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Effects of powdery mildew (*Sawadaea bicornis* (Wallr.) Miyabe) on photosynthetic process in Tatarian maple (*Acer tataricum* L.)

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Abstract. Damage to woody plants caused by phytopathogenic fungi in urban environments leads to disturbances in photosynthetic processes and reduced plant vitality, which necessitates the search for effective methods for the early diagnosis of physiological changes. The aim of this study was to determine the effectiveness of the chlorophyll fluorescence induction (CFI) method for assessing the functional state

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of the photosynthetic apparatus in leaves of *Acer tataricum* L. infected with *Sawadaea bicornis* (Wallr.) Miyabe. The study was conducted in September 2025 in the city of Dnipro using a portable fluorometer "FLS 10s" to diagnose disturbances in native chlorophyll photosynthesis in living leaves of *A. tataricum*. Measurements were performed on completely undamaged leaves and leaves affected by powdery mildew by more than 50% within the same tree, followed by analysis of the Kautsky curve parameters. The degree of leaf blade damage by phytopathogen was determined visually. Fo, Fm, Fv, the ratio of Fv/Fo and Fv/Fm, as well as the indices (Fm – Fst)/Fst and (Fp –Fo)/Fv were revealed as the most significant parameters. Analysis of these indicators allowed to identify specific changes associated with pathogenic exposure and assess the degree of photosynthetic activity violation. The results obtained indicate that CFI method using the portable device "FLS 10s" is an effective technique for rapid diagnostics of the plant general condition, and allows to perform timely detection of the negative effect of biotic factors. Thus, the analysis of chlorophyll fluorescence parameters can be considered as a powerful and reliable tool for determining the degree of parasitic fungi influence on the host plant and assessing its functional state in urbanised environment

Keywords: plant fungal diseases; fluorescence induction; urban ecosystems; photosynthetic apparatus; biosensors

INTRODUCTION

Urban trees are increasingly exposed to combined climatic and anthropogenic pressures that alter their physiological condition, reduce their vitality, and complicate the management of green spaces. Climate change-induced aridisation affect negatively the growing conditions of trees, restricting their ability to perform environmental and social functions (Blanco *et al.*, 2021). A qualitative assessment of the response of trees to extreme climatic conditions and related changes in their growing sites is an important aspect of urban green space management, as noted by O.M. Kunakh *et al.* (2022). In addition, the urban environment creates a wide range of stressors that have a serious negative impact on vegetation. B. Cui *et al.* (2021) argued that trees growing within urbanised space are affected by multiple unfavourable factors: air pollution from exhaust gases, heavy metal accumulation in the soil, and specific aerodynamics of the city. According to C.E. Aucique-Perez & A.E. Román Ramos (2024), this causes depletion of plant organisms, making them more vulnerable to disease (viral, bacterial, fungal) and pest damage. Despite this, urban ecosystems need to enrich plantings and expand their species composition. In such conditions, the care of green spaces should include modern methods of rapid plant health diagnostics, specifically chlorophyll fluorescence induction (CFI). The CFI method constitutes a critical analytical tool for assessing the physiological status and photosynthetic performance of plants subjected to environmental stressors, as emphasised by Y. Liu *et al.* (2024) and B. Park *et al.* (2024). Maples are some of the most valuable in green construction, forestry, and forest stands among the deciduous tree species growing in the temperate zone. D. Korányi *et al.* (2022) pointed out, that in urban development, plants of the genus *Acer* L. are widely used for construction of park and forest-park phytocenoses, in cluster and single plantings, in landscaping city squares, avenues, and boulevards. Maples are widely considered premier landscaping trees used in industrial, residential and recreational areas due to its high decorative qualities with a seasonal aspect. Their massive crown can perform a sanitary and hygienic function, adsorbing dust and aerogenic pollutants through the leaf surface structures. Today, the species composition of maples is very limited in plantings of various functional purposes, and especially in industrial areas. In Ukraine, Tatarian maple is one of the most common species of the genus *Acer* used in urban landscaping. This is a frost-resistant, shade-tolerant woody species highly tolerated to drought and soil salinity, and is also a nectar-bearing plant. However, like as other species of the genus *Acer*, Tatarian maple is more vulnerable to pathogens in urban conditions. A study by A. Alexeyeva *et al.* (2024) demonstrated that damage by phytopathogenic fungi reduces the decorative effect of maples, and also results in violation of photosynthetic and transpiration processes, causing drying and death of both individual branches and entire trees.

