HEALTHY STATUS OF THE APPLE THREE (*MALUS DOMESTICA* BORKH.) ORCHARDS IN THE RUSCIORI DIDACTIC AND RESEARCH FARM, SIBIU COUNTY

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Abstract

The maintenance of healthy status of a didactic apple tree orchard is very important for teaching students as well as for research purposes. Fungal diseases represent a significant threat to apple tree orchards, affecting both yield and fruit quality. The scope of this study was to evaluate the phytosanitary status of two apple orchards in the Rusciori Didactic and Research Farm, Sibiu County, for 2024 season, focusing on fruit brown rot caused by Monilinia fructigena (Aderhold & Ruhland) Honey.

Thus, an old apple orchard (i.e. planted in 1960) and a new one (i.e. planted in 2019) were investigated. The analysis of our results proved that the older orchard was more susceptible, with an infection rate of 43.58%, an intensity of 11.21%, and a damage degree of 4.39%, compared to the new orchard where accordingly were recorded 15.40%, 2.86%, and 0.28%.

Our preliminary study results support the idea that the age of apple tree can be a determinant factor for susceptibility to these diseases, that can be enhanced by some relevant environmental factors. Thus, it can be considered that high humidity, optimal temperatures range (15–25°C), and wind, may favour pathogen development, especially during the fruit ripening period. Preventive treatments applied within the framework of integrated disease management effectively reduced infection rates and consequently economic losses, particularly for the young orchard. Our preliminary study results highlight that the old orchard may act as primary inoculum sources, emphasizing the importance of cultural hygiene and timely interventions.

***Key words**: Malus domestica, Monilinia fructigena, plant diseases, Didactic and Research Farm, phytosanitary monitoring*

INTRODUCTION

Apple orchards are recognized for long time that play an important role in ensuring food security, supporting during the history of human civilization, the economic development of rural areas, and maintaining ecological balance with the wild (Fuller *et* Stevens, 2019). The apple tree (*Malus domestica* Borkh.) holds a primary position among the species cultivated in temperate regions, due both to its significant economic value and to the large, cultivated area worldwide for many millennia (Boualleg *et al*., 2024).

Assessing the healthy status of apple orchards is essential for achieving high yields, as well as for preventing diseases and pest attacks and for maintaining for long time a living orchard as an important unit of larger landscapes (Simon *et al*., 2011). Nowadays this process is complex and involves among others the early identification of symptoms caused by potential pathogenic agents and pests, evaluating the intensity and spread of infections, and implementing an integrated and timely management approach to apply the best appropriate phytosanitary treatments (Okoro *et al.*, 2024).

The present study aims to evaluate the healthy status of two orchards by apply both modern and traditional methods used in monitoring, in Rusciori village, Șura Mică commune from Sibiu County. The selected apple orchards are located within the Rusciori Didactic and Research Farm. Both orchards consist of cultivars well known for their adaptability and high production potential (Iancu *et al.*, 2023). Thus, observed symptoms with the responsible pathogenic agents, quantifying the degree of infestation, and formulating integrated intervention recommendations based on real field data were realized (Morariu *et al.*, 2025).

Also, we were interested to identify the main environmental factors affecting the healthy status of the two apple orchards such as temperature range, humidity and wind.

Relevant for our study was observing foliar symptoms, colour changes, shape, or texture of the fruits, as well as on identifying characteristic signs of phytopathogenic diseases known in Romania - mainly brown rot (*Monilinia fructigena*), in line with other authors methodology of study (Guzu *et al*., 2024).

MATERIALS AND METHODS

The study was developed during the 2024 growing season (from May till September 2024), in Rusciori village, Șura Mică commune, Sibiu County, within the premises of the Rusciori Didactic and Research Farm. The farm is geographically located at 45°48'40.43" N latitude and 24°3'1.37" E longitude.

