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PHYSIOLOGICAL CHARACTERISTICS OF SOME FRUIT TREE SPECIES AFFECTED BY FUNGAL PATHOGENS

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ABSTRACT

This study analyzed the physiological effects of the pathogens Venturia inaequalis (Cooke) Winter on Malus domestica (Suckow) Borkh. and Stigmina carpophila (Lév.) M.B. Ellis on Prunus armeniaca L. Pathogen attack reduced the photosynthetic rate in both species due to the appearance of necrotic leaf lesions, a decrease in photosynthetic surface area, and structural damage; concurrently, the transpiration rate declined as a result of disrupted water balance, associated with tissue damage, reduced leaf area, and altered stomatal activity. Infected leaves also exhibited a slight decrease in water content, accompanied by an increase in dry matter content. Chlorophyll content decreased by 10.8 % in Malus domestica and by 6.9 % in Prunus armeniaca. The results indicate that both pathogens negatively affected photosynthesis, water relations, and assimilatory pigment content, with the physiological impact being more pronounced in apple trees infected by Venturia inaequalis.

INTRODUCTION

This research focuses on two economically important species of the *Rosaceae* family: the apple tree (*Malus domestica* (Suckow) Borkh.), attacked by *Venturia inaequalis* (Cooke) G. Winter, and the apricot tree (*Prunus armeniaca* L.), attacked by *Stigmina carpophila* (Lév.) M.B. Ellis.

Fruit tree productivity depends on maintaining a functional balance among photosynthetic carbon assimilation, transpiration, water status, mineral nutrition, and biomass accumulation. Among the numerous factors capable of disrupting this balance, pathogens are particularly significant, as they can affect both structural integrity and physiological activity. Infection can induce changes in primary metabolism, gas exchange, water status and photosynthetic pigment content, ultimately impacting vegetative growth, fruit development and yield (Berger et al. 2007, Cheaib & Killiny 2025, Grimmer et al. 2012, Zhang et al. 2022).

Photosynthesis is the physiological process most sensitive to attack by pathogens. The pathogen infection was associated with a reduction in the photosynthesis rate.

Pathogens also affected photosynthetic pigments; the decrease in chlorophyll content in affected plants may be due to chloroplast degradation, premature senescence, or the direct destruction of mesophyll tissues.

Apple scab, caused by *Venturia inaequalis*, is present in most major apple-growing regions and is particularly favored by low-temperature and high-humidity conditions during leaf and young fruit development (González-Domínguez et al. 2017). After penetrating the cuticle, the pathogen develops predominantly in the subcuticular space, where fungal stromata expand. The close association with epidermal tissues leads to the appearance of characteristic olive-green to dark scab lesions on leaves and fruit.

Shot-hole disease, caused by *Stigmina carpophila*, affects leaves, fruits, shoots, and buds. On apricot leaves, the infection begins with small reddish or purplish spots that expand and become necrotic. Subsequently, the central necrotic tissue separates from the surrounding healthy tissue and falls away, giving the leaf a characteristic "shot-hole" appearance. Fruit infection can cause corky or scab-like lesions and significantly reduce the commercial quality of the fruit (Farooq et al. 2023, Hussain et al. 2023, Xu et al. 2026).

MATERIAL AND METHODS

The assessment of the infestation and the physiological measurements were conducted on June 20th, 2025, taking into account the climatic conditions of the Oltenia region.

The Oltenia region is located in southwestern Romania and is characterized by marked geographical diversity, extending from the Danube floodplain and the Oltenia Plain in the south to the Getic Plateau, the Sub-Carpathian hills, and the Southern Carpathians in the north.

The regional climate is predominantly temperate-continental. The low-lying areas in the south are generally characterized by higher temperatures and greater exposure to water deficit, whereas the hilly and mountainous areas in the north experience lower temperatures and higher precipitation levels. Recent studies indicate a clear warming trend in Oltenia and highlight the increasing significance of drought and heat stress for cultivated vegetation (Crișu et al. 2025, Dumitrașcu et al. 2018, Licurici et al. 2025).