Sawadaea bicornis (Wallroth) Miyabe 1937 is a parasitic fungus causing powdery mildew on young seedlings and adult plants of the genus *Acer*; it is one of the most common plant diseases. At the leaf level, effect of powdery mildew infection strongly depends on the infection time and severity, since the leaf susceptibility to phytopathogen depends on their age. Young foliage and tops of shoots are more vulnerable to damage by *S. bicornis*; so, powdery mildew initially occurs on the tops of plants. In case of severe infection, the foliage and stems are covered with coating followed by their yellowing and drying up. According to R.A. Ramut & W. Pusz (2023), powdery mildew is one of the most destructive plant diseases, especially in the early ontogenesis stages, leading to stunted growth of seedlings, significantly reduced winter hardiness, causes complete premature leaf drop and significantly weakens the plant. Photosynthesis is a universal process of plant survival, and immune defence is a key process of plant adaptation to growing conditions. Various studies have shown that these two processes are interconnected in a complex network. Photosynthesis can influence signalling pathways and provide materials and energy for immune defence, while the immune defence mechanisms can also have feedback effects on photosynthesis (Cheaib & Killiny, 2025).

Modern techniques allow obtaining information on the state of the plant photosynthetic health and assessing the level of environmental factors impact on the plants (Chang *et al.*, 2025). The important advantage of these techniques over others is that they can determine even minor alterations in photosynthetic apparatus activity, and can be applied in the field, quite rapidly and simply. The technique of chlorophyll fluorescence induction is based on detection of changes in chlorophyll fluorescence under intense light following short period of dark adaptation. This technique is enough sensitive and allows to perform a rapid access of alterations in photosynthetic apparatus under the stress and the regeneration potential of intact plants. Thus, it can be used in large-scale ecological research and benefits forestry, agriculture, horticulture and arboristics (Swoczyna *et al.*, 2022). The purpose of the paper was to establish the effectiveness of applying a technique based on estimating the intensity of chlorophyll fluorescence induction to determine the functional state of the photosynthetic apparatus in *S. bicornis*-affected foliage of *A. tataricum*.

MATERIALS AND METHODS

The study was a field comparative study and was aimed at assessing the impact of the biotrophic pathogen *Sawadaea bicornis* (Wallr.) Miyabe on the functional state of the photosynthetic apparatus of *Acer tataricum* L. leaves. The object of the study was the leaves of the Tatar maple, and the subject was changes in the parameters of chlorophyll fluorescence induction upon powdery mildew infection. The study design involved comparing chlorophyll fluorescence indices in unaffected and infected leaves within the same trees. The research presented was conducted during the 2025 growing season in Dnipro city. The region's climate has distinct continental features, and is characterised by seasonal high-temperature droughts and dry, hot winds. A small average precipitation amount (472 mm) decreases in dry years to 250 mm, and the total annual evaporation exceeds annual precipitation by 2-3 times. Here, woody plants grow in conditions of ecological inconsistency and show high sensitivity even to minor changes in climatic factors, as well as to anthropogenic pollution. The Botanical Garden of Oles Honchar Dnipro National University was founded on Dnipro city territory (48°26' N, 35°02' E; 127 m above sea level) in 1931. In the Garden, *A. tataricum* is cultivated, that naturally grow in the Steppe zone of Ukraine. The soil cover is represented by urban soil developed on zonal ordinary low-humus middle loamy chernozems on loess-like loams (Lovynska *et al.*, 2022).

