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RĂSPUNSUL UNOR SOIURI DE MĂR ROMÂNEȘTI ȘI STRĂINE LA INFECȚIILE NATURALE CAUZATE DE CIUPERCA *PODOSPHAERA LEUCOTRICHA*, ÎN ZONA BISTRIȚA

THE RESPONSE OF SOME ROMANIAN AND FOREIGN APPLE CULTIVARS TO THE NATURAL INFECTIONS CAUSED BY *PODOSPHERA LEUCOTRICHA*, IN BISTRIȚA AREA

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Abstract

It is desirable that in the newly established apple orchards to be promoted as many Romanian cultivars that have genetic resistance to diseases. That is why we considered important the evaluation of some Romanian apple varieties whose expansion in culture is desired, in terms of their behaviour to the attack of the fungus *Podosphera leucotricha*, one of the most harmful pathogens that damage apples. The evaluation of the cultivars was performed in the period 2019 – 2021, in the experimental plots of Research Station for Fruit Growing (RSFG) Bistrita and targeted six Romanian cultivars and five foreign cultivars. Observations were made both in the untreated plots and in the plots where conventional treatment schemes were applied. The results highlight the varieties created at SCDP Bistrița: 'Bistrițean' and 'Starkprim' which, together with 'Starkrimson', stood out due to the absence of powdery mildew symptoms in the three years of study.The cultivars known to be sensitive to powdery mildew, 'Idared' and 'Jonathan' were most affected, followed by 'Golden Delicious'. The cultivars 'Florina', 'Generos' and 'Auriu de Bistrița' showed a medium to low sensitivity and 'Aura' and 'Salva' very low sensitivity.

Cuvinte cheie: tratamente convenționale, camp experimental, *Podosphaera leucotricha,* făinare, toleranță.
Key words: conventional treatments; field trial, *Podosphaera leucotricha,* powdery mildew, tolerance.

1. Introduction

Powdery mildew is one of the most widespread and damaging fungal diseases of apple. Powdery mildew significantly reduces the production capacity of the trees and the quality of the apples, therefore requiring costly control operations and treatments year after year. Production is reduced by at least half in orchards where no treatments are applied compared to those where only sulfur compounds are applied. There are studies that attest to the dramatic effect that powdery mildew has not only on the production of the current year but also for the following year, in the case of sensitive cultivars. The case of the 'Ginger Gold' cultivar, known for its sensitivity to powdery mildew, was documented by Yoder in 2000. In the absence of treatments to combat powdery mildew, not only the current year's fruit production is affected, but in the following year the number of inflorescences appearing on the trees decreased up to 6 times compared to the treated orchards (Yoder, 2000). The curative measures against this pathogen can be the removal of the affected organs from the crown of the trees and their destruction, the treatments with fungicide products, or combining the two methods. Pruning of the infected shoots as an integrated pest management strategy can be an efficient method in young orchards in the nonbearing period (Borovinova and Ivanova, 2004) depending on the cultivars selected by the grower. The results show that it is possible to maintain the damage under the economic treshold by this strategy alone in the case of cultivars such as: 'Florina', 'Prima' and 'Erwin Baur'. Of course in case of susceptible cultivars combined methods of control are recommended.

Among the substances that can be used to control powdery mildew, those based on sulfur, sterol demethylation inhibitors (myclobutanil, tebuconazole) or those based on neem oil, jojoba oil (George, 2019) and various combinations of vegetable oils (Cîrstea et al., 2019) have proven reliable efficacy. The number of sprays varies according to the susceptibility of the cultivar, meteorological conditions of each year and the inoculum reserve that is present in the orchard.

Permanent examination of orchards is extremely important for detecting the presence of the fungus on tree organs. This operation must be repeated many times during the growing season, especially during the early summer with high humidity, over 70%. To facilitate this assessment, recent research in the field of high-resolution cameras in the RGB (red, green, blue) spectrum attached to drones is noteworthy. They can detect *Podosphaera leucotricha* infection areas with 77% accuracy (Chandel et al., 2021). Combining this techique with drone performed localized sprays on the damaged trees could provide an important reduction of costs in the near future.

Given the efforts made by farmers year after year to control this disease, it is advisable to use cultivars that are resistant or have low-susceptibility to *Podosphaera leucotricha* infections, especially when planting new orchards. Over time, various assessments have been made of the different cultivars widespread in apple cultivation, in order to detect resistance to powdery mildew so that farmers can make an informed choice. Moreover, the resistance of the apple to powdery mildew has been less studied than that of the apple scab, and much fewer sources of resistance are known. The genome of the pathogen *Podosphaera leucotricha* was only sequenced and reported in 2020 by Gañán L. et al. Thus much remains to be studied in the mechanisms of interaction between apple and powdery mildew at genetic and molecular level.

