

EVALUATION OF PHOTOSYNTHETIC RATE AND CHLOROPHYLL CONTENT IN FIVE FOREST SPECIES

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Abstract

The photosynthesis and chlorophyll content are fundamental to understanding ecological processes in forest ecosystems, providing valuable clues to the health and functioning of these complex systems. The study of photosynthetic rates and chlorophyll content in five different tree species (Carpinus betulus, Fraxinus excelsior, Robinia pseudoacacia, Acer campestre and Acer pseudoplatanus) conducted in two different locations, namely in the Iron Gates Natural Park in Moldova Nouă (PNPF) and in Timișoara, brings to the fore a detailed analysis of the adaptations and responses of vegetation to environmental variability. Across the whole study, Acer pseudoplatanus revealed a significantly higher value of chlorophyll content, followed by Robinia pseudoacacia and Carpinus betulus with similar values and Acer campestre and Fraxinus excelsior with the lowest values, respectively. Acer campestre had a significantly higher photosynthesis rate than the other species, while Acer pseudoplatanus had the lowest values in both locations.

Key words: *Carpinus betulus, chlorophyll, Fraxinus excelsior, photosynthesis, Robinia pseudoacacia.*

INTRODUCTION

Chlorophyll (Chl) is an important photosynthetic pigment for plants, strongly determining photosynthetic capacity and consequently plant growth. This concept has not been widely tested in natural forests (Li et al., 2018.).

Photosynthesis is the most important source of energy for plant growth since Chl is an important pigment for photosynthesis (Baker et al., 2008; Li et al., 2018.). The photosynthetic reaction is mainly divided into three stages (1) primary reaction, (2) electron transport and photophosphorylation, and (3) carbon assimilation. Chlorophyll *a* (Chl *a*) and chlorophyll *b* (Chl *b*) are essential for the light reactions of photosynthesis. Chl *a* and Chl *b* absorb sunlight at different wavelengths (Chl *a* mainly absorbs red-orange light and Chl *b* mainly absorbs blue-violet light) (Lichtenthaler & Buschmann, 2001.). Thus, it is assumed that the total amount of chlorophyll content in leaves (Chl *a+b*) and the ratio of chlorophyll *a* to *b* (Chl *a/b*) directly influence the photosynthetic capacity of plants (Croft et al., 2018).

Excessively high or low temperatures inhibit the enzyme reaction, even destroying

chlorophyll. The optimal temperature for general plant chlorophyll synthesis is 30°C (Nagata et al., 2005.).

Therefore, temperature has an influence on chlorophyll synthesis as well. Precipitation could affect the photochemical activity of chloroplasts (Zhou, 2003), as water is used for nutrient transport in plants because mineral salts must be dissolved in water to be absorbed by plants. Therefore, chlorophyll synthesis and water are closely linked. Lack of water in leaves influences chlorophyll synthesis and favours its breakdown, accelerating leaf turning yellow. There is also indirect evidence that chlorophyll is controlled by climate and soil. Thus, chlorophyll could be an indicative trait for characterizing how plants respond to climate change (Li et al., 2018.).

During periods of drought, forest plants experience a decrease in water availability, leading to a reduction in photosynthesis and other physiological processes (Brodribb et al., 2009). As a result, plant growth is suppressed and plants may wither (Bigler et al., 2006; Choat et al., 2018). Studies have shown that drought can also cause changes in plant anatomy, morphology and physiology, such as

reduced leaf surface area, increased root-to-shoot ratio and decreased stomatal conductance (Schäfer, 2011; Urban et al., 2023).