To study the impact of powdery mildew on photosynthesis processes, 10 *A. tataricum* trees, about 10 years old, growing under the same conditions on the territory of the Botanical Garden of Oles Honchar Dnipro National University, were selected. The trees were characterised by a satisfactory general condition, similar morphometric indicators and the same level of crown illumination. The selection of trees was purposeful and was carried out within the same area of plantations. The measurements were carried out in September 2025, which corresponded to the period of maximum activity of *S. bicornis* development on the leaves of Tatar maple. From each tree, 10 completely unaffected and 10 affected leaves were selected, thus the total number of leaves examined was 200. Comparisons of affected and unaffected leaves were performed within the same trees (paired study design). The analysis included fully formed leaves of the same phenological stage without mechanical damage or signs of additional stress. Leaves with visually pronounced development of powdery mildew mycelium on more than 50% of the leaf blade area were considered affected. The degree of damage was determined visually. Leaves were collected from the middle part of the crown on the illuminated side of the tree with the same orientation relative to the light source. Measurements were performed in situ on live leaves between 12:00 and 13:00 under conditions of maximum natural light. Light intensity was measured using a PCE-174 lux meter (PCE Instruments, Germany). Temperature and humidity were recorded using an HE-173 thermohygrometer (Huato Electronic Co. Ltd, China).

To diagnose photosynthetic process disorders, a portable fluorimeter "FLS 10s" (manufacturer: V.M. Glushkov Institute of Cybernetics of the National Academy of Sciences of Ukraine) was used. Before measurement, the leaves were subjected to dark adaptation for 300 s. Chlorophyll fluorescence induction was recorded over a 10-second interval, during which the device automatically generated a Kautsky curve from 470 consecutive signal measurements, in accordance with the method of O. Voronenko (2024). To interpret the Kautsky curve, its established critical parameters were utilised, including Fo – the initial value of fluorescence induction measured immediately after switching on the illumination; Fp – the "plateau" of chlorophyll fluorescence induction; Fm – the maximum value of chlorophyll fluorescence induction; Fst – the steady-state value of chlorophyll fluorescence induction reached after light adaptation of the plant leaf. In addition to the critical parameters of the Kautsky curve, the following calculated variables were employed: Fv = Fm – Fo – variable chlorophyll fluorescence; Fv/Fm – maximum quantum efficiency of photosystem II (PSII); Fv/Fo – maximum yield of PSII primary photochemistry; (Fm – Fst)/Fst – coefficient of photochemical processes efficiency; (Fp – Fo)/Fv – the share of QA acceptors in non-renewable reaction centres PSII (Kautsky & Hirsch, 1931; Kalaji *et al.*, 2016). Statistical comparisons between damaged and undamaged leaves were performed separately for each chlorophyll fluorescence and environmental parameter using linear mixed-effects models. Leaf condition (damaged vs undamaged) was treated as a fixed effect, whereas tree identity was included as a random intercept to account for non-independence among leaves sampled from the same tree. Models were fitted using restricted maximum likelihood, and the significance of leaf condition was assessed by analysis of variance with Satterthwaite's approximation. Model assumptions were evaluated using residual diagnostic plots (Q-Q plots and residual vs fitted plots), and no major violations of normality or homogeneity of variance were detected. For each parameter, the estimated mean difference (undamaged – damaged) ±SE, t-values, F-values, p-values, and marginal R^2 were extracted. To account for multiple comparisons among fluorescence parameters, p-values were additionally adjusted using the Benjamini-Hochberg false discovery rate procedure. All statistical analyses were conducted in R Core Team (n.d.) using the packages lme4, lmerTest, emmeans, and performance.

RESULTS AND DISCUSSION

Undamaged tree leaves showed higher values of the main chlorophyll fluorescence parameters, including Fo, Fm, Fp, Fst, and Fv, as well as the ratios Fv/Fo and Fv/Fm compared to damaged leaves (Fig. 1). The most pronounced differences were observed for Fm, Fp, Fst, and Fv, indicating that leaf damage was associated with a marked decline in the functional activity of the photosynthetic apparatus. In particular, lower Fm and Fv values in damaged leaves suggest a reduced capacity of photosystem II for excitation energy capture and photochemical conversion. The decrease in Fv/Fm further indicates a reduction in the potential quantum efficiency of photosystem II, which is commonly interpreted as a sign of physiological stress or photoinhibition. The variability within groups differed among parameters. For the main fluorescence parameters, damaged and undamaged leaves showed some overlap, but their medians and interquartile ranges were clearly shifted, indicating a consistent effect of leaf condition rather than only the influence of individual outliers. Greater within-group variability may reflect differences in the degree of leaf injury, local microenvironmental conditions, leaf age, or tree-level heterogeneity. This supports the use of tree identity as a random effect in the mixed models.

