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The behaviour of some plum cultivars to brown rot fruit infection in northern Transylvania

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ABSTRACT

The plum tree (*Prunus domestica* L.) is the dominant fruit tree species in Romania, according to the FAOSTAT (2021) data base. Globally, Romania ranks the second place after China at the top of major plum growing countries. This species is susceptible to various economically impactful diseases such as brown rot, produced by *Monilinia* spp. Climatic conditions have an important role in the occurrence and frequency of disease damage depending of a cultivar. Therefore, in 2023 at the FRDS Bistrita, was monitored the behaviour of brown rot damage on 18 plum cultivars with different ripening periods. During the growing stage, 12 conventional phytosanitary treatments were applied up to the harvest time. The determinations were made in the field after fruit harvesting, at the consumer's ripeness stage. Expectedly, the response to brown rot infection on fruits was different through all the cultivars studied. The results revealed low infections with *Monilinia* spp. on 'Zamfira' (6.9%), 'Anna Späth' (7.0%), and 'Doina' (7.7%), while 'Matilda' (39.5%), 'Elena' (33.1%), and 'Jubileu 50' (31.9%) expressed symptoms and a higher percentage of infected fruits. All the data obtained are statistically supported. The results are encouraging, allowing a selection of resistant or tolerant cultivars to brown rot, considering the increasing impact of climate change. Furthermore, the global trend toward organic farming requires the use of resistant cultivars to problematic pathogens for successful farming.

Keywords: brown rot, climatic changes, cultivar diseases, plum.

INTRODUCTION

Prunus domestica L., commonly known as the plum tree, is a highly popular and valued fruit-bearing species worldwide. Due to its high adaptability to various environmental conditions and its nutritional value (vitamins and antioxidants), it is recommended to consume 2–4 fruits daily for a healthy diet (Gil *et al*., 2002; Ortega-Vidal *et al*., 2022). Plums are enjoyed fresh, processed (dried plums, jams, preserved) and distilled to produce alcoholic beverages (plum brandy – Botu *el al*., 2008). Interest in plums is continuously increasing, as evidenced by the over 2000 cultivars of this species available (Sottile *et al*., 2022). According to data base from FAOSTAT (2021), worldwide plum production ranks fifth after apples, bananas, pears and oranges. Regarding the top plum-

producing countries, China leads in global plum fruit production with 6.61 million tons and Romania ranks second with 0.8 million tons.
The trend among farmers to establish high-performance orchards, in Romania, has led to the introduction of new, largely unknown foreign cultivars, in terms of their adaptability and behavior in the face of various economically impactful diseases. In this context, both foreign and Romanian cultivars require increased attention to their susceptibility to specific pathogens, especially in the context of increasingly prevalent climate changes (Milošević and Milošević, 2023).
Monilinia laxa, Monilinia fructicola and *Monilinia fructigena* are a group of fungal diseases that cause the brown rot of the fruits in many fruit species including *Prunus* spp. They belong to the phylum Ascomycota, class Leotiomycetes, order Helioteliales, family Sclerotiniaceae, and genus *Monilinia* (Tronsmo *et al*., 2020). All these three *Monilinia* species have resembling symptoms on tree organs including fruits, and consequently, visual observation is not enough to differentiate them. Therefore, for precise identification molecular techniques are required (Oliveira Lino *et al*., 2016).
All of these species have been reported over all continents and the genetic similarity is extremely high: 97.5% of the DNA is identical to *M. fructigena* and *M. fructicola* and 99.1% of *Cyt b* gene is identical for *M. fructigena* and *M. laxa* (Hily *et al*., 2011). This is the reason why many researchers including the present study referred to the above-mentioned species of *Monilinia* as *Monilinia* spp.
For growers, it is low interest to perform an accurate of the fungus identification because species of *Monilinia* have similar damaging effects on fruits and the treatments are similar.
Although damages various tree organs (blossoms, twig, immature and mature fruits) the most sensitive phenological phase is represented by the blossoms and the mature fruits before and after harvesting. Brown rot is an extremely dangerous disease due to its long period of incidence, from bloom to fruit maturity and divers' climatic factors that favour disease spread (Florian and Puia, 2021).
These characteristics added up to the restrictions on pesticide use and low availability of biological control methods form an accurate picture of the difficulty of brown rot control. In these circumstances, the objective of finding resistant cultivars to fruit brown rot and breeding new cultivars with this trait is considered very important all over the world. Selecting cultivars with reduced requirements for external control methods is even greater when aiming for the ecological cultivation of plums (Moldovan *et al*., 2022).
The behavior of different stone fruit cultivars (including plum) has been studied in many parts of the world but the results are difficult to compare because of the variability of the method used to investigate the susceptibility (Oliveira *et al*., 2016) and maybe even more important because of the high variability of the behavior of the disease in different conditions. This is the reason for which it is very important to know how the cultivars behave in specific conditions and it is the aim of our study.

