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STUDIES ON THE PHYSIOLOGY OF THE SPECIES *FAGUS SYLVATICA L.* IN THE CLIMATE CONDITIONS OF THE YEAR 2024 FROM THE PROTECTED AREA DOMOGLED-CERNA VALLEY

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Abstract

The studies were carried out in 2024, starting from April and ending in October, in the Tesna Gorges and Stan's Peak Natural Reserves from the Domogled-Cerna Valley protected area. The processes targeted were photosynthesis, transpiration and leaf respiration. Also, were determined: cell sap concentration, osmotic pressure of mesophyll cells, total leaf water content, free and bound water.

The intensity of the photosynthesis process was determined in the year 2024 in each month of the vegetation period to make the seasonal variation graphs. After analyzing these graphs, it was found that the photosynthesis process recorded a maximum in June, followed by a reduction in the intensity of the process, although it was normal to remain at high values until the time of fruiting. The reduction in photosynthesis was due to very high temperatures associated with very low soil moisture.

The total reduced leaf water content recorded since July indicated a negative water balance caused by the very low amount of available water.

Key words: drought, photosynthesis, transpiration, water content

INTRODUCTION

Domogled – Cerna Valley National Park was established in 1990 and has its own Administration since 2003. The Park is located in the south-western Romania, overlapping three counties: Caraş-Severin, Mehedinţi and Gorj. The biggest area is in Gorj - 29 806 ha, followed by Caraş-Severin - 23 185ha and Mehedinti 8220 ha. Geographically, the Park covers Cerna River basin, from its spring to the confluence with Belareca. It covers Godeanu and Cernei Massifs with the right bank and Vâlcan and Mehedinţi Massifs with the left bank. The total area covered by the park is 61 211ha, 44º 50' 10" to 45º 16' 50" north latitude and 22º 23' 50" to 22º 51' 35" east longitude.
https://domogled.ro/en/

The park is notable for its great geographical diversity, including limestone cliffs, deep gorges, alpine meadows, beech forests and endemic species. Due to the complexity of the stationary physical-geographical and climatic aspects, the protected natural area is characterized by a remarkable floristic diversity, the rich floristic inventory totaling 1100 plant species and 30 plant associations, of which 9 are endemic.
https://poim149842.domogled.ro/specii-si-habitate/plante/

In the Domogled-Cerna Valley National Park, *Fagus sylvatica* (European beech) plays a crucial role within a highly biodiverse ecosystem. The beech forests in the Domogled area are part of an old-growth forest ecosystem that supports a variety of plant and animal species. These forests are especially important for unique Biodiversity. *Fagus sylvatica* forests in Domogled host a range of endemic plant species, as well as fauna such as bears, wolves, and lynxes, which rely on these forests for shelter and food. The understory of these beech forests supports various shade-tolerant plants, creating a multi-layered habitat that supports numerous species.

Beech trees in Domogled often form dense forests that contribute to the unique microclimate of the area, providing cooler and more humid conditions. This microclimate supports species that require specific humidity and temperature ranges.

The beech forests of Domogled- Cerna Valley are recognized as UNESCO World Heritage sites due to their ancient and primeval characteristics.

https://www.europeanbeechforests.org/world-heritage-beech-forests/romania/domogled-valea-cernei

This designation highlights:

-Protection from Logging: Strict conservation regulations are in place to prevent illegal logging and habitat destruction. Despite this, some areas have faced threats from unsanctioned activities, and continuous monitoring is necessary.

- Conservation Efforts: Conservationists emphasize the importance of protecting the genetic diversity within these beech populations, which could be crucial for adaptability to climate changes. Additionally, efforts to prevent forest fires and manage natural hazards are essential to maintaining forest health.