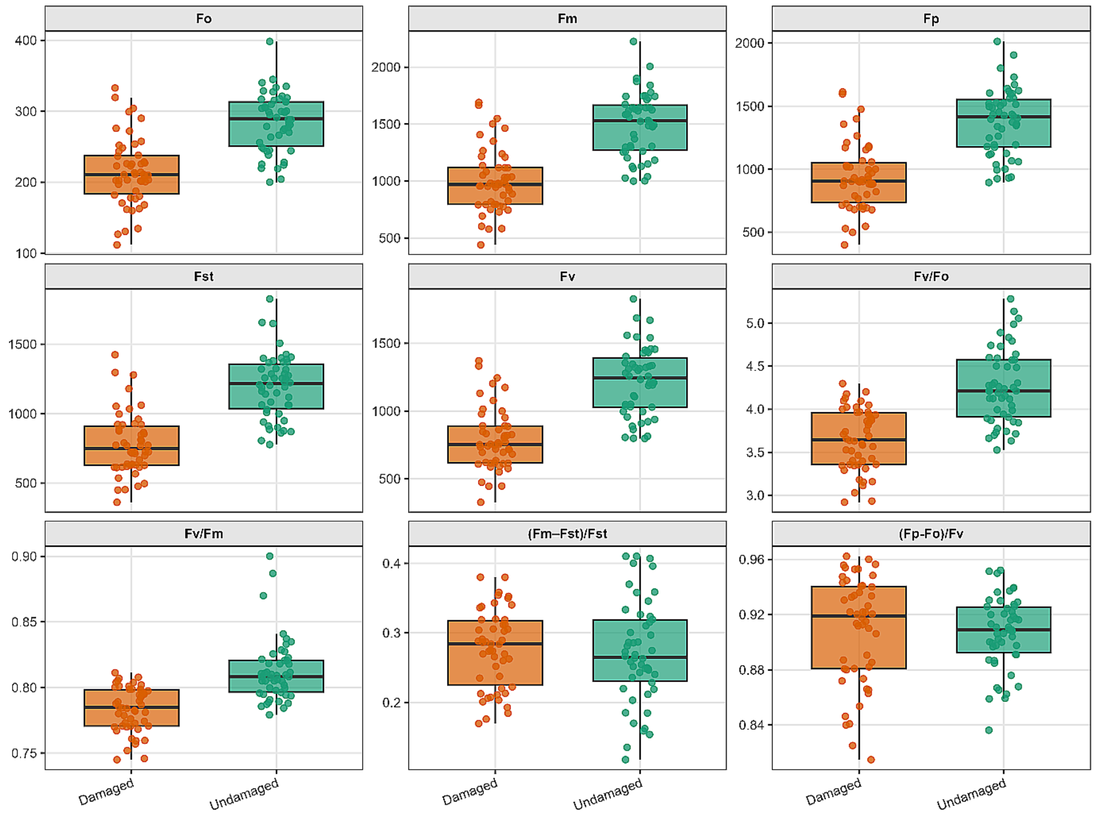

Figure 1. Variation in chlorophyll fluorescence parameters between damaged and undamaged leaves of *A. tataricum*