MATERIALS AND METHODS

The study was performed in a young plum orchard (Fig. 1) established in 2020 at the Fruit Research and Development Station Bistrita (FRDS Bistrita). It involved a sample of 18 different plum cultivars, both Romanian ('Matilda', 'Elena', 'Gras ameliorat', 'Zamfira', 'Iulia', 'Agent', 'Flora', 'Andreea', 'Jubileu 50', 'Minerva', 'Doina', 'Centenar', 'Carpatin' and 'Diana') and foreign ('French Improved', 'Jojo', 'Anna Spath', 'Stanley') with varying ripening periods.
The cultivars were monitored throughout the entire growing season to assess their behavior in response to various pathogens. In the current study, the focus was on the

sensitivity of plum cultivars to brown rot (*Monilinia* spp.) infection. All data were collected from the same plot, under the same environmental conditions, and using the same agricultural methodology.

Figure 1. The plum orchard where the study was performed

During the growing season 12 conventional phytosanitary treatments were applied, distributed along the vegetative period (Table 1).

Table 1. Chemical fungicide treatments applied into experimental plot

I. Winter treatments	Copper (Cu) 380 g/l **(3.3 l/ha)**
II. Growing season treatments	
a.) Contact treatments	Copper (Cu) 380 g/l **(1.5 l/ha)**
b.) Systemic treatments	Cyprodinil 500 g/kg **(0.5 kg/ha)**
	26.7% Boscalid, 6.7% Piraclostrobin **(0.5 kg/ha)**
	Cyprodinil 375 g/kg, Fludioxonil 250 g/kg **(1kg/ha)**

In the current study, to establish the sensitivity of cultivars to brown rot infection, the frequency (F%) of disease on fruit was assessed. Six trees of each cultivar (3 repetitions x 2 trees) were selected for this assessment. From the total fruit yield on each tree, healthy fruits were separated from those affected by *Monilinia* spp., and then affected fruits were quantified and expressed as a percentage relative to the total number of fruits per tree. The calculation formula used to determine the frequency was:

$$F\% = \frac{total\ number\ of\ fruits\ with\ brown\ rot/tree}{total\ number\ of\ fruits/tree}\ x\ 100$$

The fruit harvesting and the determination of the frequency of brown rot infection on fruits (Fig. 2) were carried out for each cultivar separately based on the fruit ripening period. Fruit inspection was conducted in the field visually, immediately after harvesting.

Figure 2. Brown rot symptoms on 'Centenar' plum cultivar

During the study, all climatic indices that may favour the occurrence of infection with brown rot, such as the average monthly temperature, the average air humidity and the amount of precipitation, were monitored. The summer was hot and humid, and the winter was dry and cold. The micrometeorological parameters were recorded using an Adcon Telemetry automated weather station into the orchard.
Statistical analysis was performed to determine the differences between plum cultivars considering susceptibility to brown rot. The data were analysed using the XLSTAT by Addinsoft software (version 2019.3.2 - Addinsoft. XLSTAT, 2019), which utilizes the MS Office Excel Professional Plus 2019 platform. The XLSTAT program was used to perform the analysis of variance (ANOVA - Fisher, R.A., 1925). Afterward, Duncan's Multiple Range Test (Duncan, D.B., 1955) was used to analyse the differences between the different variants at $p < 0.0001$.