Domogled beech forests are sensitive to the effects of climate change, especially due to warmer and drier conditions in the region in recent years. Studies indicate that the shallow root system of Fagus sylvatica makes it vulnerable to drought stress. With warming trends, Beech trees in Domogled may have difficulty sustaining their current growth and may show reduced regeneration rates in some areas.

https://www.europeanbeechforests.org/world-heritage-beech-forests/romania/domogled-valea-cernei

There is ongoing research into how best to support the resilience of these forests, including selective conservation of hardy beech trees, as well as encouraging mixed species stands to protect the ecosystem against environmental stress (Martin -Benito D, 2022).

Researchers are actively studying *Fagus sylvatica* dynamics to better understand how climate, soil and biotic factors affect these forests.

Key research areas include forest dynamics and carbon sequestration. The carbon storage capacity of old-growth beech forests is a topic of research, as these forests play a role in mitigating climate change by storing large amounts of carbon (Castilo E.M, 2022).

Researchers are also studying interactions between *Fagus sylvatica* and other species, particularly the influence of herbivores and some fungi to understand the long-term sustainability of the beech population in this area (Mangels Jule et al, 2023)

European forests are becoming increasingly threatened by climate change and more frequent droughts. The likely responses of species to climate change will vary, affecting their competitiveness, their existence, and consequently, forest management decisions and measures (Adamic P.C, 2023)

Overall, the high values of the radial growth have been recorded for the rainy years. Similarly, high values for radial growth have been recorded in the situations where the aridity index had been recorded to be in the optimal range for beech. The primary limiting factor for beech forests located at low altitudes is the temperature recorded in the growing season, also associated with a reduction in rainfall (Budean M. et al, 2016)

MATERIAL AND METHODS

The determinations were made in Stan Peak Natural Reserve and Tesna-Valley Natural Reserve.

The Stan Peak Natural Reserve is located in Caras-Severin County, near the Băile Herculane resort, being accessible by well-marked mountain trails.

Tesna is a tributary of the Cerna River and the gorges formed by its access are characterized by steep cliffs, lush forests and streams.

As the species *Fagus sylvatica* grows over large areas in the Valea Domogled-Cerna National Park, it was considered important to know the physiology of the species and mainly how the various processes react to the constantly changing environmental conditions. In recent years, and especially in 2024, the recorded temperatures were above the limits of different periods, and the precipitation was well below the annual averages recorded in the past (figure 1).

Figure 1. Temperatures and precipitation in 2024 in the Domogled Cerna Valley Park https://www.meteoblue.com/ro/vreme/historyclimate/weatherarchive/b%c4%83ile-herculane_rom%c3%a2nia_685796?fcstlength=1y&year=2024&month=12

The data presented in figure 1 show that during the winter of 2024 the amount of precipitation was very low. For this reason, since the spring the water deficit at the soil level has been very high. Considering the geological and pedological structure of the area, although in May the amount of precipitation was higher, a small part of the water was retained by the soil, so the water deficit increased. Very dry summer months followed, with extreme temperatures, which amplified the drying of the land.

Fagus sylvatica (European beech) is a species of deciduous tree in the Fagaceae family, native to Europe. It is one of the most widespread and ecologically and economically important species.

Beech can reach heights of 30-40 meters and a trunk diameter of up to 1.5 meters. It is an imposing tree with a wide, rounded and dense crown (Streitz, 2016).

The leaves are simple, ovate, 4-9 cm long, with wavy edges. They are glossy green in summer and turn yellow or reddish-brown in autumn (Roloff et al., 2009).

The bark is smooth, thin and grey, and remains so even in old specimens, which is a distinctive feature (Mitchell, 1974)

The flowers are small, greenish yellow in color, and the fruits are small nuts, edible, but slightly toxic in large quantities.

European beech is found in most of Europe, except in very northern or southern regions. It prefers well-drained, fertile soils and a temperate climate with moderate rainfall (Peters, 1997).

They form pure (beech) or mixed forests, together with other species, such as oak or fir.