Source: developed by the authors

The stronger response of Fm, Fst, and Fv may be explained by their direct dependence on the functional state of the chlorophyll fluorescence emission and PSII activity. In contrast, the derived indices (Fm – Fst)/Fst and (Fp – Fo)/Fv showed substantial overlap between damaged and undamaged leaves and were not statistically significant. This may indicate that these ratios are less sensitive to the type of damage observed in this study, or that proportional relationships among fluorescence components were partly preserved despite the overall reduction in absolute fluorescence values. The observed differences are not only statistically significant but also physiologically meaningful. They indicate that visible leaf damage was accompanied by a decline in photosynthetic performance, especially in parameters related to PSII efficiency and variable fluorescence. At the same time, the absence of significant changes in some derived indices suggests that damage affected the overall intensity and efficiency of fluorescence responses more strongly than the relative balance among selected fluorescence components. The statistical analysis showed significant effects of leaf damage on Fo, Fm, Fp, Fst, Fv, Fv/Fo, and Fv/Fm (all $p < 0.001$) (Table 1). Positive mean differences (undamaged – damaged) indicated that these parameters were higher in undamaged leaves vs damaged ones. The strongest effects were observed in Fst, Fv, and Fm, as reflected by the highest F-values and coefficients of determination ($R^2 = 0.45$, 0.44, and 0.43, respectively). In contrast, no significant effect of leaf damage was found for the derived indices (Fm – Fst)/Fst and (Fp – Fo)/Fv ($p = 0.66$ and 0.76, respectively).

Table 1. Comparison of chlorophyll fluorescence parameters between undamaged and damaged leaves of *A. tataricum*

Parameter	(Undamaged – damaged) ± SE	t-value	F-value	p-value	R^2
Fo	69.72 ± 7.92	8.81	77.56	<0.001	0.37
Fm	493.96 ± 50.95	9.70	94.01	<0.001	0.43
Fp	436.60 ± 48.38	9.02	81.43	<0.001	0.40
Fst	416.20 ± 41.26	10.09	101.76	<0.001	0.45
Fv	428.84 ± 44.03	9.74	94.84	<0.001	0.44
Fv/Fo	0.62 ± 0.07	8.36	69.87	<0.001	0.37
Fv/Fm	0.03 ± 0.00	7.18	51.48	<0.001	0.32
(Fm – Fst)/Fst	-0.01 ± 0.01	-0.44	0.19	0.66	0.00
(Fp – Fo)/Fv	-0.00 ± 0.01	-0.31	0.10	0.76	0.00

Note: application of the Benjamini-Hochberg correction for multiple comparisons did not alter the significance pattern of the results

Source: developed by the authors

Slightly higher temperature values were associated with undamaged leaves, whereas damaged leaves tended to appear under somewhat higher humidity (Fig. 2). Light intensity varied broadly in both groups and showed substantial overlap, although undamaged leaves were characterised by a slightly higher median and a wider range of values. Overall, the distributions of the environmental parameters overlapped considerably between damaged and undamaged leaves, indicating only moderate separation between the two leaf conditions.

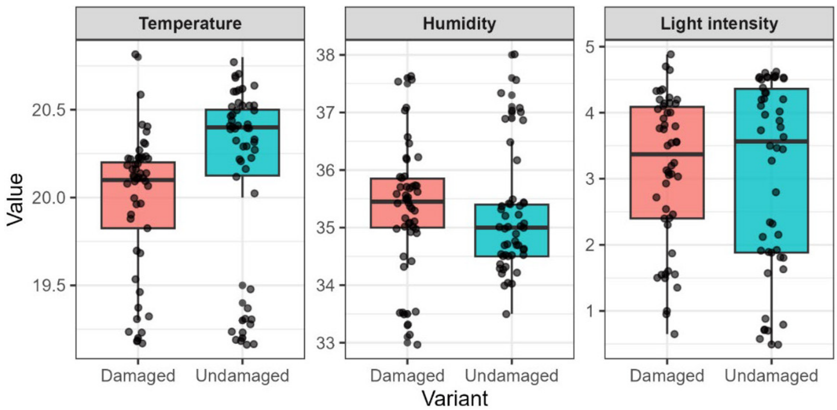

Figure 2. Variation in temperature, humidity, and light intensity parameters between damaged and undamaged leaves of *A. tataricum*

