation of genotypes resistant to cryptogamic grapevine diseases can help reduce the application of plant protection products. Therefore, the negative effects of these products on the environment and human health is reduced as well as the reduction of vineyard production costs (Salotti et al., 2022). Some studies have shown that resistant grapevine cultivars can reduce fungicide application by 100% (Wingerter et al., 2021), while other studies indicate that resistant cultivars still require biocide application to protect against certain oomycetes and pathogens (Zendler et al., 2021; L Delmas et al., 2016). Our study provides insight into the resilience of these cultivars under field conditions that we believe are more nuanced and more useful than the ones provided by laboratory studies. Information on resistance/tolerance patterns could support both strategic and tactical grapevine disease management decisions (Rossi and Caffi 2012; Pertot et al., 2019). There is an urgent need to find suitable alternatives for disease management in organic viticulture systems (Carisse et al., 2009; Yildimir and Dardeniz 2010; Lu H et al., 2020). Among these, it is of great importance to develop resistant cultivars with a high degree of resistance/tolerance to the respective pathogens in order to produce high quality grapes and wines correlated with the parameters for higher food safety standards (Pap D et al., 2016; Riaz et al 2020; Lukšić et al., 2022).

MATERIALS AND METHODS

The study was carried out during 2021-2022, on vine cultivars created at SCDVV Blaj: Selena, Blasius, Rubin, Radames and Brumăriu. The experimental plots are located within the premises of the unit, at the following coordinates 46º 17' 27.85" N /23º 93' 38.33" E. The planting year is 2012, the planting distance of 2x1 m giving a density of 5000 vines/ha. The cultivation system was classic low and in 2022 it was transformed into demi-high Guyot system with periodic replacement arms. The soil maintenance system was a cultivated field alternated with grass system (*Phacelia tanacetifolia* and *Trifolium repens*). All experimental groups received the same phytosanitary treatment. In 2021, 7 treatments for powdery mildew and 8 treatments for downy mildew were applied, and in 2022, 6 treatments for powdery mildew and 7 for downy mildew were carried out. The assessment of the severity of downy and powdery mildew symptoms was carried out in several series of observations assessing the frequency (F) and the visual intensity (I) of the attack on leaves (3*20) and grapes (3*20), based on which the degree of attack (AD) was calculated. Climatic data were recorded with a weather station Adcon telemetry GmbH . The collected data were processed (as daily mean temperatures, daily mean humidity and the sum of daily precipitations) and correlated with the development phases of the grapevine and the pathogens *Plasmopara viticola* and *Uncinula necator*.

Statistical Analysis

The experimental data were statistically analyzed with Statview 5.0, performing one-way analysis of variance (ANOVA), followed by a Fisher protected least-significant difference (PSLD) test. p-values lower than 0.05 were considered significant, while p-values between 0.05 and 0.1 were considered tendencies.

RESULTS AND DISCUSSIONS

Climatic conditions

The climatic conditions from the growing season of 2021 in Târnave Vineyard were favorable for the development of *Plasmopara viticola* and *Uncinula necator*, including also critical periods for disease management. The average annual temperature was 11.5 ºC, and the total amount of precipitation was 788 mm, of which 459 mm was in the growing season. The absolute minimum temperature was -13.1 °C, and the absolute maximum temperature was recorded in August with a value of 34.6 °C. Spring -March, April and May- Figure 1, started with lower temperatures than the multiannual monthly means, by up to 2.3 degrees. These climatic events had negative consequences on the vines by delaying the budding phenophase. Over the summer - the months of June, July and August - the means of monthly temperatures were slightly higher than the multiannual monthly means. In September, an average monthly temperature of 15 °C was recorded, lower than the multiannual monthly means (by 0.5 °C). Regarding the rainfall regime, the year 2021 was rich in precipitation. Larger amounts of precipitation than the multiannual means were recorded in most months: January, March, April, May, July, August and September Figure 1, the rainiest month being July with a quantity of 133 l/m². They negatively influenced the health of the vineyards, by favoring the cryptogamic diseases: downy and powdery mildew. During the growing season of 2021, an average monthly temperature of 18.4°C and an average monthly humidity of 73.5% were recorded.