Fagus sylvatica is a key species in European forest ecosystems. Beech forests provide habitat for a diverse range of plant and animal species. It also influences the microclimate and hydrological cycle of forests (Packham et al., 2012).

It is sensitive to climate change, especially drought, and can be affected by pests and pathogenic fungi (Tinner and Lotter, 2006).

Trees with a stem diameter of approximately 90 cm were chosen for the determination. Leaves on basal branches were analyzed from mid-April to mid-October. The data presented in the charts represent the average of the determinations made on 10 specimens from each of the two protected areas.

The physiological processes targeted were photosynthesis and transpiration, and the physiological parameters analyzed were total water, free and bound water, leaf chlorophyll content.

The intensity of the photosynthesis and transpiration processes was determined with the Lci portable device that measures the respective parameter with great precision and also has the advantage that the leaves of the analyzed plants can be kept on the plant, so that at intervals of time, new determinations can be made on the same leaves. In this way, graphs can be made regarding the diurnal dynamics, but also the seasonal dynamics of this physiological process. In addition, the device also measures the temperature in the assimilation chamber, as well as the amount of water vapor and light intensity, factors that influence all the vital processes of the plants.

The content of chlorophyll pigments was determined directly on plant leaves with the Minolta portable apparatus, which measures and expresses this parameter in SPAD units.

The water content of the leaves was determined by the gravimetric method, after drying the plant material in an oven at 105 degrees Celsius.

RESULTS AND DISCUSSIONS

The intensity of photosynthesis was determined in the middle of each month under almost identical light conditions, but different in terms of air temperature. Since temperature is not the factor that most strongly influences the process, they were ignored.

In the pedoclimatic conditions of the Tesna Gorges for the analyzed plants, in April the highest value of the intensity of photosynthesis (8.76 μmol/m^2/s) was recorded, at a photosynthetically active radiation value of 1143 μmol/m^2/s and a leaf temperature from the assimilation chamber of 19 degrees Celsius (graph 1)

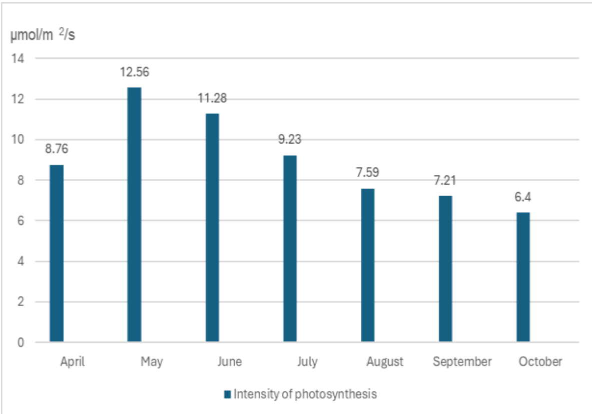
At approximately the same values of light intensity and temperature, in the Stan Peak area, the photosynthesis value was 7.96 μmol/m^2/s (graph 2).

In May, according to the growth of the leaf surface and the greater amount of water in the soil, an intensification of the process was recorded, at the light intensity of 1200 μmol/m^2/s and the temperature of 24 degrees Celsius. In these conditions, photosynthesis had an average value of 12.56 μmol. /m^2/s in the Tesna Gorges and 12.78 in Stan's Peak.

Although the temperature of 31 degrees Celsius and the light intensity of 1340 μmol/m^2/s in June should have intensified the process, it had lower values than in May on the Tesna Gorges and they remained at approximately the same values in the area Stan's peak.

Starting from July, the photosynthesis process showed much lower intensities, with a minimum in mid-October, when the last determination was made.