Source: developed by the authors

The assessment of temperature, air humidity, and light intensity was necessary to account for the possible influence of microclimatic conditions on chlorophyll fluorescence parameters, since these factors directly affect the photochemical activity of photosystem II and the course of photosynthetic processes. Temperature may alter the rate of electron transport, the activity of Calvin cycle enzymes, and the level of thermal energy dissipation, whereas air humidity affects stomatal conductance and transpiration. Light intensity determines the degree of excitation of the photosynthetic apparatus and is one of the key factors influencing the parameters of the Kautsky curve. Statistical analysis identified temperature as the only environmental variable parameter significantly associated with leaf condition (Table 2). The positive mean difference (undamaged – damaged = 0.19 ± 0.04) indicated slightly higher temperatures for undamaged leaves, and this effect was significant ($p < 0.001$), although the explained variance was low ($R^2 = 0.04$). In contrast, humidity and light intensity were not significantly affected by leaf condition ($p = 0.32$ and 0.60, respectively), indicating substantial overlap between damaged and undamaged leaves for these parameters.

Table 2. Comparison of temperature, humidity, and light intensity parameters between undamaged and damaged leaves of *A. tataricum*

Parameter	(Undamaged – damaged) ± SE	t-value	F-value	p-value	R^2
Temperature	0.19 ± 0.04	4.54	20.59	< 0.001	0.04
Humidity	-0.15 ± 0.15	-1.00	1.00	0.32	0.00
Light intensity	-0.08 ± 0.15	-0.53	0.28	0.60	0.00

Note: application of the Benjamini-Hochberg correction for multiple comparisons did not alter the significance pattern of the results

Source: developed by the authors

Over the past decade, the research has increasingly focused on using changes in CF parameters to interpret plant physiological mechanisms. The CF technique is used not only to determine the plant response to stress factors, but also as an indicator of feedback when developing strategies for their mitigation. The analysis of chlorophyll fluorescence (CF) changes revealed a distinct effect of the biotrophic pathogen *S. bicornis* on individual fluorescence induction (CFI) indicators of *A. tataricum* leaves. Furthermore, this effect extended to the coefficients characterising the phases of light-dependent photosynthesis and the efficiency of photochemical processes underlying the dark-dependent stages of light energy absorption. The results obtained indicate a negative effect of powdery mildew infection on the photosynthetic activity in Tatarian maple. Under conditions of biotic stress, CO_2 uptake by the host plants changes significantly due to pathogenic infection, regardless of the pathogen lifestyle (Silva *et al.*, 2021). Biotrophic pathogens grow and feed off living plant tissues, colonising cells through mechanisms that inhibit plant defence responses. This strategy, known as obligate parasitism, involves establishing molecular and physiological interactions with the host cell, which provides the pathogen with energy for growth (Salcedo-Sarmiento *et al.*, 2021; Mapuranga *et al.*, 2022). During the host plant-pathogen interaction, the affected plants show a decrease in CO_2 assimilation, dynamic stomatal response (in particular, stomatal closure), chronic inhibition of photosystems, increased energy dissipation manifested as chlorophyll *a* fluorescence (non-photochemical quenching), changes in the content of photosynthetic pigments, structural damage to chloroplasts, a decrease in the leaf area index, a violation of the source/absorber ratio, as well as changes in the expression profiles of genes, proteins and metabolites associated with photosynthesis. Pathogenic infection of leaf tissue reduces light conductivity due to cell damage, which negatively affects photosynthetic activity and causes the development of chlorotic and necrotic spots (Cheaib & Killiny, 2025). In particular, coffee and eucalyptus, being affected by biotrophic fungi, such as *Hemileia vastatrix* and *Austropuccinia psidii* respectively, showed a decrease in CO_2 assimilation by 20-50% subsequent to manifestation of symptoms. At the same time, a significant inhibition of stomatal conduction and transpiration rate by 30-50% was found in the leaves of affected plants (Einhardt *et al.*, 2020; Salcedo-Sarmiento *et al.*, 2021). L. Shupranova *et al.* (2022) found that feeding by *Parectopa robiniella* larvae significantly altered antioxidant enzyme activities and soluble protein content in *Robinia pseudoacacia* leaves under urban industrial conditions, with variable responses depending on tree age and pollution exposure, indicating substantial biochemical stress effects of this invasive phytophage. I. Ivanko *et al.* (2025) demonstrated that infection of *Quercus robur* seedlings by the foliar pathogen Erysiphe alphitoides significantly disrupted photosynthetic processes, as evidenced by pronounced alterations in Kautsky chlorophyll fluorescence parameters, indicating severe impairment of the photosynthetic apparatus in infected leaves compared with healthy controls.