Between January and September 2022, the monthly mean temperatures were slightly higher than the multiannual mean, and the rainfall regime (478.2 mm) was lower than the multiannual one, which caused a sharp deficit of precipitation until August. The absolute minimum temperature was -18.56 °C, recorded in January, and the absolute maximum was recorded in July with a value of 37.4 °C. In the spring of 2022, in March and April, monthly mean temperatures were lower than the corresponding multiannual means, Figure 1. The months of May, June, July and August recorded monthly mean temperatures higher than the multiannual mean values Figure 1. The rainfall regime in 2022 was quite low, the amount of precipitation during the vegetation period was 380.6 mm. An exception was recorded in September, when an amount of precipitation more than triple (174.6 mm) was recorded compared to the multiannual amount related to this month (52.9 mm) Figure 1. The average monthly temperature during the growing season was 19.2 °C, higher than in 2021 (18.4 °C), and the average monthly humidity was 69.3%, lower than in 2021 (73.5%). In these climatic conditions, the studied cultivars had a good state of health, the climatic conditions being unfavorable for the development of downy mildew and powdery mildew.

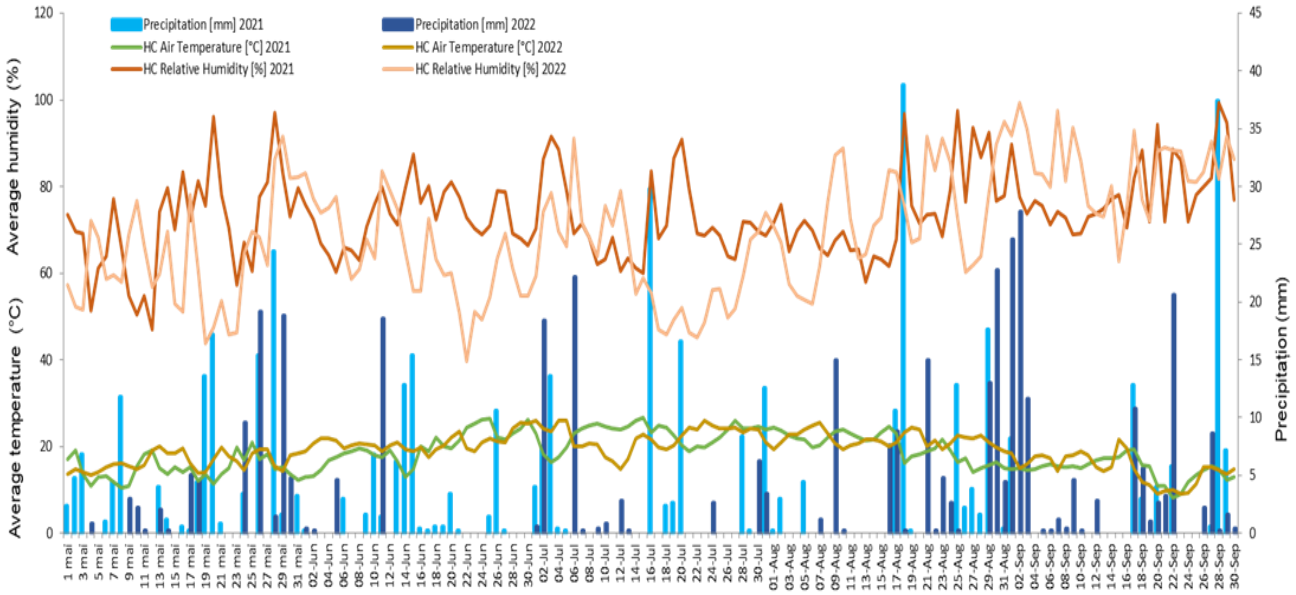

Figure 1. Climatic conditions (air temperature, precipitations and air humidity during the vegetation period of the study years 2021-2022