One impact of low light on forest species is the alteration of chlorophyll content, which affects photosynthetic rate (Sui et al., 2012). Low light decreases chlorophyll content in plants (SPAD value) (Park et al., 2018). Some results have reported that chlorophyll a and total chlorophyll contents for two maize leaf varieties increased after shading treatment (Wang et al., 2017.). Chlorophyll content, especially chlorophyll b content, in tomato seedlings increased under low light (Wang et al., 2010). Consequently, low light is a key factor in plant photochemical efficiency and has different influences on leaf chlorophyll content (He et al., 2020). In Central European forestry, the establishment of mixed broadleaved forests is becoming increasingly important, but there is little information on the gas exchange characteristics of some tree species. In an old-growth forest in central Germany (Hainich, Thuringia), photosynthetic parameters of saplings and adult trees (lower and upper tree level) were analysed in four species (*Acer pseudoplatanus* L., *Carpinus betulus* L., *Fraxinus excelsior* L. and *Tilia platyphyllos* Scop.) (Hölscher, 2004).

The hornbeam (*Carpinus betulus*) is a deciduous species of the Betulaceae family. It is also an invasive species due to its high budding and draining ability.

The roots live in symbiosis with various fungi or bacteria. The leaves are alternate, simple with deciduous stipules. The flowers are unisexual, grouped in mixed inflorescences. The fruit of the hornbeam is of the achene type (Croft et al., 2017). It is an indigenous tree, native to Europe and Southwest Asia.

In Romania the hornbeam is found from the plain area (100-400 m altitude) to the mountain floor at 1,000-1,200 m altitude (Croft et al., 2017).

Common ash (*Fraxinus excelsior* L.), also known as European ash, is a species of the genus *Fraxinus*, native to most of Europe, from Portugal to Russia, with the exception of northern Scandinavia and southern Iberia. It is also considered native to southwest Asia, from northern Turkey to the Caucasus mountain range, as far north in the Trondheim Fjord

region of Norway. The species is widely cultivated and naturalised in New Zealand and locations in the United States and Canada (Nova Scotia, New Brunswick, Quebec, Massachusetts, Connecticut, New York, New Jersey, Maryland, Ontario, Ohio, Kentucky and British Columbia) (Pautasso et al., 2013).

The acacia (*Robinia pseudoacacia* L.), a member of the Fabaceae family, is a honey tree with tall stems up to 25-30 metres and sparse thorny branches, acclimatised in North America, Europe, South Africa and Asia. The acacia originates from the North American continent. The genus *Robinia* is named after the French royal gardeners Jean Robin and his son Vespasien Robin, who introduced the acacia to Europe in 1601.

Sârbu and Oprea stated that even in North America, where it is native, outside the primary habitat, it poses a serious threat to native vegetation in dry and sandy meadows (Sârbu et al., 2011). Acacia grows spontaneously on almost any type of land. With high frost resistance, it loves light, tolerates drought, prefers permeable, light, fertile soils, but does not tolerate calcareous soils. Acacia grows well on light soils, even on loose sands, and is cultivated for fixation. It has the ability to fix nitrogen from the atmosphere, and the seeds retain their ability to germinate for many years. It has compound leaves and white, clustered, strongly fragrant flowers, and the fruit are flattened, reddish-brown pods. It flowers in late spring, in May-June. The acacia lives for around 100 years and belongs to the category of hardwood trees, being hard, tough and particularly resistant to moisture.

Jugastrum (*Acer campestre* L.) is a tree of the genus *Acer*, family Acerceae. It is also called field maple or common maple. The leaves are glabrous, 5- or 3-lobed palmate-lobed, up to 8 cm long. The flowers appear in spring arranged in compound corymbs, are polygamous and greenish in colour.

Jugastrum is a hard white tree with reddish bark, which grows frequently in the lowlands and hills up to altitudes of 1000 m. At maturity it is 15-25 m high. The crown of the tree forms low and provides good shade.

The mountain ash (*Acer pseudoplatanus*) is a tree of the family Acerceae with thick, palmate leaves, disseminated fruit and white, very

resistant, elastic and fine wood, used for making furniture and musical instruments. It is considered the tree with the highest sound vibration. Also known as the "singing paltin", the mature tree is in great demand among the lute players of Bihor. The famous bugle violins are made from it.