The results of this research also indicated a significant decrease in Fo and Fm parameters of chlorophyll fluorescence induction in Tatarian maple leaves covered with *S. bicornis* mycelium by 50% or 75% of the area. A decrease in the Fv parameter, defined as the difference between Fm and Fo, is associated with a violation of the energy transformation in photosystem II, as well as with partial closure of reaction centres. This leads to a fragmented disruption of their functioning in the process of converting light energy into chemical potential (Stefanov *et al.*, 2022), which indicates a decrease in photosynthetic competence per unit of chlorophyll and, accordingly, a decrease in PSII activity. Studies aimed at analysing energy dissipation using CF have made it possible to better understand the physiological processes that occur in both the asymptomatic and symptomatic stages of the disease development. According to Q. Xia *et al*. (2023), the Fv/Fm index is widely used as one of the most common parameters of chlorophyll a fluorescence for assessing the stress level caused by abiotic and biotic factors. In the present research, powdery mildew-caused biotic stress led to a significant decrease in this indicator. Under normal conditions, the Fv/Fm value for undamaged leaves was about 0.80-0.83, while its decrease indicates damage to component of the PSII reaction centres that cause photoinhibition of the photosynthetic apparatus and is often accompanied by the oxidative stress development, as noted by B.O. Calvo *et al*. (2025). Thus, the Fv/Fm parameter is a reliable indicator of photochemical activity and the general physiological state of plants. A. Cheaib & N. Killiny (2025) emphasised that in phytopathology, its use has proven effective for assessing the degree of damage to the photosynthetic apparatus, depending on the type of pathogen. Another relevant indicator of PSII efficiency is the maximum quantum yield of water photolysis, Fv/Fo. This parameter is more sensitive to stress effects, since it is normalised by the Fo, and not by the Fm, as in the case of Fv/Fm. A decrease in Fm and an increase in Fo cause significant changes in Fv/Fo, even when the changes in Fv/Fm are less pronounced (Jat *et al.*, 2024).

The efficiency ratio of dark-dependent photochemical processes (Fm – Fst)/Fst is also an important indicator of the leaf functional state. It reflects the level of fluorescence quenching developed under the influence of both photochemical processes (CO_2 fixation) and non-photochemical mechanisms (thermal energy dissipation in excited chlorophyll molecules). The parameter (Fm – Fst)/Fst is closely correlated with the activity of ribulose-1,5-bisphosphate carboxylase/oxygenase, a key enzyme of the Calvin cycle, and reflects the adaptive capacity of plants to environmental conditions, which is consistent with the findings of X. Song *et al*. (2023). Based on the Fm, Fst indicators and calculated parameter (Fm – Fst)/Fst, which determine the shape of the descending part of the Kautsky curve, the activation and flow of Calvin cycle reactions and the transport of substances through the leaf membranes and vessels might be argued to be more efficient in *A. tataricum* plants not affected by powdery mildew (undamaged). Being parameter that characterises the relative proportion of inactive reaction centres to their total number, photosynthetic rate (Fp – Fo)/Fv reflects the saturation rate of inactive PSII centres responsible for water photolysis and oxygen release, according to O. Vasylenko *et al*. (2021). An increase in the value of this parameter indicates a violation of both energy migration and electron transport, while its decrease may indicate an acceleration of electron transport processes. The results confirmed the high sensitivity and informative value of CF/CFI methods in studies of plant-pathogen interaction, and indicate the feasibility of their use for early diagnosis of biotic stress, plant phenotyping and development of effective approaches to the control of phytopathogens in combination with other physiological and biochemical methods of analysis.

