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THE PHYSIOLOGICAL RESPONSE TO WATER STRESS OF SOME HYGROPHILOUS PLANT SPECIES FROM THE SOUTHWEST OF ROMANIA

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Abstract

This work investigates the physiological responses of hygrophilous plants from southwestern Romania to water deficit conditions. The study quantifies variables such as stomatal conductance, osmotic potential, chlorophyll content, photosynthetic activity and osmolyte accumulation, to understand the mechanisms of tolerance and the capacity to recover from stress. The results will provide information on the vulnerability of hygrophilous species in the context of climate change and will propose directions for the conservation and management of wetland habitats. Two hygrophilous species, Petasites kablikianus and Telekia speciosa, were included in this study due to their ecological significance and sensitivity to water availability. Both species are characterized by large stature and high photosynthetic efficiency under conditions of normal soil moisture, reflecting their adaptation to consistently humid habitats. However, when water levels decrease and a water deficit is established, these species exhibit pronounced reductions in key physiological processes, most notably in photosynthetic activity. This decline is associated with stomatal closure, reduced CO_2 *assimilation, and limitations in photochemical efficiency, all of which are common responses to water stress in moisture-demanding plants. Moreover, prolonged exposure to suboptimal water availability can lead to osmotic stress, reduced turgor, and potential cellular damage, compromising overall plant growth and survival. The observed sensitivity of P. kablikianus and T. speciosa to declining soil humidity highlights their vulnerability in the face of habitat alteration, suggesting an increased risk of maladaptation in environments that no longer provide stable water conditions. These findings emphasize the importance of monitoring hydric changes in wetland and riparian ecosystems, particularly in the context of climate variability*

Key words: water stress, photosynthesis, transpiration, water content

INTRODUCTION

Water stress is one of the most important limiting factors affecting plant distribution, growth rate, and biomass accumulation at various growth stages. Variations in species tolerance to drought fundamentally shape global biodiversity patterns by influencing survival rates, distribution areas, and community composition under changing environmental conditions (Dong M. et al, 2025).

Hygrophilous species are adapted to saturated and anoxic soils through anatomical and physiological characters (aerenchyma, superficial roots, thin leaves), but these adaptations generally make them vulnerable to water deficit because they have lost some mechanisms that confer drought tolerance.Drought responses vary greatly between groups: vascular macrophytes (*Phragmites, Typha,* etc.) have plasticity (stomatal closure, osmotic adjustment, radial root growth), while many bryophytes (mosses, lichens) are poikilohydric — they can survive rapid dehydration through desiccation tolerance mechanisms and rapid rehydration (Haghpanah M.et al, 2024).

The common physiological mechanisms used in water stress are reduction of stomatal conductance (decreased photosynthesis), osmotic adjustment (accumulation of soluble compounds), activation of antioxidant system (escape

of ROS), foliar senescence and allocation of resources to the root. The intensity and order of these responses depend on the duration and severity (Sun Y et al, 2024).
Water stress induced a quic and strong stomatal closure and leading to photosynthesis inhibition with consequent negative effects on biomass production (Brunetti C. et al, 2028).
Some hygrophilous species exhibit stress plasticity/"memory": previous exposure to deficit or alternation (flooding→drought) can modify the subsequent response (priming or sensitization), sometimes making plants more resistant and sometimes more sensitive, depending on the type and sequence of stresses (Diaz-Barradas et al, 2022).
At the community scale, the drying of wetlands leads to the loss of strictly hygrophilous species, changes in structure and function, and more xeric species successively colonize. This has effects on ecosystem services (De Araujo, Silveira, 2024).
Under drought conditions, leaves display various stress responses including shrinkage, yellowing, and abscission, resulting in reduced leaf area and numbers. These modifications decrease transpirational water loss and represent adaptive self-regulatory mechanisms for drought environments (Xiao, L et al, 2023).
Hygrophilous species are dependent on environments with high humidity (wetlands, swamps, riverbanks). Knowing their degree of adaptability allows the identification of species vulnerable to drought, the prevention of local or global extinction, the development of specific conservation strategies. They play an essential role in regulating the water cycle, stabilizing soils, and naturally filtering pollutants. Therefore, reduced adaptability can lead to ecosystem degradation and the loss of ecosystem services.
Studying the response of hygrophilous species to falling water levels, rising temperatures and changing hydrological regimes allows forecasting changes in the structure and distribution of habitats. Hygrophilous species can be used as bioindicators of water stress, early signals of ecological imbalances, and tools for monitoring climate change.

