ANNALS OF THE UNIVERSITY OF CRAIOVA

Series: ✓*Biology*
✓*Horticulture*
✓*Food products processing technology*
✓*Environmental engineering*

Vol. XXXI (LXVII) - 2026

EFFECTS OF PATHOGENS ON PHYSIOLOGICAL PROCESSES IN SOME SOLANACEOUS VEGETABLE PLANTS

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Keywords*: attacked leaves, pathogen, photosynthesis, transpiration.*

ABSTRACT

This study presents the effects of the pathogens Phytophthora infestans (*Mont.) de Bary on Solanum lycopersicum L. and Alternaria solani (Ellis & Martin) Sorauer on Solanum melongena L., focusing on alterations to physiological processes. The attack produced by the pathogen reduced the photosynthesis rate in both species due to the appearance of chlorotic and necrotic zones and the loss of functional leaf area, while transpiration decreased as a result of changes in stomatal regulation, reduced functional leaf area, and disruptions to the plant's water balance. Leaves attacked by the pathogens exhibited lower water content and a corresponding increase in dry matter content, as well as reduced chlorophyll content. The results indicate that both pathogens negatively affected carbon assimilation, water relations, and chlorophyll content, with the physiological impact generally being more pronounced in tomato plants attacked by Phytophthora infestans (Mont.) de Bary.*

INTRODUCTION

Solanum lycopersicum L. and *Solanum melongena* L. are important species of the *Solanaceae* family, and their productivity is strongly influenced by abiotic and biotic stress factors.

Plant-pathogen interactions involve alterations in plant metabolism. Once infection is established, the host plant redirects carbon resources, energy, and metabolites away from growth and development processes toward defense mechanisms. This phenomenon affects both primary and secondary metabolism, potentially leading to changes in photosynthesis, respiration and carbohydrate metabolism (Berger et al. 2007, Cheaib & Killiny 2025). The research conducted has demonstrated that the pathogen infection generally leads to reduced photosynthetic efficiency, caused by the destruction of photosynthetically active tissue, the degradation of photosynthetic pigments, stomatal limitations, the disruption of chloroplast structure and function, and the impairment of biochemical reactions involved in the process.

Studies conducted by Zhang et al. (2022) demonstrated that biotic disturbances significantly reduced the net photosynthesis rate. Changes in photosynthesis were

positively correlated with variations in stomatal conductance and transpiration, while the content of photosynthetic chlorophyll pigments was also affected.

Photosynthesis and transpiration are essential processes for assessing pathogen-induced stress. Foliar pathogens can affect stomata either directly, through structural damage to epidermal tissues, or indirectly by altering tissue hydration and the host plant's defense mechanisms.

Water content determines cell turgescence and influences transpiration, nutrient transport, and metabolic processes. These changes in tissue hydration also affect the dry matter content of plant organs.

Chlorophyll content is another useful indicator of disease-induced physiological changes. Chlorophyll degradation can occur as a result of chloroplast damage, accelerated senescence, and the destruction of leaf tissues. Thus, integrating chlorophyll measurements with gas exchange parameters allows for a more comprehensive assessment of the effects of pathogens on the photosynthetic apparatus (Cheaib & Killiny 2025, Lu & Yao 2018, Zhang et al. 2022).

Among the diseases affecting tomatoes, late blight, caused by *Phytophthora infestans* (Mont.) de Bary,is one of the most significant. Physiological studies conducted on pathogen-infected tomato plants have revealed changes in the daily dynamics of photosynthesis and transpiration, as well as a reduction in tissue water content and chlorophyll pigment concentrations (Nicolae 2008).

In eggplants infection by *Alternaria solani* (Ellis & Martin) Sorauer, which causes early blight (brown spot), manifests as progressive necrotic lesions that reduce the leaf area active in photosynthesis. Beyond the direct destruction of tissue, this infection alters the plant's physiological, biochemical and metabolic processes.

Pronounced effects of *Alternaria solani* on eggplant photosynthetic pigments were also reported by Attia et al. (2022), who observed reductions of approximately 63.9 % for chlorophyll a and 60.9 % for chlorophyll b compared to healthy plants.

MATERIAL AND METHODS

The assessment of attacks caused by the *Phytophthora infestans* (Mont.) de Bary on *Solanum lycopersicum* L. and *Alternaria solani* (Ellis & Martin) Sorauer on *Solanum melongena* L., as well as the physiological analyses, were conducted on July 10th, 2025, taking into account the climatic conditions of the Oltenia region.