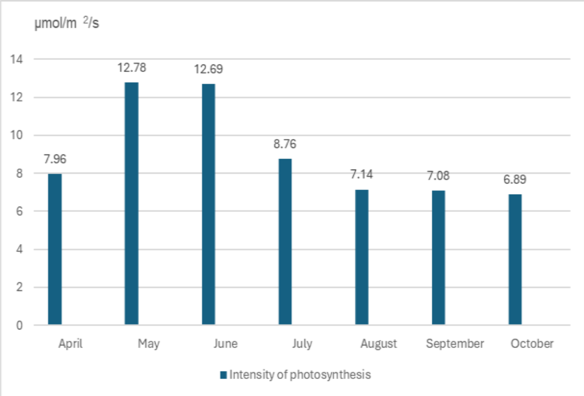
The data indicate that drought has a strong negative effect on the photosynthesis process in the *Fagus sylvatica* species, leading to a decrease in the amount of accumulated biomass.



Graph 1. The intensity of photosynthesis of *Fagus sylvatica* leaves in Tesna Gorges area (μmol/m^2/s)

There is not enough data on the behavior of mature trees under conditions of water stress. Some studies focused on only saplings grown under controlled conditions.

Drought stress significantly reduces photosynthesis by impairing gas exchange and altering water-use efficiency.



Graph 2. The intensity of photosynthesis of *Fagus sylvatica* leaves in Stan Peak area (µmol/m ²/s)

Considering the relationships between the hydraulic functional traits and the leaves, Aranda I. et al (2015) tested whether local adaptation to water stress occurs in this species. To address these objectives, they conducted a greenhouse experiment in which 2-year-old seedlings from six beech populations were subjected to different watering treatments. These populations spanned central and marginal areas of the area, with variations in macro- and microclimatic water availability. The results highlight subtle but significant differences between populations in their functional response to drought. Population differences in hydraulic traits suggest that vulnerability to cavitation is greater in populations with greater drought sensitivity. However, there was no clear relationship between variables related to hydraulic efficiency, such as xylem-specific hydraulic conductivity or stomatal conductance, and those reflecting resistance to xylem cavitation. The results suggest that while a trade-off between leaf-level photosynthetic capacity and xylem hydraulic function may be established between populations, it operates independently of the trade-off between safety and hydraulic efficiency in water use at the interpopulation level.

The intensity of transpiration

Drought affects transpiration by reducing soil water availability, which has several consequences for plants.

In drought conditions, plants close their stomata to minimize water loss. While this reduces transpiration, it also limits water absorption, affecting the suction power of the leaves. Drought reduces the soil's water potential, making it harder for plants to extract water. This can lead to reduced water transport through the xylem.

Persistent drought can also cause xylem cavitation (the formation of air bubbles), disrupting water transport and further limiting transpiration.

Fagus sylvatica has a shallow root system, which makes it vulnerable to reduced soil moisture. During drought, water absorption decreases significantly, which limits transpiration.

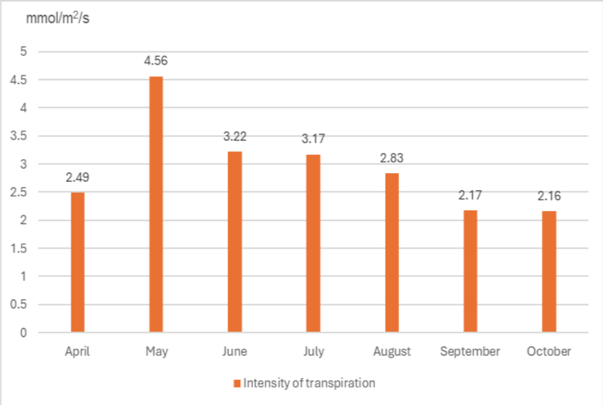
Exhibits early and strong stomatal closure during drought to prevent excessive water loss. This response, although protective, reduces transpiration and photosynthesis.

Trees may accumulate stress hormones like abscisic acid (ABA) under drought conditions. This promotes stomatal closure and further reduces transpiration.