It usually reaches heights of 20-30 metres. The leaves are large, palmate, five-lobed and dark green. They are similar to the leaves of the common maple. The flowers are arranged in large inflorescences and are greenish-yellow in colour, but are not as decorative as other maple species.

It is adorned by its large, rich leaves in spring. Its leaves provide dense shade in summer. The leaves turn shades of yellow and red before they fall.

It is commonly planted in alleys or along streets. It is a popular choice for parks and gardens due to its impressive size.

It prefers sun or semi-shade exposure. Also it needs regular watering, especially in the first year after planting. Pruning may be necessary to improve shape or control size.

The objective of this study was to assess the photosynthetic rates and chlorophyll content in five tree species (*Carpinus betulus*, *Fraxinus excelsior*, *Robinia pseudoacacia*, *Acer campestre* and *Acer pseudoplatanus*) in two locations, namely in the Iron Gates Natural Park in Moldova Nouă and in Timișoara, in order to obtain information regarding the physiological responses of these species to the particular environments.

MATERIALS AND METHODS

The biological material studied was represented by five tree species of similar age, hornbeam (*Carpinus betulus* L.), ash (*Fraxinus excelsior* L.), acacia (*Robinia pseudoacacia* L.), juniper (*Acer campestre* L.) and mountain ash (*Acer pseudoplatanus* L.). Representative leaves were measured from 5 trees of each species, during April-August, from two locations, namely Timișoara and from the Iron Gates Natural Park (PNPF) in Moldova Noua.

During the study period the temperatures in Timișoara ranged from 14°C in April to 26.5°C in August, and from 15.5 to 28.4°C in PNPF, respectively (Table 1). The cumulative rainfalls

in Timișoara were 240 mm during April-June and 100 mm in July-August. In PNPF the amount of rainfalls was lower, ranging from 90 mm in July-August to 215 mm in April-June.

Table 1. Average temperature and rainfall from Timișoara and PNPF during April-August 2023

Location	Timișoara		PNPF	
	Temperature (°C)	Rainfall (mm)	Temperature (°C)	Rainfall (mm)
April	14.0	70	15.5	60
May	18.5	80	19.7	75
June	23.0	90	24.5	80
July	26.0	55	27.2	50
August	26.5	45	28.4	40

Every month, we selected for measurements 10 representative leaves from different parts of the crown from each of the five trees per species. The measurement was repeated three times in different parts of each leaf to obtain an average for each leaf. The amount of total chlorophyll (SPAD) in leaves was estimated using the Konica Minolta SPAD-502 handheld chlorophyll meter. This meter determines the relative chlorophyll content by measuring the absorbance of a leaf in two wavelength ranges. The apparatus measures the light absorbance of the leaf in the range of red and near-IR light radiation. Using this principle the chlorophyll meter calculates a numerical value, SPAD (single photon avalanche diode) which is directly proportional to the amount of chlorophyll present in the leaf. The process highlights the nitrogen uptake, but also the amount needed to reach the maximum yield potential.

Photosynthetic capacity (%) was determined with the EARS Plant Photosynthesis Meter (PPM) which measures the photosynthetic light use of plants. The measurement is based on chlorophyll fluorescence, a very weak optical signal emitted by the plant, but which can be detected by the meter. Because of its light weight, the instrument is very suitable for laboratory and field use. In addition, long measurement series can be carried out automatically.

The data regarding photosynthetic rate and chlorophyll content were evaluated using three-factor ANOVA, followed by LSD test for post hoc comparison of means and determine the significance of differences at $p \leq 0.05$ (Ciulca 2006).

RESULTS AND DISCUSSIONS

It was observed that all three factors (species, location and study period - month) and their interactions had a significant influence on photosynthesis rates. Species had a higher contribution to the variability of photosynthetic rate compared to location and month, while among the interactions, species x month and location x species x month had a high influence. The results for this trait were influenced to an extent of about 8.15% by other sources of variation.