A 2-year study of 680 apple varieties in the Dresden-Pillniz Gene Bank found that only five of the cultivars ('Ariwa', 'Bramleys Seedling', 'Erbachhofer', 'Großer Api', 'Virginia Crab') have resistance genes to powdery mildew, while another 11 cultivars have been classified as slightly susceptible to powdery mildew (Höfer et al., 2021). All other cultivars showing various degrees of susceptibility to powdery mildew, year after year.

Another study focused its attention on some wild apple genotypes belonging to the species *Malus orientalis* that grows spontaneously in the Caucasian region where apple originates. The aim was to identify new sources of genetic resistance to apple scab and powdery mildew. Although five apple powdery mildew resistance genes are known and three of them have been tested with molecular markers, only one of them was detected in this first study that tested 100 trees selected from Iranian forests (Amirchakhmaghi et al., 2018). It is the P1-d gene that was found in trees from 8 locations out of 14, spread throughout Northern Iran.

In our country, recent studies were carried out that focused on the behavior of some old cultivars and local varieties of apple to the infections with the fungus *Podosphaera leucotricha* in field conditions (Antofie et al., 2018) as well as on some F1 descendants of some crosses between different cultivars (Militaru et al., 2018).

Unfortunately the data regarding the presence of *Podosphaera leucotricha* rezistence genes in the Romanian cultivars that were part of our study are low at this time, but the behaviour that they displayed in the field trials was mostly good.

2. Material and methods

Eleven apple cultivars grown in the experimental plots of the Research Station for Fruit Growing Bistrita (RSFG Bistrita) were evaluated in terms of behaviour to the infection with the fungus *Podosphaera leucotricha* under natural conditions. RSFG Bistrita is located at 47^{o}10' Northern latitude and 358 m altitude. The average annual temperature is around 10 ^{o} Celsius and with a multiannual average of 720 mm of rainfall. The cultivars that we studied are grafted on M9 or M26 rootstock and grown in a super-intensive cultivation system at densities between 1667-2500 trees per hectare. The crown shape is thin spindle and each year the trees were pruned, standard herbicides and fertilizers were applied. In the treated variant twelve treatments with fungicides were applied every year, of which 9 included substances specific to control powdery mildew, based on: sulphurur, diphenoconazole, myclobutanil, tebuconazole and fluopyram. The experience included two variants: treated and untreated with three replicates on each cultivar and each variant. In each replication a minimum of three trees per cultivar were evaluated. The trees were 19 years old at the beginning of the experience in 2019.

The assessment of the damage degree was made using a scale with 9 levels of intensity. Given the specificity of the attack of *Podosphaera leucothrica* the intensity was determined according to the percentage of leaves affected by powdery mildew in the crown of trees as shown in Table 1.

The statistical analysis of the experimental data was performed with the Microsoft Excel program, through the Two-way Anova test followed by the least significant difference (LSD) test.

3. Results and discussions

The observations made in the three years in the treated and untreated blocks have shown the differences between the studied cultivars as well as the way the application of specific fungicides influences their reaction to the infection with powdery mildew.

The powdery mildew damage was different on the sensitive cultivars (Fig. 1), where the flowers and shoots were fully covered by the fungus mycelium, compared to the less sensitive cultivars, where the mycelium only partially covered some leaves but did not include the entire shoots (Fig. 2).

Comparing the degree of damage on the leaves between the treated and untreated variants of the same cultivar showed that there were significant differences between cultivars with different degrees of sensitivity, all having a lower degree of attack in the treated variants (Fig. 3 and Fig. 4).

In the case of sensitive cultivars the degree of damage was high in the treated variants, in the experimental years. 'Jonathan' and 'Idared' have been very damaged in both experimental variants, in all of the three years. 'Golden Delicious' and 'Auriu de Bistrita' also presented quite important degrees of damage. This fact emphasizes once again how threatening this disease is in the case of sensitive cultivars and what great importance has to use cultivars that have resistance or low sensitivity to this pathogen. This statement is also supported by the behavior of the cultivars with low sensitivity that have not registered statistically significant differences between the treated and untreated variant in none of the three years.

We observed that the cultivars 'Aura', 'Bistrita', 'Starkprim' and 'Starkrimson' are noted by the lack of damage or by the sporadic presence of sporulating spots of powdery mildew in all three years in both variants. 'Salva' had a very good behavior in the treated plot presenting only sporadically affected leaves in 2019 but in the untreated plot was noted with note 3 in all three years. 'Auriu de Bistrita' and 'Generos' also had better grades in the treated plot while in the untreated plot the damage was significant, up to 25 % of the leaves presenting sporulating spots (Fig. 3 and Fig. 4)

The corroboration of the data from the three years led to the grouping of the 11 varieties in 4 categories. In the category of cultivars with phenotypic tolerance to the natural powdery mildew attack (with green in Figure 5) we included 'Starkrimson' and 'Starkprim' on which we did not encounter symptoms, in any of the replicates of the experimental variants, in none of the three seasons. In the following category (light blue in Figure 5) are the cultivars that sporadically presented sporulant spots on leaves or even fully covered leaves but with very low frequency. We considered that these cultivars showed low sensitivity to powdery mildew. 'Generos' and 'Golden Delicious' (orange in Figure 5) have medium sensitivity and 'Jonathan' and ‚Idared' (red in Figure 5) showed high sensitivity as expected.