Photosynthesis and transpiration rates were determined using the ultra-compact photosynthesis measurement system (LCi), which offers the advantage of allowing leaves to remain attached to the plant, thereby facilitating repeated measurements at different time intervals.

Water and dry matter contents were determined using gravimetric methods. Chlorophyll content was analyzed using a Minolta SPAD 502 chlorophyll meter.

The plant material analyzed in this study consisted of the species *Malus domestica* (Suckow) Borkh. and *Prunus armeniaca* L.

Malus domestica (Suckow) Borkh. is native to Central Asia and is widely cultivated in temperate regions. It features a well-developed root system and a branched crown, with simple, alternately arranged leaves ranging in shape from elliptical to ovate. The hermaphroditic flowers are clustered in corymbs and possess five petals, varying in color from white to pink, as well as numerous stamens. The fruit is a pome, characterized by considerable variability in size, shape, and color depending on the cultivar (Rieger 2006).

Prunus armeniaca L. is native to Central and East Asia and is currently cultivated in numerous temperate regions. It develops a relatively deep root system and a heavily branched crown, with simple, alternately arranged leaves ranging in shape from ovate to elliptical. The flowers are typically solitary or clustered, featuring

five petals in shades ranging from white to pale pink and numerous stamens. The fruit is a fleshy drupe, usually yellow to orange in color, containing a lignified endocarp that encloses the seed (Lu & Bartholomew 2003, Rieger 2006).

RESULTS AND DISCUSSIONS

The aim of this study was to evaluate the effects of pathogen infection on physiological processes in *Malus domestica* (Suckow) Borkh. attacked by *Venturia inaequalis* (Cooke) Winter and in *Prunus armeniaca* L. attacked by *Stigmina carpophila* (Lév.) M.B. Ellis [syn. Wilsonomyces carpophilus (Lév.) Adaskaveg, Ogawa & Butler].

Venturia inaequalis (Cooke) Winter, the causal agent of apple scab, develops primarily in the subcuticular region of young host plant tissues, favored by conditions of low temperature and high humidity. The fungus overwinters in fallen infected leaves, where pseudothecia containing asci and ascospores are formed. In spring, ascospores are released, serving as the primary source of infection. Subsequently, conidia formed on infected tissues cause repeated secondary infections throughout the growing season (Gauthier 2018, MacHardy 1996, Steiner & Oerke 2024). The conidia are pyriform in shape, with a smooth surface and an olive-brown color, and are produced at the tips of the conidiophores (Figure 1).

On young leaves, initial symptoms consist of pale green areas that gradually develop into characteristic, velvety lesions ranging in color from olive-green to dark brown, resulting from the formation of conidia and conidiophores (Gauthier 2018, MacHardy 1996). As the disease progresses, the lesions expand and darken, and severely affected leaves become deformed and drop prematurely (Figure 2).

On fruit, infection initially appears as small, velvety, olive-green or brown spots, which later transform into dark, corky lesions. Early infection of young fruit impairs normal tissue development, causing deformation, skin cracking, and premature fruit drop. Consequently, severe infection can significantly reduce both fruit yield and commercial quality (Gauthier 2018, Gessler et al. 2006).



Figura 1. *Venturia inaequalis* (Cooke) Winter - pyriform conidia - (Original).



Figure 2. The leaves of the *Malus domestica* (Suckow) Borkh. attacked by *Venturia inaequalis* (Cooke) Winter - (Original).

Stigmina carpophila (Lév.) M.B. Ellis is a pathogenic fungus responsible for the disease known as shot-hole. The pathogen produces fusiform conidia, generally characterized by the presence of three to four septa (Figure 3).

The fungus survives primarily in infected buds, shoots, and necrotic tissues. Infection can occur on leaves, fruit, shoots, buds, and other young tissues. On leaves, the initial symptoms appear as small, circular spots ranging in color from reddish-purple to brown, often surrounded by a yellowish or chlorotic halo. As the lesions progress, the central tissue becomes necrotic and detaches, leaving behind a perforation (Figure 4). Under severe infection, numerous lesions may coalesce and premature defoliation can occur (Shi et al., 2025; Ye et al., 2020).