The Oltenia region is located in southwestern Romania and covers an area of approximately 29,212 km², representing about 12.25 % of the country's territory. Its topography is highly diverse, extending from the Danube floodplain and the lowlands of the Oltenia Plain in the south to the hilly areas, the Sub-Carpathians, and the Southern Carpathians in the north. Consequently, the altitude ranges from approximately 30 m in the southern lowlands to over 2,500 m in the Parâng Mountains (Licurici et al. 2025).

Climatic conditions vary considerably depending on altitude and geographical location. The southern part of Oltenia is characterized by a temperate-continental climate with Mediterranean influences, generally associated with hot summers, relatively mild winters, and annual precipitation of approximately 500-600 mm in the plain area (Dumitrașcu et al. 2018).

Photosynthesis and transpiration rates were determined using the LCi portable, ultra-compact photosynthesis measurement system.

Water content and dry matter content were determined using gravimetric methods.

Chlorophyll content was analyzed using a Minolta SPAD 502 chlorophyll meter.

Solanum lycopersicum L. (tomato) and *Solanum melongena* L. (eggplant) are frequently used in physiological and phytopathological studies, as their growth and productivity are strongly influenced by environmental conditions and by biotic and abiotic stress factors (Flores-Saavedra et al. 2023).

Solanum lycopersicum L. is native to South America. The plant develops a branched stem and an extensive root system, comprising both primary and adventitious roots. The leaves are alternate, compound, and pubescent, featuring glandular and non-glandular trichomes involved in plant protection and the production of secondary metabolites (Liu et al. 2022). The flowers are arranged in cyme-type inflorescences. The fruit is a fleshy berry, the shape, size and color of which vary considerably depending on the cultivar.

Solanum melongena L. (eggplant) originates from Africa, from where it subsequently spread to tropical Asia. It is a heavily branched herbaceous plant with a relatively deep root system. The stems and leaves are characteristically covered with stellate trichomes. The leaves are simple and alternately arranged, generally ovate in shape with entire, sinuate, or lobed margins. The flowers are predominantly hermaphroditic, usually violet or purple. Depending on the cultivar, the fruits may be globose, ovoid, cylindrical, or elongated, and the skin can be white, green, violet, purple, nearly black, or variously striped (Knapp et al. 2013).

RESULTS AND DISCUSSIONS

The aim of this study was to evaluate the effects of the pathogens *Phytophthora infestans* (Mont.) de Bary and *Alternaria solani* (Ellis & Martin) Sorauer on the physiological processes of certain vegetable plants.

Phytophthora infestans is the causal agent of late blight, one of the most destructive diseases affecting tomatoes worldwide. The pathogen initially develops within the host plant tissues, subsequently causing their necrosis. Asexual reproduction occurs via sporangia produced on sporangiophores (Figure 1).

Depending on environmental conditions, the sporangia may germinate directly or release motile zoospores. Disease progression and spread are particularly favored by low temperatures, high relative humidity, precipitation, and prolonged moisture retention on the leaf surface (Nowicki et al. 2012, Leesutthiphonchai et al. 2018).

On tomato leaves, initial symptoms generally consist of irregular, water-soaked lesions ranging in color from pale green to olive green; these expand and turn brown, causing extensive leaf necrosis, wilting, and premature death. Under high-humidity conditions, characteristic whitish sporulation may appear, particularly on the underside of the leaf. On stems, the pathogen produces elongated, irregular lesions ranging from dark brown to almost black, which can extend along the stem. Lesions of various shapes and colors, ranging from olive green to dark brown, appear on the fruit and can spread across the fruit's surface. Under humid conditions, whitish sporulation may also appear on the affected areas, and various microorganisms may subsequently colonize the damaged tissue.

Alternaria solani causes early blight (or brown spot) in eggplants. The pathogen produces multicellular, pigmented conidia that are primarily disseminated by wind and rain and germinate on susceptible plant tissues (Figure 2).

Disease development is generally favored by high temperatures combined with high humidity and periods of prolonged leaf wetness (Schmey et al. 2024, Attia et al. 2022).



Figura 1. *Phytophthora infestans* (Mont.) de Bary - sporangiophores with sporangia (Original).



Figura 2. *Alternaria solani* (Ellis & Martin) Sorauer - conidia (Original).