Also, in the case of chlorophyll content, a significant influence of all sources of variation was observed, against the background of a higher contribution of species to the variability of this character and close effects of location and period. Considering the different interactions, a very high variation in chlorophyll content of the different species is

observed in the studied locations. Chlorophyll content values were influenced to an extent of about 3.39 SPAD by other uncontrollable variables.

From Table 2 it can be concluded that all three factors (species, location and study period - month) and their interactions had a significant influence on photosynthesis rate. Species had a higher contribution to the variability of photosynthetic rate compared to location and month, while among the interactions, species x month and location x species x month showed a high influence. Also in the case of chlorophyll content, a significant influence of all sources of variation is observed, amid a higher contribution of species to the variability of this character and close effects of locality and period. Considering the different interactions, a very high variation in chlorophyll content of the different species in the studied locations is observed.

Table 2. Analysis of variance for photosynthetic rate and chlorophyll content in five forest species and two locations during April-August

Source of variation	DF	Photosynthetic rate (%)			Chlorophyll content (SPAD)		
		SS	MS	F value	SS	MS	F value
Location (L)	1	3104.64	3104.6	270.96**	80.66	80.66	68.00**
Species (S)	4	4625.94	1156.49	100.93**	2048.98	512.24	431.84**
Month (M)	4	2638.06	659.52	57.56**	147.44	36.86	31.07**
L x S	4	1343.18	335.79	29.31**	3417.36	854.34	720.25**
L x M	4	2032.74	508.18	44.35**	30.36	7.591	6.40**
S x M	16	5473.22	342.08	29.85**	307.35	19.21	16.19**
L x S x M	16	6608.94	413.06	36.05**	724.89	45.31	38.19**
Residual	200	2291.6	11.46		237.24	1.19	
Total	249	28118.3			6994.29		

**significant at $p < 0.01$

Table 3. Variation of photosynthetic rate and chlorophyll content in five forest species and two locations

Parameter Species	Photosynthetic rate (%)			Chlorophyll content (SPAD)		
	Location			Location		
	PNPF	Timișoara	Mean	PNPF	Timișoara	Mean
<i>Carpinus betulus</i>	55.36 a	56.04 b	55.70 B	29.25 b	24.10 c	26.68 B
<i>Fraxinus excelsior</i>	54.24 a	57.56 b	55.90 B	14.55 e	24.41 bc	19.48 D
<i>Robinia pseudoacacia</i>	48.32 c	56.44 b	52.38 C	28.46 c	24.80 b	26.63 B
<i>Acer campestre</i>	52.28 b	66.20 a	59.24 A	21.81 d	26.19 a	24.00 C
<i>Acer pseudoplatanus</i>	41.92 d	51.12 c	46.52 D	32.64 a	21.52 d	27.08 A

Photosynthetic rate: Species $LSD_{5\%} = 1.34$; Location x Species $LSD_{5\%} = 1.89$

Chlorophyll content: Species $LSD_{5\%} = 0.43$; Location x Species $LSD_{5\%} = 0.61$

Different letters (a-e) in the columns indicate significant differences ($p < 0.05$) between species.

Capital letters were used for species means (A-D) comparisons

The photosynthesis rate at Iron Gates Natural Park had variation amplitude of 13.44% with values ranging from 41.92% for *Acer pseudoplatanus* to 55.36% for *Carpinus betulus* which was significantly equal to the value recorded for *Fraxinus excelsior*. *Acer campestre*

produced a higher photosynthesis rate than both *Robinia pseudoacacia* and *Acer pseudoplatanus* (Table 3). In the Timișoara conditions the amplitude between species was higher, against a significantly higher photosynthesis rate in *Acer campestre*. The species *Carpinus betulus*,

Fraxinus excelsior and *Robinia pseudoacacia* recorded small and insignificant variations of this parameter, but significantly higher by 4.92-6.44% compared to the value for *Acer pseudoplatanus*.