On fruit, the infection causes small, reddish or brown lesions, often slightly sunken, that gradually expand and take on a corky appearance.



Figura 3. *Stigmina carpophila* (Lév.) M.B. Ellis - conidia (Original).



Figure 4. The leaves of the *Prunus armeniaca* L. attacked by *Stigmina carpophila* (Lév.) M.B. Ellis - (Original).

The assessment of pathogen attack revealed higher values for apple trees affected by *Venturia inaequalis* compared to apricot trees affected by *Stigmina carpophila.* The degree of attack was 9.60 % for apple trees, whereas lower values were recorded for apricot trees, with a degree of attack of 6.63 % (Figure 5).

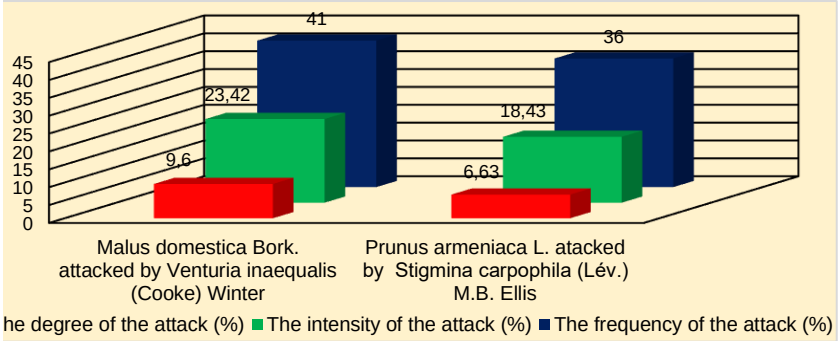


Figure 5. Estimation of the attack produced by pathogen on fruit tree species

The diurnal dynamics of photosynthesis and transpiration rates, as well as water, dry matter, and chlorophyll content, were analyzed for both attacked leaves by pathogen and unattacked leaves.

Diurnal dynamics of photosynthesis. In the analyzed species, the photosynthetic rate exhibited a similar diurnal pattern: it increased from morning until midday, followed by a gradual decline towards evening.

In *Malus domestica* leaves attacked by *Venturia inaequalis* showed lower photosynthesis rates compared to unattacked leaves. At midday, peak values reached 15.21 µmol CO_2 m^{-2} s^{-1} for unattacked leaves and 14.18 µmol CO_2 m^{-2} s^{-1} for those attacked leaves (Figure 6). The pathogen reduced the photosynthetic rate due to the reduction of functional leaf area and the alteration of photosynthetic tissues caused by lesions characteristic of apple scab (Gessler et al. 2006, MacHardy 1996).

In *Prunus armeniaca* leaves attacked by *Stigmina carpophila* exhibited lower photosynthetic rates. At midday, peak values were 12.35 µmol CO_2 m^{-2} s^{-1} for unattacked leaves and 11.72 µmol CO_2 m^{-2} s^{-1} for attacked leaves (Figure 7). The pathogen reduced the photosynthetic rate as a result of necrotic leaf lesions, reduced photosynthetic surface area, and structural damage induced by the "shot-hole" disease (Shi et al. 2025; Ye et al. 2020).

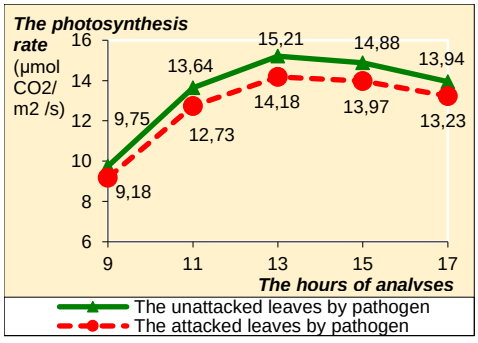


Figure 6. The photosynthesis rate in the leaves of *Malus domestica (Suckow) Borkh.* - the attack produced by *Venturia inaequalis (Cooke) Winter.*