The infection typically begins on the basal leaves, initially manifesting as small, circular necrotic spots; as the lesions expand, concentric circles form.

The lesions are often surrounded by a yellow or chlorotic halo. Under favorable conditions, adjacent lesions may coalesce, causing the leaf blade to dry out and leading to premature defoliation. On stems and shoots, the disease may manifest as small, brown lesions that expand to become circular or elongated, often displaying concentric zonation. Severe infection can result in leaf necrosis and defoliation, reduced photosynthetic capacity, and impaired plant growth, ultimately compromising crop productivity and quality (Attia et al. 2022, Danish et al. 2025).

Assessment of pathogen attack indicates a severe infection in *Solanum lycopersicum* attacked by *Phytophthora infestans*, compared to *Solanum melongena* attacked by *Alternaria solani*. In the case of tomatoes, the attack frequency reached 35 %, the intensity was 29.14 %, and the resulting degree of attack was 10.19 %. Considerably lower values were recorded for eggplants: an attack frequency of 16 %, an intensity of 14.85 % and a degree of attack of 2.37 % (Figure 3).

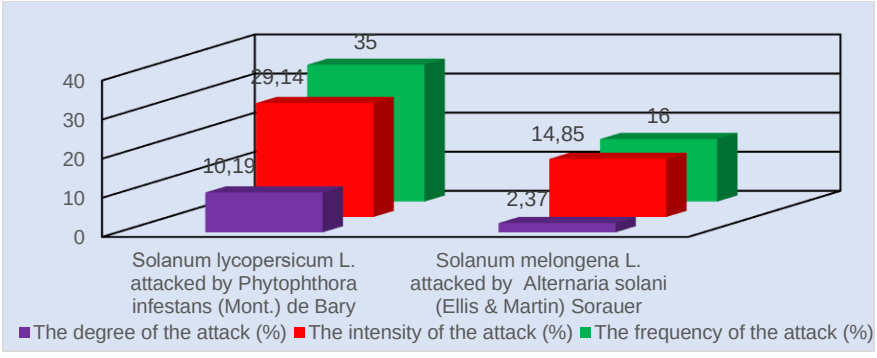


Figure 3. Estimation of the attack produced by pathogens on vegetable species

Plants attacked by the pathogen and those not attacked were compared by analyzing the diurnal dynamics of photosynthesis and transpiration rates, as well as by determining tissue water content, dry matter content and chlorophyll content. Through an integrated assessment of gas exchange, water status, and photosynthetic pigments, the study seeks to characterize the physiological effects of pathogen infection and to outline the relationships between disease progression and the functional performance of these economically important crops.

Diurnal dynamics of photosynthesis. The photosynthesis rate showed a similar diurnal pattern in both unattacked leaves and those attacked by pathogens.

In *Solanum lycopersicum* leaves attacked by *Phytophthora infestans*, the photosynthesis rate increased from morning until midday and then gradually declined towards evening. The maximum photosynthesis rate reached at midday was 10.21 µmol CO_2 m^{-2} s^{-1} in unattacked leaves and 9.18 µmol CO_2 m^{-2} s^{-1} in those attacked by the pathogen (Figure 4). Pathogen infection reduced the average photosynthetic rate, and this reduction can be attributed to the appearance of chlorotic and necrotic lesions, the loss of functional leaf area, and the disruption of photosynthetic processes (Nowicki et al. 2012, Leesutthiphonchai et al. 2018).

In *Solanum melongena* leaves attacked by *Alternaria solani*, the photosynthesis rate also increased until midday and then decreased towards evening. The maximum values recorded at midday were 10.86 µmol CO_2 m^{-2} s^{-1} for unattacked leaves and 10.26 µmol CO_2 m^{-2} s^{-1} for those attacked by the pathogen (Figure 5). Infection reduced the average photosynthetic rate, indicating moderate impairment of the assimilation process, likely associated with tissue damage and alterations in photosynthetic activity (Attia et al. 2022, Schmey et al. 2024).