In *Carpinus betulus* a stable photosynthesis rate was observed, amidst a reduced variation between the two locations. Local environmental conditions had the highest influence on this parameter in *Acer* species (*Acer campestre* and *Acer pseudoplatanus*), with higher values in Timișoara. Overall, *Acer campestre* showed a significantly higher photosynthesis rate than the other species, while *Acer pseudoplatanus* showed the lowest values in both locations.

In terms of chlorophyll content at the Iron Gates Nature Park, the five species showed an average of 18.09, with ranges from 14.55 SPAD for *Fraxinus excelsior* to 32.64 SPAD for *Acer pseudoplatanus*. Chlorophyll content in *Acer pseudoplatanus* was significantly higher than in the other species, amid significant variation between species. In *Carpinus betulus* the value of this parameter was significantly higher than in *Robinia pseudoacacia*, *Acer campestre* and *Fraxinus excelsior*, which differed from each other. At Timișoara the variability between species for this trait was considerably lower, ranging from 24.1 SPAD in *Carpinus betulus* to 26.19 SPAD in *Acer campestre*, which showed a significant superiority over the other species. *Carpinus betulus*, *Fraxinus excelsior* and *Robinia pseudoacacia* showed values close to and significantly higher than *Acer pseudoplatanus*.

For all five species there is a significant variation in chlorophyll content between the two locations. Thus, for *Robinia pseudoacacia*, *Carpinus*

betulus and *Acer pseudoplatanus* in the conditions of the Iron Gates Natural Park significantly higher values were recorded by 14.76-51.37%. For *Acer campestre* and *Fraxinus excelsior*, the conditions of Timișoara favoured an increase in chlorophyll content by 20.08-67.77%. In the whole study, *Acer pseudoplatanus* showed a significantly higher value of chlorophyll content, followed by *Robinia pseudoacacia* and *Carpinus betulus* with similar values and *Acer campestre* and *Fraxinus excelsior* with the lowest values.

Considering the variation in photosynthesis rate of the five species during the active vegetation period, it can be seen that in April values ranged from 53.1% in *Acer pseudoplatanus* to 68.8% in *Fraxinus excelsior* followed by *Acer campestre* (Table 4). In May the range between species was 19.7% associated with a grouping into three categories, namely *Fraxinus excelsior* and *Acer campestre* with the highest values followed by *Carpinus betulus* and *Robinia pseudoacacia* with close values and *Acer pseudoplatanus* with the lowest photosynthesis rate. During June *Acer campestre* recorded the highest photosynthesis rate, followed by *Fraxinus excelsior* and *Robinia pseudoacacia* with close values and *Carpinus betulus* and *Acer campestre* with significantly lower values. In July *Carpinus betulus* and *Acer campestre* showed significantly higher values compared to *Fraxinus excelsior* and *Acer pseudoplatanus* respectively, with *Robinia pseudoacacia* showing the lowest values. During August the range between species was between 44% in *Fraxinus excelsior* and 58.8% in *Carpinus betulus*, followed by *Robinia pseudoacacia* and *Acer campestre* with values close to 51-51.7%.

Table 4. Variation of photosynthetic rate (%) in five forest species during April-August

Species	Month				
	April	May	June	July	August
<i>Carpinus betulus</i>	56.20 c	49.00 b	48.90 c	65.60 a	58.80 a
<i>Fraxinus excelsior</i>	68.80 a	58.00 a	54.30 b	54.40 b	44.00 d
<i>Robinia pseudoacacia</i>	55.70 cd	51.10 b	56.90 b	47.20 c	51.00 b
<i>Acer campestre</i>	60.80 b	57.60 a	60.50 a	65.60 a	51.70 b
<i>Acer pseudoplatanus</i>	53.10 d	38.30 c	43.80 d	49.50 c	47.90 c

LSD 5%=2.99; Different letters in the columns indicate significant differences (p<0.05) between species.