CONCLUSIONS

The damage of the *A. tataricum* foliage by biotrophic pathogen *S. bicornis* was found to be accompanied by a significant decrease in the main CFI parameters (Fo, Fm, Fp, Fst, Fv) and indicators of photochemical efficiency of PSII (Fv/Fo and Fv/Fm); it indicates the functional state inhibition of the photosynthetic apparatus. The parameters Fst, Fv and Fm were the most sensitive to pathogenic damage, in which the highest values of variance and statistical significance were recorded ($p < 0.001$; $R^2 = 0.43\text{-}0.45$); it indicated their high informative value in assessment of plant physiological state. A decrease in variable fluorescence (Fv) and the FV/Fm ratio confirms a violation of the efficiency of converting light energy into PSII and partial inactivation of reaction centres, which is indicative of the development of photoinhibition under the influence of biotic stress. The derived parameters (Fm – Fst)/Fst and (Fp – Fo)/Fv showed no statistically significant changes between damaged and undamaged leaves ($p > 0.05$), which indicates their lower sensitivity to pathogen action under the research conditions. Among environmental factors, only temperature had a significant, though weak, effect on leaf condition ($p < 0.001$; $R^2 = 0.04$), while humidity and light intensity showed no statistically significant differences between the variants. The technique of chlorophyll fluorescence induction was proved to be an effective tool for diagnosing *S. bicornis*-caused disorders of the photosynthetic apparatus in *A. tataricum*, and it might be used for early detection of biotic stress and assessment of the physiological state of plants in urban ecosystems. Further research should focus on evaluating seasonal dynamics of chlorophyll fluorescence parameters and integrating fluorescence analysis with biochemical and molecular markers of plant stress resistance.

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CONFLICT OF INTEREST

None.

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Особливості впливу борошнистої роси (*Sawadaea bicornis* (Wallr.) Miyabe) на процес фотосинтезу клену татарського (*Acer tataricum* L.)

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Анотація. Ураження деревних рослин фітопатогенними грибами в умовах урбанізованого середовища призводить до порушення фотосинтетичних процесів і зниження життєздатності рослин, що зумовлює необхідність пошуку ефективних методів ранньої діагностики фізіологічних змін. Метою роботи було встановлення ефективності застосування методу індукції флуоресценції хлорофілу (ІФХ) для оцінки функціонального стану фотосинтетичного апарату листків *Acer tataricum* L., уражених *Sawadaea bicornis* (Wallr.) Miyabe. Дослідження проводилося у вересні 2025 році на території м. Дніпро із використанням портативного флуориметра «FLS 10s» для діагностики порушення фотосинтезу нативного хлорофілу в живих листках *A. tataricum*. Вимірювання виконували на абсолютно не уражених та уражених понад 50 % борошнистою росою листках клену татарського у межах одного дерева з подальшим аналізом параметрів кривої Каутського. Ступінь ураження листкової пластинки фітопатогеном визначали візуально.

Найбільш значущими параметрами виявилися Fo, Fm, Fv, співвідношення Fv/Fo та Fv/Fm, а також індекси (Fm – Fst)/Fst і (Fp – Fo)/Fv. Аналіз цих показників дозволив виявити специфічні зміни, пов'язані з патогенним впливом, та оцінити ступінь порушення фотосинтетичної активності. Отримані результати свідчать, що метод ІФХ із використанням портативного приладу «FLS 10s» є ефективним підходом для швидкої діагностики загального стану рослин і дає змогу своєчасно виявляти негативний вплив біотичних чинників. Таким чином, аналіз параметрів флуоресценції хлорофілу можна розглядати як потужний і надійний інструмент для визначення ступеня впливу паразитичних грибів на рослину-хазяїна та оцінки її функціонального стану в урбанізованому середовищі

Ключові слова: грибкові захворювання рослин; індукція флуоресценції; міські екосистеми; фотосинтетичний апарат; біосенсори