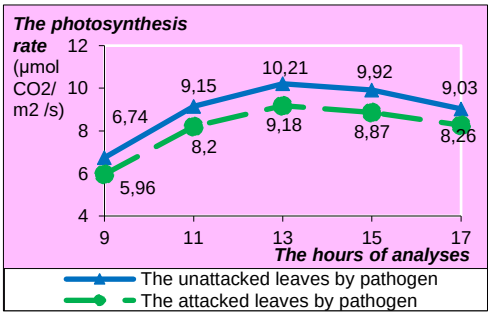


Figure 4. The photosynthesis rate in the leaves of *Solanum lycopersicum* L. - the attack produced by *Phytophthora infestans* (Mont.) de Bary.

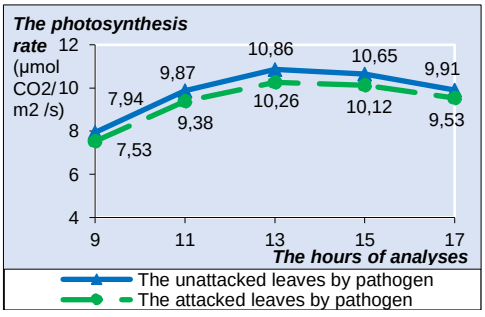


Figure 5. The photosynthesis rate in the leaves of *Solanum melongena L.* - the attack produced by *Alternaria solani* (Ellis & Martin) Sorauer

Diurnal dynamics of transpiration. The transpiration rate also exhibited a similar diurnal variation in both unattacked and attacked leaves by pathogen.

In *Solanum lycopersicum* attacked by *Phytophthora infestans*, the transpiration rate rose to a peak at midday and then gradually declined towards evening. Peak values were 2.98 mmol H_2O m^{-2} s^{-1} for unattacked leaves and 2.65 mmol H_2O m^{-2} s^{-1} for attacked leaves (Figure 6). The infection reduced the transpiration rate, a result that may reflect changes in stomatal regulation, a

reduction in functional leaf area, and disruptions to the plant's water balance (Nowicki et al. 2012, Leesutthiphonchai et al. 2018).

In *Solanum melongena* attacked by *Alternaria solani* the transpiration rate increased from the morning hours to a maximum value at midday and then gradually decreased. The maximum values were 3.25 mmol H_2O m^{-2} s^{-1} for unattacked leaves and 2.84 mmol H_2O m^{-2} s^{-1} for those attacked by the pathogen (Figure 7).

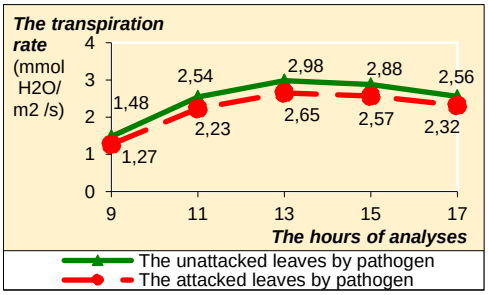


Figure 6. The transpiration rate in the leaves of *Solanum lycopersicum* L. - the attack produced by *Phytophthora infestans* (Mont.) de Bary.

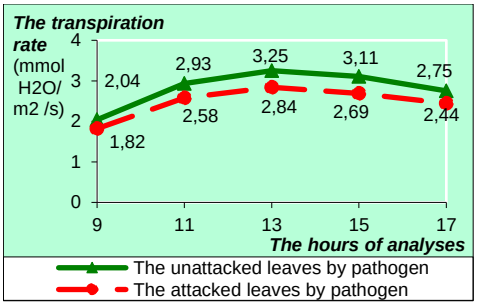


Figure 7. The transpiration rate in the leaves of *Solanum melongena L.* - the attack produced by *Alternaria solani* (Ellis & Martin) Sorauer.

Infection reduced the average transpiration rate, indicating an alteration in the plant's water status, likely associated with pathogen-induced leaf tissue damage and changes in stomatal functioning (Attia et al. 2022, Alhaithloul et al. 2019).

Water and dry matter content. Infection of *Solanum lycopersicum* leaves by the *Phytophthora infestans* resulted in a decrease in water content and a corresponding increase in dry matter content. Unattacked leaves contain 79.68 % water and 20.32 % dry matter, whereas leaves attacked by the pathogen contain 78.53 % water and 21.47 % dry matter (Figure 8). These changes suggest an alteration in the water balance and tissue composition of the leaves, likely associated with cellular damage, necrosis, and the disruption of normal physiological processes (Nowicki et al. 2012, Whisson et al. 2016).