4. Conclusions

Our research indicate that ‘Starkrimson’ cultivar and its descendant ‘Starkprim’ behave well against powdery mildew natural infection in untreated plot and the use of cultivars with resistance or tolerance to powdery mildew in newly established apple orchards is an important point in the technology of the plantation.

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Tables and Figures

Table 1. Assessment scale for powdery mildew symptoms

Grade awarded	Symptoms	Susceptibility
1	No visible symptoms	Resistant/Tolerant
2	Sporadic sporulating spots that do not cover the entire leaf	Very slightly susceptible
3	Up to 10% of symptomatic leaves on the tree	Slightly susceptible
4	Between 11 and 25% of the tree's leaves are covered with symptoms of infections	Susceptible to moderately susceptible
5	Between 26 and 50% of the tree's leaves are covered with symptoms of infection	Moderately susceptible
6	Between 50 and 74% of the tree's leaves are covered with symptoms of infection	Moderate to susceptible
7	75% of the tree's leaves are covered with symptoms of infection	Susceptible
8	Between 76 and 99% of the tree's leaves are covered with symptoms of infection	Very susceptible
9	100% of the tree's leaves are covered with symptoms of infection	Extremely susceptible

Table 2. The significance of the differences* from the susceptible control 'Jonathan' in the three years according to the Least significant difference (LSD) test

Soiul	Average notes in 2019	The significance of the difference from 'Jonathan'	Average notes in 2020	The significance of the difference from 'Jonathan'	Average notes in 2021	The significance of the difference from 'Jonathan'
Aura	1,5	***	1	***	1	***
Auriu de Bistrita	3	***	3,5	***	3,5	***
Bistritean	2	***	1	***	1	***
Generos	3	***	3	***	3	***
Florina	2,5	***	2	***	2	***
Idared	5,5	ooo	4	***	5	ooo
Jonathan	7	-	6,5	-	6,5	-
Golden Delicious	3,5	***	3,5	***	3,5	***
Salva	2,5	***	1,5	***	2	***
Starkrimson	1	***	1	***	1	***
Starkprim	1	***	1	***	1	***

*The values of the limit differences for α = 5% and GL = 10, were: 1.55 for the data of 2019; 1.64 for data from 2020 and 1.73 respectively for 2021

Table 3. The significance of the differences* from the susceptible control 'Starkrimson' in the three years according to the Least significant difference (LSD) test

Soiul	Average notes in 2019	The significance of the difference from 'Starkrimson'	Average notes in 2020	The significance of the difference from 'Starkrimson'	Average notes in 2021	The significance of the difference from 'Starkrimson'
Aura	1,5	ooo	1	ooo	1	ooo
Auriu de Bistrita	3	***	3,5	***	3,5	***
Bistritean	2	ooo	1	ooo	1	ooo
Generos	3	***	3	***	3	***
Florina	2,5	ooo	2	ooo	2	ooo
Idared	5,5	***	4	***	5	***
Jonathan	7	***	6,5	***	6,5	***
Golden Delicious	3,5	***	3,5	***	3,5	***
Salva	2,5	ooo	1,5	ooo	2	ooo
Starkrimson	1	-	1	-	1	
Starkprim	1	ooo	1	ooo	1	ooo

*The values of the limit differences for α = 5% and GL = 10, were: 1.55 for the data of 2019; 1.64 for data from 2020 and 1.73 respectively for 2021

Table 4. Powdery mildew intensity of symptoms on some cultivars, in Germany, 2012-2013 (Source: Höfer et al., 2021)

Cultivar	2012 (Score between 1-9)	2013 (Score between 1 -9)
Florina	3	1
Generos	6	6
Idared	7	9
Golden Delicious	5	7
Starkrimson	3	1