In terms of chlorophyll content, *Acer pseudoplatanus* and *Robinia pseudoacacia* had the highest values in April, followed by *Carpinus betulus* and *Fraxinus excelsior* with

the lowest (Table 5). *Robinia pseudoacacia* also had a significantly higher value in May than the other species, with significantly equal values for *Acer campestre*, *Acer*

pseudoplatanus and *Carpinus betulus*. During June, *Acer pseudoplatanus*, *Robinia pseudoacacia* and *Carpinus betulus* showed a high chlorophyll content with values of 25.92-26.2 SPAD, while *Fraxinus excelsior* and *Acer campestre* showed values of 20.18-22.31 SPAD. Chlorophyll content variation in July

ranged from 19.18 SPAD in *Fraxinus excelsior* to 27.02-27.73 SPAD in *Acer pseudoplatanus* and *Carpinus betulus*. Also in August *Carpinus betulus* showed the highest chlorophyll content, followed by *Robinia pseudoacacia* and *Acer pseudoplatanus* with close values and respectively *Fraxinus excelsior* with the lowest content.

Table 5. Variation of chlorophyll content (SPAD) in five forest species during April-August

Species	Month				
	April	May	June	July	August
<i>Carpinus betulus</i>	26.78 b	25.52 b	26.20 a	27.73 a	27.15 a
<i>Fraxinus excelsior</i>	19.88 d	21.04 c	20.18 c	19.18 d	17.12 d
<i>Robinia pseudoacacia</i>	29.32 a	27.67 a	25.92 a	24.42 b	25.81 b
<i>Acer campestre</i>	23.97 c	26.22 b	22.31 b	23.20 c	24.30 c
<i>Acer pseudoplatanus</i>	29.93 a	26.45 b	26.12 a	27.02 a	25.86 b

LSD 5%=0.96; Different letters in the columns indicate significant differences ($p<0.05$) between species.

The dynamics of photosynthesis rate at Iron Gates Nature Park in Figure 1 shows that *Carpinus betulus* showed a significant reduction from April to June followed by a 20.8% increase in July and a 12.6% reduction in August. *Fraxinus excelsior* showed a significant reduction from month to month with a variation from 73.6% in April to 33.8% in August. For *Robinia pseudoacacia* there is a fluctuation in photosyn-

thesis rate, characterised by an 18.6% reduction in April-May, followed by an 8.4% increase in June and then an 18.8% reduction. In *Acer campestre*, a 13.6% decrease in photosynthesis rate in April-May was followed by a gradual increase of 7.2-9.6% until July and a 12% decrease in August. The same trend is observed in *Acer campestre* and *Acer pseudoplatanus*, with lower values than in *Acer campestre*.

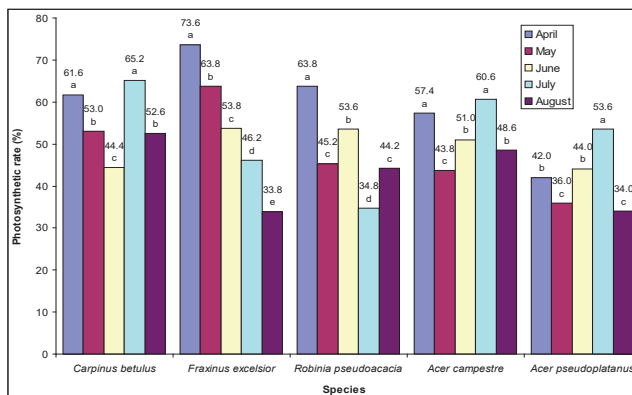


Figure 1. Dynamic of photosynthetic rate (%) in each of the five forest species during April-August in Iron Gates Natural Park LSD 5%=4.22; Different letters indicate significant differences ($p<0.05$) within species