The water and dry matter content of *Solanum melongena* leaves underwent slight changes following infection by *Alternaria solani*. Unattacked leaves contain 82.74 % water and 17.26 % dry matter, while leaves attacked by the pathogen contain 81.86 % water and 18.14 % dry matter (Figure 9).

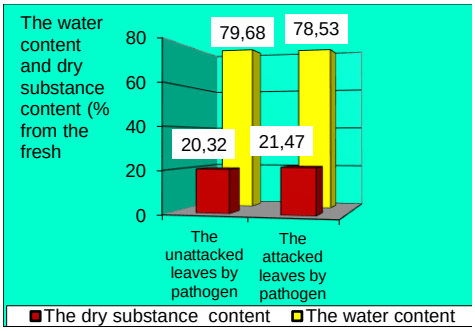


Figure 8. The water and the dry substance content in leaves of *Solanum lycopersicum* L. - the attack produced by *Phytophthora infestans* (Mont.) de Bary.

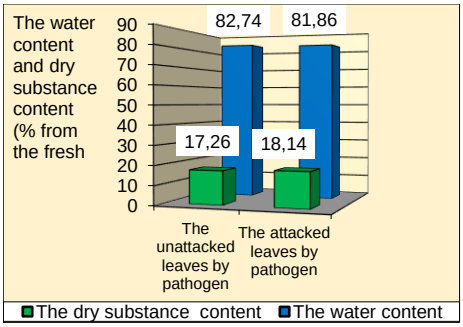


Figure 9. The water and the dry substance content in the leaves of *Solanum melongena L.* - the attack produced by *Alternaria solani* (Ellis & Martin) Sorauer

Chlorophyll content. Chlorophyll content was lower in pathogen-attacked leaves for both plant species. In the case of *Solanum lycopersicum* infection with *Phytophthora infestans* reduced chlorophyll content from 57.4 SPAD units in unattacked leaves to 53.1 SPAD units in those attacked by the pathogen, corresponding to a decrease of approximately 7.5 %.

Similarly, in *Solanum melongena*, chlorophyll content dropped from 62.1 to 58.3 SPAD units following the attack by *Alternaria solani*, representing a reduction of approximately 6.1 % (Figure 10).

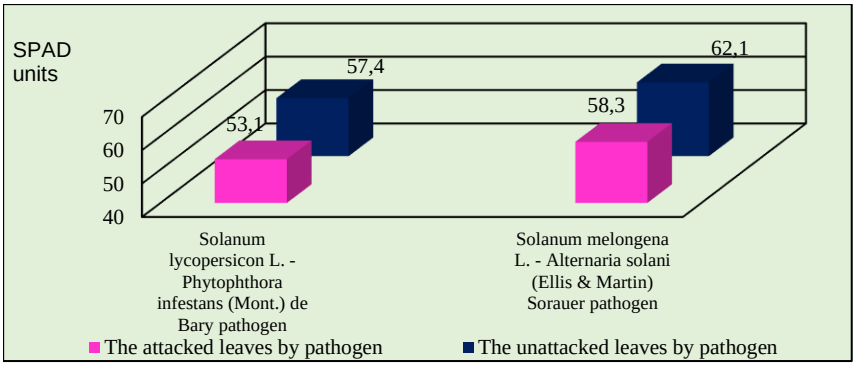


Figure 10. Chlorophyll content in leaves of the *Solanum lycopersicum* L. and the *Solanum melongena* L.

These results indicate that pathogen attack negatively affects chlorophyll content, likely due to chloroplast damage, tissue chlorosis and necrosis, and disruptions to normal photosynthetic metabolism. The reduction in chlorophyll content is consistent with the lower photosynthetic activity observed in infected leaves (Nowicki et al. 2012, Attia et al. 2022).

CONCLUSIONS

The results demonstrate that the pathogen attack negatively affected physiological processes in both *Solanum lycopersicum* and *Solanum melongena* Both pathogens, *Phytophthora infestans* and *Alternaria solani*, reduced photosynthesis and transpiration rates while maintaining the characteristic diurnal variation of these physiological processes. The attack by pathogens led to a decrease in leaf water content, accompanied by a corresponding increase in dry matter content. Chlorophyll content was lower in the attacked leaves, with a reduction of approximately 7.5 % recorded in plants attacked by *Phytophthora infestans* and 6.1 % in those attacked by *Alternaria solani*.

The results indicate that pathogen attack affects carbon assimilation, water status, and chlorophyll content in the analyzed vegetable species.

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