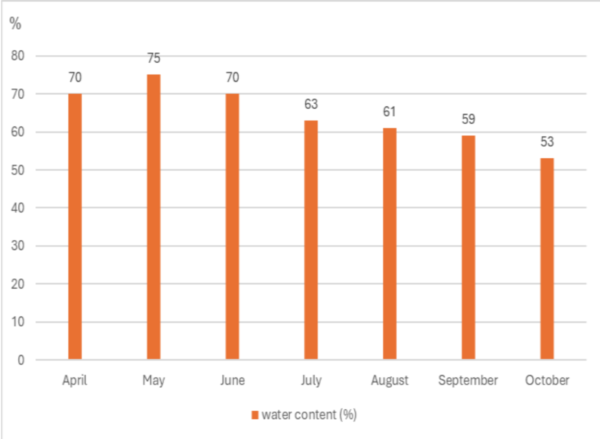
Drought significantly decreases transpiration in european beech due to reduced soil water availability and increased atmospheric vapor pressure deficits. Dominant trees tend to reduce transpiration more significantly than suppressed ones, likely as a water-saving strategy. This can also lead to a reduction in water uptake from deeper soil layers during drought conditions (Madsen, P. 1994).

In the climatic conditions of 2024, beech trees showed reduced transpiration values starting in June, as a result of the drought, in both areas studied (graphs 3,4).

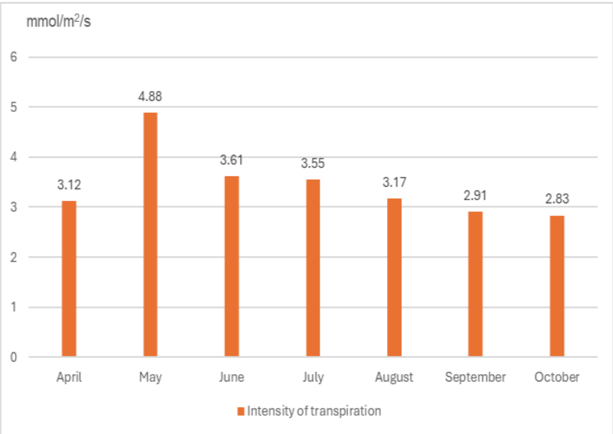
The small differences recorded of the determination in the two areas can be attributed to the small variations in temperature and light, but also the wind speed, because on vârful stan the air currents are much stronger, in contrast to cheile tesnei, which is more sheltered from this point of view. that's why the sweat was more intense on Stan Peak (graph 4).



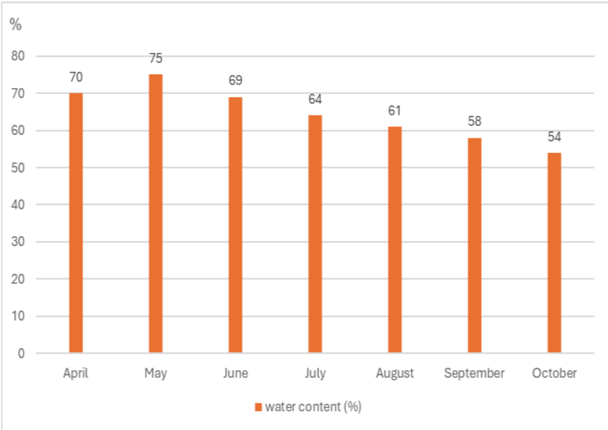
Graph 3. The intensity of transpiration of *Fagus sylvatica* leaves in Tesna Gorges area (mmol/m ^{2}/s)



Graph 5. The water content of *Fagus sylvatica* leaves in Tesna Gorges area (%)



Graph 4. The intensity of transpiration of *Fagus sylvatica* leaves in Stan Peak area (mmol/m ^{2}/s)



Graph 6. The water content of *Fagus sylvatica* leaves in Stan Peak area (%)

The water content of leaves

The water content of leaves registered a significant increase in May, after which a continuous reduction followed until october. There were no significant differences between the values recorded in the two areas studied, although the transpiration intensity values were slightly higher in Stan's Peak(graph 5,6).