RESULTS AND DISCUSSIONS

Expectedly, the response to brown rot infection on fruits was different between cultivars (Fig. 3) The obtained results regarding the damages produced by brown rot on plum fruits revealed that the most affected cultivars were 'Matilda' (39.5%) and 'Elena' (33.1%), followed by 'Jubileu 50' (31.9%), and 'Stanley' (30.2%).

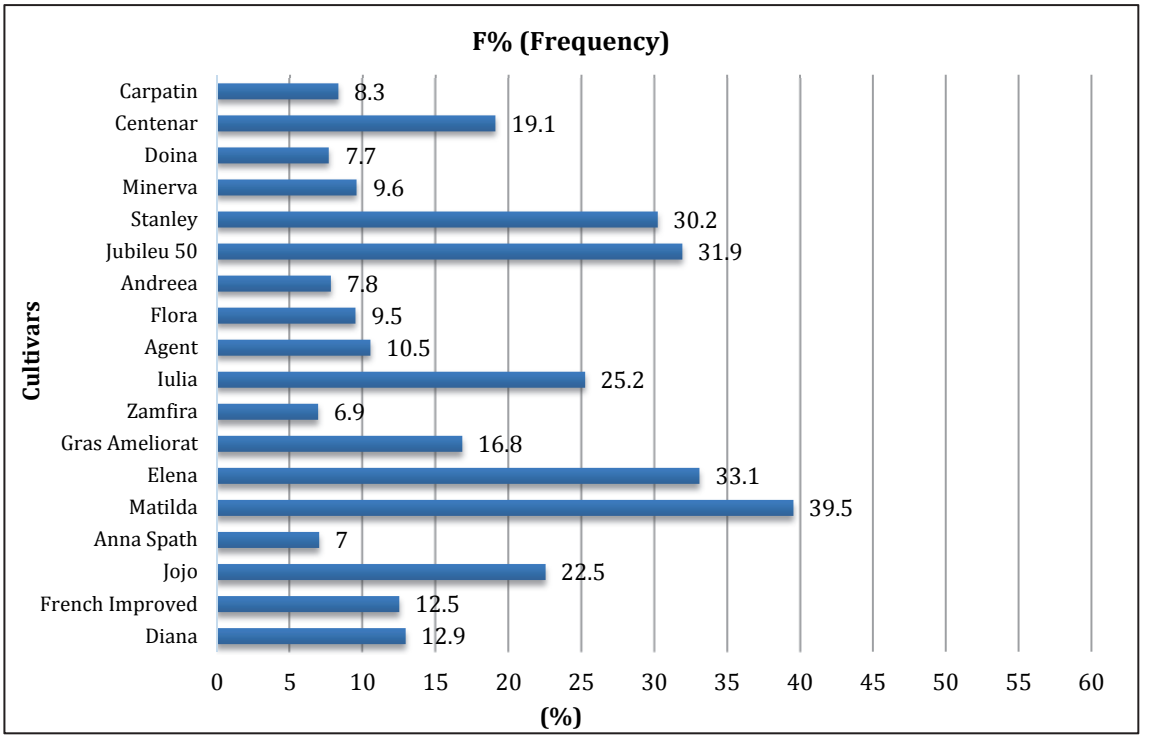

Figure 3. The frequency of brown rot infection on fruits in plum experimental plot (2023)

The least affected plum cultivars, which behaved as the most tolerant to fruit brown rot infection, in terms of the recorded frequency (F%), proved to be: 'Zamfira' (6.9%), 'Anna Späth' (7.0%), 'Doina' (7.7%), and 'Andreea' (7.8%) (fig. 3).
The results obtained from field observations regarding the frequency of brown rot disease infection that the various damages were largely influenced by favorable climatic conditions for the spread of the disease. The year 2023 was atypical, especially

considering the significant amounts of rainfall recorded during the growing season, with a total exceeding 350 mm (table 2). The rainfall, combined with high humidity and elevated temperatures, created a conductive environment for the appearance and development of brow rot disease.