Diseases evaluation

In the climatic conditions of 2021, downy mildew was present on all the studied cultivars, both on the leaves and on the grapes. The first symptoms of the primary downy mildew infection were noticed on the leaves on June 02, 2021, and the secondary infections continued to manifest themselves until the end of the growing season. The highest AD in downy mildew was recorded for the Blasius cultivars, both by intensity (I) and by the number of organs attacked (F) (AD leaves 4.9% and grapes 1.1%), the statistical differences being significantly higher compared to the other cultivars. In second place is the Selena cultivar with an AD for leaves of 3%, and for grapes of 0.6%. No statistical differences were found between Rubin and Radames cultivars, leaves AD being 1.6% for Rubin and 1.4% for Rdames, and on grapes the AD was 0.5% in both cultivars Table 1. The lowest AD, with the lowest I and F, was recorded on the Brumăriu cultivar, (AD 0.7% for leaves 0.1% for grapes) this cultivar having the highest tolerance to downy mildew. For all analyzed cultivars the frequency of the downy mildew on the leaves was higher than the intensity Table 1. On grapes, the frequency was higher in the case of Selena and Blasius cultivars, and on the case of Rubin, Radames and Brumăriu cultivars, the intensity of the attack was higher. In 2022, there were no statistical differences between the cultivars, downy mildew was not observed on grapes, and on the leaves it was reported only at the end of the vegetation period. In terms of AD in powdery mildew in 2021, the Selena cultivar was the most affected, both in terms of intensity and frequency of attacked organs (leaves AD of 4.1% and grapes AD of 0.9%), resulting in significant statistical differences compared to the other cultivars Table 1. The next sensitive cultivar was Blasius with a leaves AD of 1.3% and grapes AD of 0.3%. Between the cultivars Rubin, Radames and Brumăriu there are no statistical differences regarding powdery mildew AD in 2021 Table 1. In 2022 powdery mildew was detected only on the grapes of the Selena cultivar (AD-0.02%) without any attack on the leaves Table 1.

Table 1. Powdery mildew and downy mildew evaluation scale for 2021 and 2022

Powdery mildew leaves												
	2021									**2022**		
Cultivars	**F%**			**I%**			**AD%**			**F%**	**I%**	**AD%**
Selena	22.367	±0.664	b	13.2	±0.520	a	3.000	±0.361	b	1.000	1.000	0.010
Blasius	33.400	±2.194	a	14.700	±0.635	a	4.900	±0.153	a	1.000	2.000	0.020
Rubin	14.233	±0.549	c	10.867	±0.722	b	1.600	±0.058	c	0.000	0.000	0.000
Radames	13.767	±0.549	c	10.333	±0.731	b	1.400	±0.058	c	0.000	0.000	0.000
Brumăriu	12.233	±0.433	c	5.767	±0.318	c	0.700	±0.058	d	0.000	0.000	0.000
grapes												
Selena	12.033	±1.517	b	5.000	±0.265	c	0.600	±0.058	b	0.000	0.000	0.000
Blasius	15.533	±0.578	a	7.333	±0.219	b	1.100	±0.058	a	0.000	0.000	0.000
Rubin	6.800	±0.416	c	7.600	±0.208	ab	0.500	±0.058	b	0.000	0.000	0.000
Radames	6.600	±0.361	c	8.233	±0.285	a	0.500	±0.058	b	0.000	0.000	0.000
Brumăriu	2.967	±0.120	d	4.200	±0.153	d	0.097	±0.009	c	0.000	0.000	0.000