The decrease in water content as the drought increases also explains the reduced photosynthesis values, because it is known that water intervenes in the process, providing the hydrogen needed to reduce CO_2.

The chlorophyll content of leaves showed significant variations.

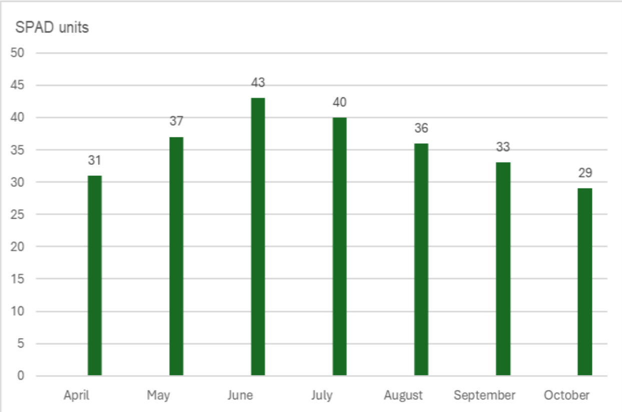
During the spring, the lower amount of chlorophyll was due to the fact that the leaves were young and had not accumulated enough pigment.

The maximum amount was recorded in June, after which the water stress determined the reduction of the content, with negative effects on the photosynthesis process(graph 7,8).

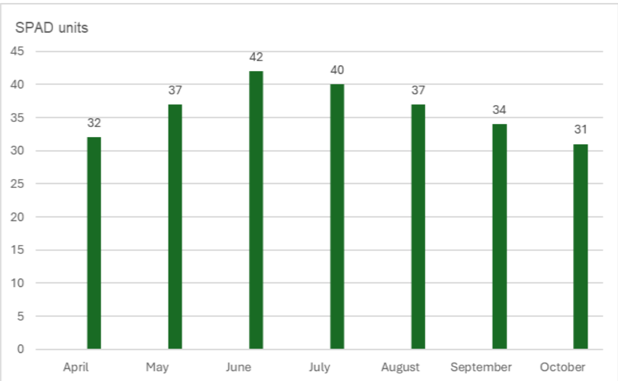
During drought, plants prioritize water conservation and root growth over chlorophyll synthesis. This often results in decreased chlorophyll levels in the leaves.

Limited water reduces the availability of nutrients such as magnesium, which is essential for chlorophyll synthesis.

Drought stress can accelerate leaf senescence, a process during which chlorophyll breaks down and nutrients are recycled to other parts of the plant.



Graph 7. The chlorophyll content of *Fagus sylvatica* leaves from the Tesna Gorges area



Graph 8. The chlorophyll content of *Fagus sylvatica* leaves from the Stan Peak area

CONCLUSIONS

Drought has a significant impact on photosynthesis in tree leaves, primarily by limiting the availability of water which is essential for the photosynthetic process

During drought conditions, trees close their stomata to reduce water loss through transpiration

This closure limits the entry of carbon dioxide (CO_2) into the leaf, which is a critical component for photosynthesis

A lack of water disrupts this process, limiting the production of energy carriers needed for sugar synthesis

Prolonged drought often leads to wilting and damage to leaf tissues, further reducing photosynthetic capacity.

Leaf area may decrease due to shedding of leaves or smaller leaf growth, which reduces the overall surface available for photosynthesis

Drought led to a decline in chlorophyll concentration (chlorosis), reducing the leaf's ability to capture light energy.

During drought, trees may redirect their resources away from photosynthesis and growth to focus on survival processes, such as root expansion to access water

Chronic drought stress can reduce tree growth, weaken the tree, and even lead to death if the drought persists or is severe

For *Fagus sylvatica,* drought has a pronounced impact due to its shallow root system, high stomatal sensitivity, and vulnerability to hydraulic dysfunction. These adaptations help the species survive short-term droughts but may compromise growth and productivity under prolonged or repeated drought events.

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