The Didactic and Research Farm covers a total area of 37 hectares, out of which 5 hectares are occupied by an apple (*Malus domestica* Borkh.) orchard established in 1960, supplemented by a 2-hectare orchard planted in 2019. The older orchard includes the apple cultivars *'Starkrimson'*, *'Wagener'*, and *'Jonathan'*, whereas the newer orchard comprises *'Idared'*, *'Ionagold'*, and *'Granny Smith'* (Antofie *et al*., 2016). These cultivars are recognized for their long storage potential, distinctive flavour, and adaptability to local pedoclimatic conditions (Cimpoieș *et al*., 2020).

Drone-based mapping and GPS georeferencing are increasingly used nowadays for orchard health monitoring and spatial inventory (Li *et al*., 2021; Suárez *et al*., 2022). These approaches support sustainable management practices by providing accurate data on orchard structure, vigour, and disease distribution.

Figure 1 shows an aerial overview of the Rusciori Didactic and Research Farm, acquired using a DJI Mavic 3M+ drone with a spectral camera, highlighting both the new orchard and the old orchard selected for the study.

Figure 1. Orthophoto map of the Rusciori Didactic and Research Farm obtained using drone imagery DJI Mavic 3M+ (red – the old orchard; yellow – the new orchard) 45°48'40.43" N latitude and 24°3'1.37" E (source: original)

In both selected orchards the trees were planted as following: 4 meters between rows and 2 meters between trees in the old orchard, and 3.5 meters between rows and 1.5 meters between trees in the new orchard (Table 1). This planting system is also facilitating the orchard maintenance and harvesting operations, allowing access for agricultural machinery (Hassanzai *et* Ayobi, 2025).

The present investigation monitored 410 of a total of 2,049 trees in the old orchard, distributed across 22 rows, along others 100 of 500 trees with 5 rows in the new orchard.

Table 1. Comparative analysis of planting systems in the new and old orchard (source: original)

Feature	Old orchard	New orchard
Planting system	Classic Rectangular	Classic Higher density
Distance between rows (m)	4	3.5
Distance between trees in a row (m)	2	1.5
Number of rows	22	5
Monitored trees	410	100
Total number of apple trees	2049	500

The study began with a visual observation of trees exhibiting disease symptoms, using a zig-zag transect sampling pattern for 1 apple tree of 5 in a row and consecutively for 3 tree rows, and marking each tree that showed morphological changes such as leaf alterations, leaf spots, branch dieback, or visible signs of stress, either physiological or infection-related. The apple tree canopy was examined from all sides. Observed symptoms included mummified fruits hanging on branches and the presence of greenish-olive spots on leaves and fruits. To record and document these symptoms, photographs were taken and labelled with the date of capture, and exact location (i.e. the row in which the tree was located), and the symptom observed. Additionally, climatic data were recorded at each assessment using the weather station at the Rusciori Didactic and Research Farm.

To accurately identify the pathogens responsible for the symptoms, a magnifying glass and an optical microscope Euromex, 2022 was used.

Climatic conditions (temperature, precipitations and wind) were monitored using the weather station Davis Pro 2.

Following symptom identification, samples were collected and analysed under the optical microscope to determine the pathogenic agents causing the diseases.

The severity of infection was assessed based on the incidence of symptoms, determined according to both the intensity and frequency of attacks by *Monilinia fructigena*. The attack and damage degree were calculated according to the formulas established by McKinney (1923).

Initially, the **frequency of infection (F%)** by the pathogen *Monilinia fructigena* was determined as the ratio of infected trees to the total number of trees analysed. The frequency was calculated using the formula:

$$F\% = \frac{n \times 100}{N}$$

where:

- n= number of infected trees
- N= total number of trees analyzed

The attack intensity (I%) represents the proportion of a tree affected by the pathogen. Each tree was assigned a score from 0 to 6, where 0 indicates no infection and 6 represents the highest level of infection. Intensity was calculated using the formula:

$$I\% = \frac{\sum(i \cdot f)}{N}$$

where:

- i= severity score of infection per tree
- f= number of cases recorded for each score
- N= total number of trees analyzed

The attack degree (GA) was calculated as the percentage product of infection frequency and intensity, using the formula:

$$GA\% = \frac{F \cdot I}{100}$$

The damage degree (GP) was determined based on the attack degree. It was used for the feasibility of applying phytosanitary treatments as a curative measure. It was calculated using the formula:

$$GP\% = GA \cdot coef.$$

where GA is the attack degree and $coef.$is the conversion coefficient, which for brown rot (moniliasis) is 0.9 (McKinney, 1923).