Fig. 1. Powdery mildew damage on flowers and young shoots on Idared, 27.04.2021

Fig. 2. Powdery mildew damage on leaves, Auriu de Bistrița, 04.07.2020

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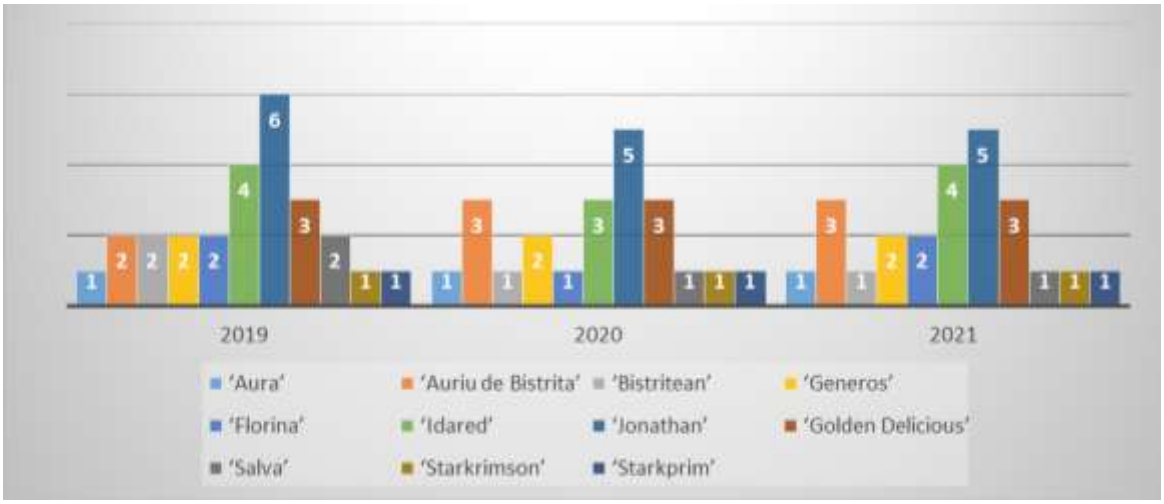

Fig. 3. The notes given to cultivars, in the treated plot, in the three experimental years.

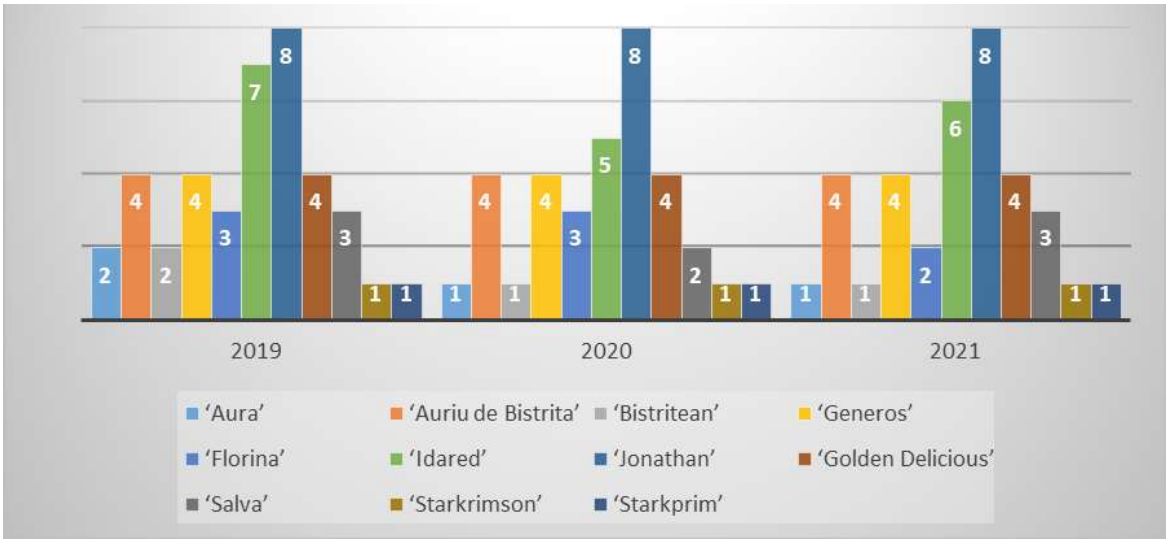

Fig. 4. The notes given to cultivars, in the untreated plot, in the three experimental years.

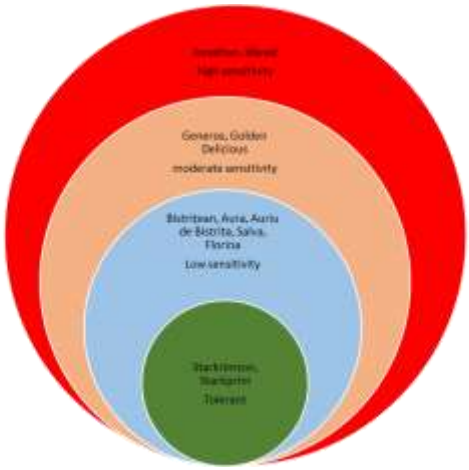

Fig. 5. Groups of cultivars studied in the experiment, according to the sensitivity manifested phenotypically, to powdery mildew, in the years 2019-2021, in Bistrița