In the conditions observed in Timișoara, *Carpinus betulus* showed a reduction in photosynthesis rate of 5.8% in April-May, followed by an increase of 8.4-12.6% by July and a similar level in August (Figure 2). In *Fraxinus excelsior*, against a value of 64% in April, there was a reduction of 9.2-11.8% in May-June, followed by an increase of 7.8% in

July and a reduction of 8.4% in August. For *Robinia pseudoacacia*, the 9.4% increase in photosynthesis rate in April-May was followed by stability in May-August. A similar trend was observed for *Acer campestre*, except that photosynthesis stability in May-July was followed by a 15.8% decrease in August. In *Acer pseudoplatanus*, the variation in

photosynthesis rate shows a different pattern from the other species, characterised by a considerable reduction of 23.6% in April-May, followed by a reduced variation of 4.8% in May-July and an increase of 16.4% in August. Regarding the dynamics of the chlorophyll content at the Iron Gates Nature Park in Figure 3 it can be seen that *Carpinus betulus* showed an increase of 4.1 SPAD from April to May, followed by a reduction of 3.4 SPAD in June and then increases of 2-3 until August. In *Fraxinus excelsior*, against a background of reduced values compared to the other species, the chlorophyll content was stable, with the exception of June where there was an increase of 3.5-5.2 SPAD compared to the other months. For *Robinia pseudoacacia* a fluctuation in

photosynthesis rate is observed, characterized by a progressive and significant reduction from month to month in April-July, followed by a 5.5% increase in August. In *Acer campestre*, a decrease in photosynthesis rate of 6.5% in June-July was followed by an increase of 2% in August. Against the background of the highest values in *Acer pseudoplatanus* there was a 6% reduction in April-May, followed by a gradual increase until July and a 4.9% reduction in August.

Based on the conditions in Timișoara, *Carpinus betulus* shows a 6.6 SPAD reduction in chlorophyll content in April-May, followed by a 4.7 SPAD increase by June-July and a 3.1 SPAD reduction in August (Figure 4).

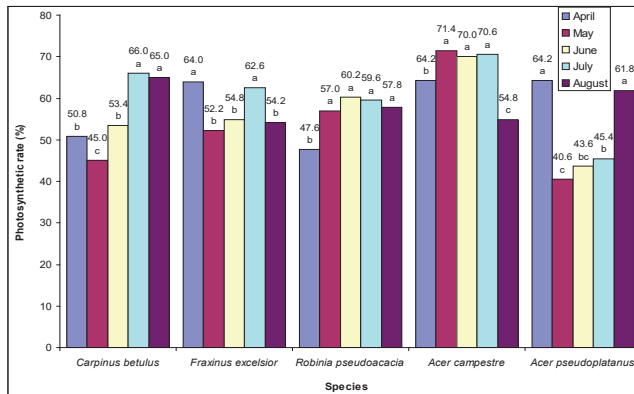


Figure 2. Dynamic of photosynthetic rate (%) in each of the five forest species during April-August in Timișoara
LSD 5%=4.22; Different letters indicate significant differences ($p < 0.05$) within species

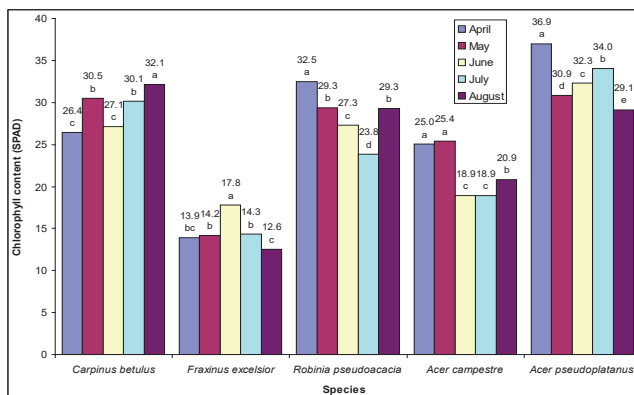


Figure 3. Dynamic of chlorophyll content (SPAD value) in each of the five forest species during April-August in Iron Gates Natural Park
LSD 5%=1.36; Different letters indicate significant differences ($p < 0.05$) within species