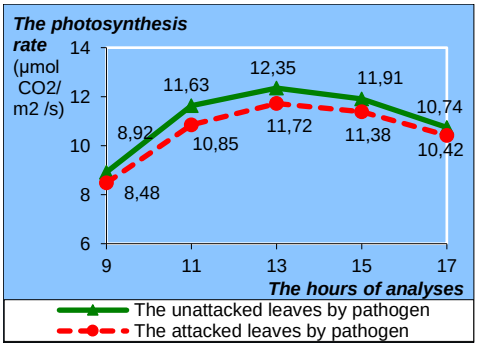


Figure 7. The photosynthesis rate in the leaves of *Prunus armeniaca L.* - the attack produced by *Stigmina carpophila (Lév.) M.B. Ellis.*

Diurnal dynamics of transpiration. The transpiration rate increased from the morning hours to a maximum value at midday, followed by a gradual decline towards evening. Attacked leaves exhibited lower transpiration rates throughout the day.

In *Malus domestica* leaves attacked by *Venturia inaequalis* the transpiration rate was lower. Peak values were 4.89 mmol H_2O m^{-2} s^{-1} for unattacked leaves and 4.62 mmol H_2O m^{-2} s^{-1} for those attacked leaves (Figure 8). The transpiration rate in attacked leaves decreased due to tissue damage, a reduction in functional leaf area and altered stomatal activity (Gessler et al. 2006, MacHardy 1996).

In *Prunus armeniaca* the transpiration rate of attacked leaves was lower throughout the day. At midday, peak values were 3.87 mmol H_2O m^{-2} s^{-1} for unattacked leaves and 3.56 mmol H_2O m^{-2} s^{-1} for those attacked leaves (Figure 9).

Pathogen attack reduced the transpiration rate due to the appearance of necrotic lesions and the loss of functional leaf tissue (Xu et al. 2026, Ye et al. 2020).

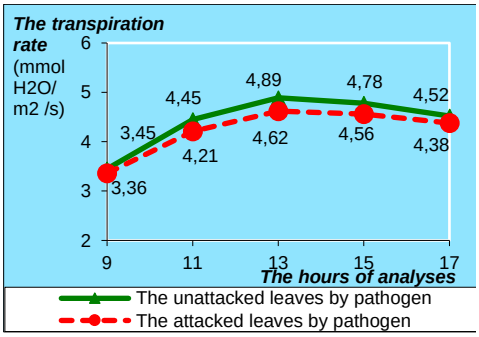


Figure 8. The transpiration rate in the leaves of *Malus domestica (Suckow) Borkh.* - the attack produced by *Venturia inaequalis (Cooke) Winter.*

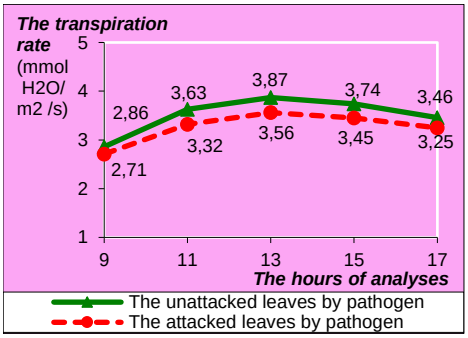


Figure 9. The transpiration rate in the leaves of *Prunus armeniaca L.* - the attack produced by *Stigmina carpophila (Lév.) M.B. Ellis.*

Water and Dry Matter Content. The water and dry matter content of *Malus domestica* leaves was only slightly influenced by the attack of the pathogen *Venturia inaequalis*. Unattacked leaves contain 76.43 % water and 23.57 % dry matter, whereas leaves attacked by the pathogen contain 75.88 % water and 24.12 % dry matter (Figure 10).

The water and dry matter content of *Prunus armeniaca* leaves showed minor changes following the attack of the pathogen *Stigmina carpophila*. Unattacked leaves contain 68.74 % water and 31.26 % dry matter, while attacked leaves show 68.32 % water and 31.68 % dry matter (Figure 11).

Pathogen attack in the analyzed species resulted in a slight decrease in water content, accompanied by an increase in dry matter content. These changes can lead to water and metabolic imbalances in the host plants.