During the 2023–2024 growing season, a total of 11 plant protection and nutritional treatments were applied in the apple orchard, carefully scheduled according to the phenological stages, phytosanitary pressure, and climatic conditions. The treatment scheme followed established integrated pest management (IPM) practices for apple orchards (Ferree *et* Warrington, 2003; EFSA, 2020).

In the dormant period (October 2023), the trees were treated with Champ 77 WG (copper hydroxide, ~50 % Cu) for wound disinfection and prevention of latent fire blight and scab, and Mospilan 200 SP (acetamiprid, 200 g/kg) to control overwintering pests such as aphids and scale insects. During bud swelling (February 2024), Alcupral 50 PU (50 % metallic copper) was applied as a preventive fungicide against early spring bacterial and fungal diseases, while Vital (micro- and macroelements) was used as a foliar fertilizer to enhance tree vigour.

At bud break (March 2024), N Oil (horticultural oil) and Mospilan 200 SP were applied to control overwintering insect stages and early aphid infestations. During leaf development and pink bud (April 2024), Aliette 80 WG (fosetyl-Al, 800 g/kg) protected against downy mildew and vascular diseases, while Vital supported foliar growth. At flowering (April 2024), a combination of Faster (lambda-cyhalothrin), Luna Experience (fluopyram + tebuconazole), and Milbeknock (fluaciziamid) provided protection against flower-damaging insects, fungi, and mites, and Algamax stimulated flower fertilization and reduced abiotic stress.

During fruit set (May 2024), fungicides Chorus 50 WG (cyprodinil) and ThyovitJet 80 WG (sulfur 80 g/L) controlled scab, powdery mildew, and mites, while insecticides Movento (spirotetramat) and Vertimec 1.8 EC (abamectin) targeted sucking insects and mites. Foliar fertilizers Folimax and Vital ensured balanced nutrition for developing fruits. In fruit growth (May–June 2024), Karate, Milbeknock, and Score (difenoconazole) were applied for pest and disease control, along with foliar supplementation (Folimax Calsa and Vital) for fruit quality and calcium enrichment.

During fruit development (June 2024), Polyram (mancozeb + zinc) and Score ensured continuous protection against scab and powdery mildew, while Faster and Vertimec 1.8 EC controlled insect and mite populations. Alcupral 50 PU and Mospilan 200 SP were used to prevent secondary bacterial infections and leaf-feeding pests. In fruit ripening (July 2024), protective treatments included Chorus 50 WG, elemental sulfur, insecticide Decis Expert 100 EC, acaricide Nissorun 10 WP, and foliar fertilizers Vital and Folimax Calsa to improve fruit quality and skin integrity. Finally, during harvest (August 2024), Alcupral 50 PU and Faster provided post-harvest protection and disinfection, while foliar fertilizers maintained nutritional and organoleptic fruit quality.

RESULTS AND DISCUSSIONS

During the summertime of 2024, our study results revealed that among the major disease symptoms identified in both orchards (the old and new orchards) were caused by two identified pathogens *Monilinia fructigena* and *Venturia inaequalis*.

Since the incidence of apple scab was low, the focus of this study was directed toward analysing the brown rot infection in the apple orchard of the Rusciori Didactic and Research Farm.

The phytosanitary analysis of the apple orchards revealed significant differences between the old and the new orchards in terms of the frequency, intensity, and attack degree of the pathogen *Monilinia fructigena*, responsible for the occurrence of fruit brown rot and they will be discussed below.