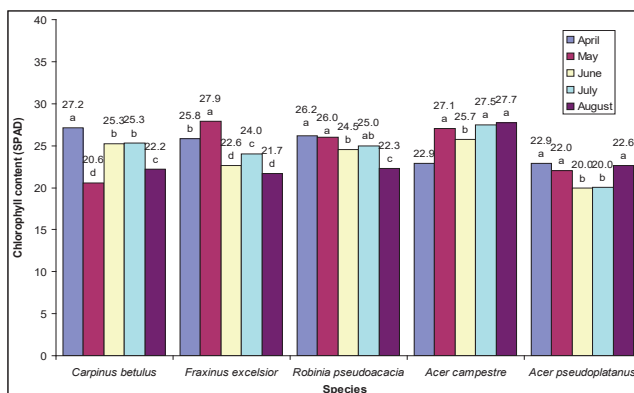


Figure 4. Dynamic of chlorophyll content (SPAD value) in each of the five forest species during April-August in Timisoara LSD5%=1.36; Different letters indicate significant differences ($p < 0.05$) within species.

In *Fraxinus excelsior*, against a value of 25.8 SPAD in April, there was an increase of 2.1 SPAD in May, followed by a reduction of 5.3 SPAD in June and a reduced variation until August. For *Robinia pseudoacacia*, relative stability was observed from April to July, associated with a change of 1.7 SPAD, followed by a reduction of 2.7 SPAD in August. For *Acer campestre*, an increase in chlorophyll content of 4.2 SPAD is observed in April-May, followed by a reduced variation in May-August.

For *Acer pseudoplatanus*, the chlorophyll content variation was characterized by a level of 22-22.9 SPAD in April-May, followed by a reduction by 2 SPAD in June-July and an increase in August, reaching the April-May level.

Environmental factors such as temperature, precipitation, and light influence both the synthesis and functioning of chlorophyll in the leaves of the trees under study.

This theme can be further developed in relation to plant adaptations to changing environments and the consequences of these changes on forest ecosystems. This need is also highlighted by the fact that climate change can influence the production and functioning of chlorophyll.

The ecological characteristics of the tree species in this study highlight specific adaptations to different habitats and their interactions with environmental factors.

CONCLUSIONS

The results obtained from the data analysis indicate a significant influence of several factors on photosynthetic rates and chlorophyll

content. In particular, the species appeared to have a major contribution to the variability of these characters compared to the location and study period (month). Interactions between these factors also revealed significant influences, highlighting the complexity and interdependence of ecological processes in the forests analysed.

Variation in photosynthetic rates and chlorophyll content between the five tree species and the two locations studied is highlighted. These variations reflect species-specific adaptations to environmental conditions and provide a detailed picture of ecological diversity within forest ecosystems.

The overall photosynthesis rate of *Acer campestre* was significantly higher than that of the other species, while *Acer pseudoplatanus* was observed to have the lowest values at both locations.

Across the entire study, *Acer pseudoplatanus* revealed a significantly higher value of chlorophyll content, followed by *Robinia pseudoacacia* and *Carpinus betulus* with similar values and *Acer campestre* and *Fraxinus excelsior* with the lowest values.

Analysis of the dynamics of photosynthetic rates and chlorophyll content during the period of active vegetation reveals seasonal changes and variations between species and locations. This information is essential for understanding how environmental factors influence plant physiological processes and for identifying potential vulnerabilities or adaptations to climate change and other disturbances.

Particularly, in the light of these results, our research aims to provide new insights into forest ecology, contributing to the sustainable management and conservation of these important terrestrial ecosystems.

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