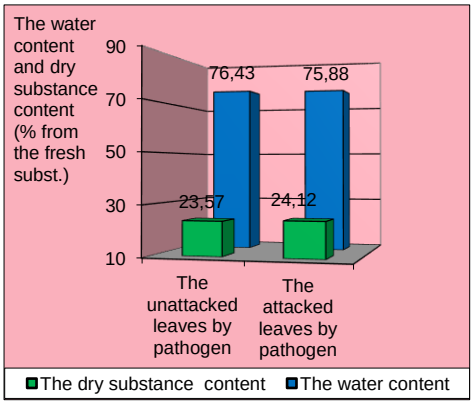


Figure 10. The water content and the dry substance content in leaves of *Malus domestica (Suckow) Borkh.* - the attack produced by *Venturia inaequalis (Cooke) Winter.*

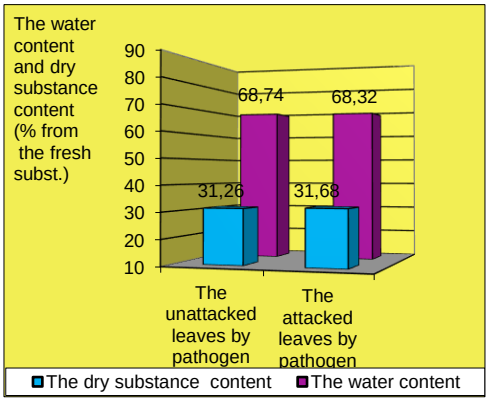


Figure 11. The water content and the dry substance content in leaves of *Prunus armeniaca L.* - the attack produced by *Stigmina carpophila (Lév.) M.B. Ellis.*

Chlorophyll content. In *Malus domestica* the attack by *Venturia inaequalis* reduced chlorophyll content from 58.6 SPAD units in unattacked leaves to 52.3 SPAD units in those attacked leaves, corresponding to a decrease of approximately 10.8 %. In *Prunus armeniaca* the attack by *Stigmina carpophila* reduced chlorophyll content from 42.3 to 39.4 SPAD units, representing a decrease of approximately 6.9 % (Figure 12).

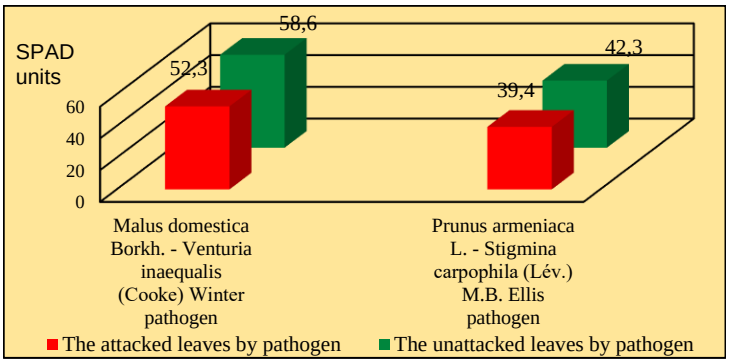


Figure 12. Chlorophyll content in leaves of the *Malus domestica (Suckow) Borkh.* and the *Prunus armeniaca L.*

A reduction in chlorophyll content can be associated with the development of chlorotic and necrotic tissues, changes in chloroplasts and a reduction in photosynthetic surface area.

CONCLUSIONS

The results showed that both *Venturia inaequalis* on *Malus domestica* and *Stigmina carpophila* on *Prunus armeniaca* negatively affected physiological processes. Pathogen attack reduced photosynthetic activity due to necrotic leaf lesions, alteration of leaf tissues, and a decrease in the photosynthetically active leaf area. The transpiration rate in infected leaves decreased due to tissue damage, the reduction of functional leaf area, and changes in stomatal activity. Water content showed a slight reduction in infected leaves, accompanied by an increase in dry matter content, indicating moderate changes in leaf water balance and tissue composition. Chlorophyll content decreased in leaves attacked by the pathogens in both species, by 10.8 % in *Malus domestica* and 6.9 % in *Prunus armeniaca*.

Pathogen attacks affected carbon assimilation, transpiration, and leaf water, dry matter, and chlorophyll content in both species, with consequences for the growth and development of the fruit trees.

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