Table 2. Frequency of infection caused by the pathogen *Monilinia fructigena* (source: original)

	Number of infected trees		Total number of trees analysed		Frequency (F%)	
	Old orchard	**New orchard**	**Old orchard**	**New orchard**	**Old orchard**	**New orchard**
	893	77	2049	500	43,58%	15,40%

According to the data presented in Table 2, the frequency of infection was higher in the old orchard (43.58%) compared to the new one (15.40%). This indicates an increased susceptibility of mature trees to *Monilinia fructigena* infection, due to their advanced age and the lack of maintenance practices in recent years. The specialized literature confirms that older trees, which are in physiological decline, exhibit reduced resistance to pathogenic agents, thus facilitating the penetration and development of fungal infections (Holb *et al.*, 2007; Xu *et* Berrie, 1995).

Table 3. The attack intensity caused by the pathogen *Monilinia fructigena* (source: original)

Number of cases recorded (f)		Assigned score	Attack degree	Midpoint of the attack degree scale (i)	Attack intensity	
Old orchard	**New orchard**				**Old orchard**	**New orchard**
1156	423	0	0%	0%		
63	32	1	1 – 3%	2%		
129	19	2	4 – 10%	8%		
450	6	3	11 – 25%	18%	11.21%	2.86%
120	10	4	26 – 50%	38%		
95	6	5	51 – 75%	63%		
36	4	6	76 – 100%	88%		

The attack intensity was 11.21% in the old orchard and only 2.86% in the new one (Table 3). This difference reflects not only the variation in tree age and maintenance but also the positive effect of the phytosanitary measures applied in the young orchard. According to the studies conducted by Balsells-Llauradó *et al.* (2021), the intensity of infection is closely correlated with the orchard microclimate and the application of preventive treatments at optimal intervals.

Table 4. Degree of infection caused by the pathogen *Monilinia fructigena* (source: original)

Frequency (F%)		Intensity (I%)		Degree of infection (GA%)	
Old orchard	**New orchard**	**Old orchard**	**New orchard**	**Old orchard**	**New orchard**
43.58%	15.40%	11.21%	2.86%	4.88%	0.32%

Table 5. Damage degree of apple culture due to *Monilinia fructigena* infection (source: original)

Frequency (F%)		Intensity (I%)		Attack severity (GA%)		Damage degree (GP%)	
Old orchard	**New orchard**	**Old orchard**	**New orchard**	**Old orchard**	**New orchard**	**Old orchard**	**New orchard**
43.58%	15.40%	11.21%	2.86%	4.88%	0.44%	4.39%	0.28%

The attack degree (GA%), resulting from the correlation between frequency and intensity, was 4.88% for the old orchard and 0.32% for the new one (Table 4). These values indicate a low level of infection, suggesting the high effectiveness of the applied treatments, especially in the young orchard. According to Holb (2008), an attack degree below 5% is considered economically insignificant, indicating effective disease control through integrated pest management (IPM).

The calculation of **the damage degree (GP%)** — according to the formula $GP = GA \times coef.$, where the conversion coefficient for *Monilinia fructigena* is 0.9 — revealed values of 4.39% in the old orchard and 0.28% in the new one (Table 5). These results indicate minimal economic losses and suggest that the applied plant protection scheme describe in material and method section was appropriate for the climatic conditions in 2024.

Similar results were reported by Madrid *et al.* (2024), who highlighted a significant reduction in losses through the application of integrated fungicidal treatments and continuous monitoring of the phytosanitary status.

Environmental factors assessment

In the present case, climatic conditions favoured the development and spread of the pathogen *Monilinia fructigena*, particularly during the fruit ripening period.

Table 6. Summary of meteorological parameters during fruit ripening period collected using the weather station Davis Pro 2

Month	Min	Max	Avg
Temperature (℃)			
July	15.4	28.0	22.05
August	16.6	25.2	21.42
September	10.9	25.7	20.64
Precipitation (mm)			
July	0.0	35.8	3.86
August	0.0	4.4	0.46
September	0.0	63.2	3.09
Wind speed (m/s)			
July	0.1	1.3	0.69
August	0.4	1.5	0.76
September	0.1	1.4	0.76

*Min = minimum; Max = maximum; Avg = Average

Table 6 summarizes the meteorological conditions during fruit ripening period, reporting the minimum, maximum, and average values of key parameters, including wind speed (m/s), precipitation (mm), and air temperature ℃.