Table 2. Climatic conditions recorded at FRDS Bistrita during the 2023 growing period

Month	April	May	June	July	August	Septembrie
T med (˚C)	8.40	14.12	20.89	17.90	21.40	18.52
Air humidity (%)	63.50	56.63	70.38	69.02	58.75	61.66
Rainfall (mm)	80.20	33.20	108.20	86.80	70.80	14.20

Data was statistically interpreted to determine the differences between plum cultivars in terms of susceptibility infection to brown rot. Following the analysis of variance (ANOVA) and subsequently using Duncan's Multiple Range Test, the assessed cultivars were grouped into 15 major significance classes (Table 3). According to the statistical analyses, the significance class (o) includes the cultivars 'Zamfira' and 'Anna Späth', which have good behaviour of fruits on brown rot infections, while 'Matilda' cv. belongs to the significance class (a) and proved to be the most susceptible to brown rot infection.

Table 3. Brown rot damage frequency on plum statistical analyses

No.	**Plum cultivar**	**Fruit rot damage (F%)**
1	'Matilda'	39.545 ± 0.006 [a]
2	'Elena'	33.115 ± 0.137 [b]
3	'Jubileu 50'	31.223 ± 0.110 [c]
4	'Stanley'	30.236 ± 0.212 [d]
5	'Iulia'	25.241 ± 0.015 [e]
6	'Jojo'	22.466 ± 0.102 [f]
7	'Centenar'	19.094 ± 0.035 [g]
8	'Gras ameliorat'	16. 848 ± 0.025 [h]
9	'Diana'	12.857 ± 0.173 [i]
10	'French Improved'	12.465 ± 0.529 [j]
11	'Agent'	10.541 ± 0.010 [k]
12	'Minerva'	9.568 ± 0.152 [l]
13	'Flora'	9.488 ± 0.080 [l]
14	'Carpatin'	8.277 ± 0.122 [m]
15	'Andreea'	7.846 ± 0.050 [n]
16	'Doina'	7.722 ± 0.057 [n]
17	'Anna Späth'	6.967 ± 0.115 [o]
18	'Zamfira'	6.867 ± 0.025 [o]
Pr > F(Model)		*< 0.0001*
Significant		*Yes*

Note: The values presented in the table are averages of the damage frequency of Brown rot to every plum cultivar studied. Averages followed by different letters indicate differences at p < 0.0001 according to Duncan`s Multiple Range Test.

On the one hand, the tolerant plum cultivars that achieved results of brown rot infection below 10% could be good candidates for establishing orchards in an ecological system or other integrated systems with a reduced number of treatments in the Northern

Transylvania region. On the other hand, the sensitive cultivars with a frequency exceeding 10% of brown rot infection require a more thorough evaluation over a longer period to observe their behavior under various weather conditions.
The obtained results are encouraging and provide valuable information regarding the susceptibility of plum cultivars to brown rot in the context of increasing climate change issues and the growing trend of organic fruit farming, which is becoming more and more attractive to farmers.

CONCLUSIONS

The behaviour of 18 plum cultivars to brown rot fruit infection under climatic conditions of the year 2023 allowed identifying six plum cultivars ('Zamfira', 'Anna Späth', 'Doina', and 'Andreea') which behaved as the most tolerant to fruit brown rot infection. Opposite, the other four plum cultivars ('Stanley', 'Jubileu 50', 'Elena' and 'Matilda') were seriously affected.

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