Downy Mildew leaves												
Cultivars	**2021**									**2022**		
	F%			**I%**			**AD%**			**F%**	**I%**	**AD%**
Selena	22.4	±0.666	a	18.333	±0.384	a	4.100	0.058	a	0.000	0.000	0.000
Blasius	13.6	±0.115	b	9.800	±0.321	b	1.300	0.058	b	0.000	0.000	0.000
Rubin	2.5	±0.503	c	0.933	±0.120	c	0.02	0	c	0.000	0.000	0.000
Radames	1.9	±0.100	c	0.700	±0.115	c	0.01	0	c	0.000	0.000	0.000
Brumăriu	0.5	±0.153	d	0.500	±0.155	c	0.01	0.001	c	0.000	0.000	0.000
grapes												
Selena	8.8	±0.265	a	10.200	±0.115	a	0.9	±0.058	a	1.000	2.000	0.020
Blasius	4.2	±0.058	b	4.200	±0.100	b	0.3	0	b	0.000	0.000	0.000
Rubin	1.4	±0.153	c	0.800	±0.153	c	0.01	0	c	0.000	0.000	0.000
Radames	1.233	±0.153	c	0.600	±0.153	c	0.01	0	c	0.000	0.000	0.000
Brumăriu	0	0.000	d	0	0	d	0.01	0	c	0.000	0.000	0.000

Note: The variants with different letters are statistically different ($p < 0.05$), and the differences between the variants with the same letter are statistically insignificant.

In the other cultivars, powdery mildew was not present. The climatic conditions in the growing season of 2021 were characterized by high cloudiness, abundant precipitation, high humidity and modest temperatures. These favored the growth of downy mildew and powdery mildew AD thus resulting in a greater degree of differentiation between cultivars. The year 2022, characterized by slightly higher average monthly temperatures, lower atmospheric humidity and reduced precipitation, prevented the development of both diseases.

the cultivars analyzed, Selena and Blasius show moderate sensitivity to downy mildew and powdery mildew, Selena being more sensitive to powdery mildew, and Blasius more sensitive to downy mildew. The cultivars Rubin and Radames have a low tolerance to downy mildew and a higher tolerance to powdery mildew. The Brumăriu cultivar shows high tolerance to both diseases.

The high tolerance to one or both diseases offer the possibility of developing differentiated treatment programs, adapted to the cultivars. A program created specifically for Brumăriu, Rubin and Radames cultivars could considerably reduce the number of treatments, even in the context of favorable climatic conditions for the development of downy and powdery mildew. If the manifestation of downy mildew is clearly conditioned by humidity and temperature, regarding powdery mildew there are many contradictions in the specialized literature regarding the effects of humidity on the development of the fungus, although it is considered a xerophilic fungus (Essling et al., 2021, Marçais et al., 2014). However, in the present study both downy and powdery mildew were favored by the climate of 2021 with modest temperatures, high cloudiness and rich in precipitation. Powdery mildew is favored by wet weather, but rainfall is not necessary for the development of the disease; the optimal conditions are temperatures between 20 and 30°C and relative humidity higher than 45% (Zendler et al., 2021).

Figure 2. Downy mildew symptoms: a - on reverse leaves, b - on front leaves, c - inflorescences, d - grape berries

Figure 3. Powdery mildew symptoms: a - primary infection on front and back leaves, b- secondary infections on front, c, d - symptoms on grapes.

CONCLUSIONS

The influence of the climatic conditions from Târnave wine-growing region on the development of downy mildew and powdery mildew in the case of Selena, Blasius, Rubin, Radames and Brumăriu cultivars was analyzed during two consecutive growing seasons. Downy mildew and powdery mildew behaved according to the climatic specifics of the year and the genetics of the cultivar: Radames, Rubin and Brumăriu are cultivars with increased biological resistance, being considered ennobled hybrids.

In 2021 the climatic conditions were favorable for both diseases and they were present on all studied cultivars. In 2022, the climatic conditions were not favorable for the development of downy mildew and powdery mildew.

Regarding the tolerance of cultivars to downy mildew and powdery mildew, the Brumăriu cultivar stands out with high tolerance to both diseases, followed by Radames and Rubin. The cultivars Selena and Blasius show moderate sensitivity to both diseases. Blasius is more sensitive to downy mildew, and Selena is more sensitive to powdery mildew.

The results of the study may have practical applications in the development of grapevine disease management strategies. The use of tolerant cultivars can reduce the number of phytosanitary treatments. These cultivars can also be used as a source of germplasm in the development and obtaining of resistant grapevine cultivars.

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Conflicts of Interest

The authors declare that they do not have any conflict of interest.

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