One of the primary factors creating a favourable environment for its development is humidity, with the disease manifesting more intensely in rainy years, especially in July–August, when the fruits are maturing. High humidity exceeding 90% creates optimal conditions for spore germination and penetration into the fruits (Holb *et al*., 2007; Balsells-Llauradó *et al*., 2021). The ideal temperature for conidia germination and infection development ranges between 15°C and 25°C (Xu *et* Berrie, 1995; Holb, 2008). Wind is also an important factor, as it disperses spores and, in the presence of fruit injuries, facilitates the fungus' entry into the fruit, *Monilinia fructigena* being known as a wound parasite (Madrid *et al*., 2024).

Considering the optimal temperature for conidia germination and the fact that the average temperature in July was 22.04°C, climatic conditions provided a favourable environment for the development of *Monilinia fructigena*.

The favourable climate during the fruit ripening period, with temperatures between 21–22°C and high humidity, created optimal conditions for the development of *Monilinia fructigena*. The wind contributed to the dispersion of spores, while the affected trees served as a primary source of infection for other crops (Xu *et al.,* 2001).

Beyond climatic conditions, another key factor influencing the evolution of fungal infections is the application of plant protection treatments. In the orchard, these were predominantly applied preventively, according to the principles of Integrated Disease Management (IDM) (Elmer *et* Michailides, 2007; Holb, 2008).

The application of preventive treatments, in accordance with the principles of integrated disease management, significantly reduced the frequency and intensity of the attack, keeping the level of damage below the economic threshold (<5%).

The aim of these interventions was to prevent and control species-specific diseases and pests, as well as to ensure balanced nutrition to support healthy tree development and high-quality production (Madrid *et al.*, 2024).

However, plant protection treatments do not eliminate the infection; they only reduce the risk of occurrence and its severity. Treatment efficacy may decrease if applied late or if only preventive, without curative action. Frequent rainfall and moderate temperatures can also diminish the effect of active substances by washing away the protective coating (Holb *et al*., 2007). Incorrect dosing, uneven spraying, faulty equipment, or repeated use of the same active substance can contribute to the development of fungal resistance to applied treatments (Leroux *et al*., 2010).

Thus, the comparative analysis of the two orchards shows that integrated disease management, combined with timely treatments and proper maintenance, significantly contributes to reducing the incidence and severity of *Monilinia fructigena* attacks. Moreover, the results confirm that old orchards serve as a major source of inoculum for new crops, emphasizing the need for strict cultural hygiene and preventive control measures (Holb, 2008; Madrid *et al*., 2024).

CONCLUSIONS

The apple orchards at the Rusciori Didactic and Research Farm, evaluated during the 2024 season proved to be in a favourable status of development, and presenting low levels of infection for brown rot (*Monilinia fructigena*). The old orchard lacking regular maintenance for the past 15 years, was more vulnerable to diseases (e.g. brown rot produced by *Monilinia fructigena*, apple scab produced by *Venturia inaequalis* and powdery mildew produced by *Podosphaera leucotricha*, while the new orchard showed minimal rate of infection.

The implementation of integrated disease management, combined with preventive treatments and appropriate maintenance, kept the infection rate below 5%, proving the effectiveness of the phytosanitary measures. The environmental factors such as temperature, humidity and wind are supporting the burst of infection disease especially for the old orchard.

Our results clearly support the need for continuous monitoring, preventive application of phytosanitary measures, as well as targeted interventions when is required for orchard protection.

Continuing research for these old and new orchards would be relevant for understanding under these microclimatic conditions the basis of interaction mechanisms among multiple diseases that will further support the best management strategies to fight against these apple tree diseases.

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