MATERIAL AND METHODS

The determinations were made in 2025 on the Bistrița Gorges (Gorj County). The Bistrița Gorges are formed in the Vâlcan mountains (the confluence of the Negoi and Groapele branches) and cross the communes in the Peștișani area (Gureni, Hobița, Telești) before continuing towards the upper course of the Tismana. This area is known locally as the " Bistrița Valley".
The Valley is shaped by a mountain stream that has carved out gorges and steep sections (gorges/ravines) in the context of the Vâlcan Massif. Access is made, in tourist areas, through forest roads and paths; there are local tourist elements (trails, caves, bridges) reported by the community https://www.valeabistritei.org/valea-bistritei-gorjene
Bistrița Gorges is a spectacular canyon with vertical limestone walls, approximately 8–10 km long, through which the Bistrița River flows. There are also waterfalls or small rapids.
The climate is mountainous, with cool summers and cold winters, favorable to the development of forests and fauna specific to the Subcarpathian Mountains.
Telekia speciosa - Asteraceae family is a perennial plant, with a large size (can reach 2–3 m). It prefers wet meadows, forest edges, meadows and open lands with fertile and loamy soil. It is tolerant of partial shade but prefers indirect light. From an ecological point of view, it attracts pollinators, especially bees and butterflies, can contribute to soil stabilization in wetlands and to the creation of a microhabitat for insects and small animals. https://www.infoflora.ch/en/flora/telekia-speciosa.html

In Romania it is a protected species in certain natural areas, because natural populations are limited, and it occurs in natural communities associated with habitat type 6430 edge communities with tall hygrophilous grasses, where it contributes to floristic diversity. (https://legislatie.just.ro/).

The species can form dense local populations in humid forests or meadow edges, influencing the structure of the plant community. https://alienplantsbelgium.myspecies.info/content/telekia-speciosa

With large leaves and extensive rhizomes, the species builds hygrophilous floral communities that contribute to soil stabilization and the provision of microhabitats for small fauna especially in riparian areas.

Petasites kablikianus is a rhizomatous perennial species of the Asteraceae family, known at European level as a characteristic plant of hygrophilous vegetation in mountainous areas. It grows in moist remnants of alluvial soil, especially on the edges of valleys, streams and pronounced moist soils in the beech and submontane layers of the Carpathians. Communities dominated by *Petasites kablikianus* develop in the edges of rivers and on moist soils, with high nutrients, but often less structured (skeletal), rich in magnesium, nitrogen and carbon (Uziębło A et al, 2018).

Altitudinal, these populations are important between 650m and 1450m and appear especially in the shadows of forests or in transit to forest meadows (Nazarov M. et al, 2022).

With large leaves and extensive rhizomes, the species builds hygrophilous floral communities that contribute to soil stabilization and the provision of microhabitats for small fauna (insects, invertebrates), especially in riparian areas. *Petasites kablikianus* communities are part of hygrophilous alpine/montane plant associations, along with other plant species. Although it is not necessarily a directly threatened species, the habitat in which it lives is sensitive to alterations in the water regime and fragmentation

The physiological processes targeted were photosynthesis and transpiration, and the physiological parameters analyzed were total water and 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, figures 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

The determinations carried out during the summer months highlighted the significant reduction in photosynthesis as the water level decreased and soil drought set in.

Regarding the *Telkia speciosa* species, the maximum photosynthesis values were recorded in mature leaves in June, but at the time of flowering when the need for assimilation products should have been greater, the process was significantly reduced, affecting flowering and subsequently fruiting. Thus, *Telekia* plants are very sensitive to drought, reacting by rapidly decreasing photosynthesis and wilting. If in conditions of good water supply, Telekia shows high values of photosynthesis, water stress reduces it almost completely, reaching a value of 1.34 μmol/m ^{2}/s in August.

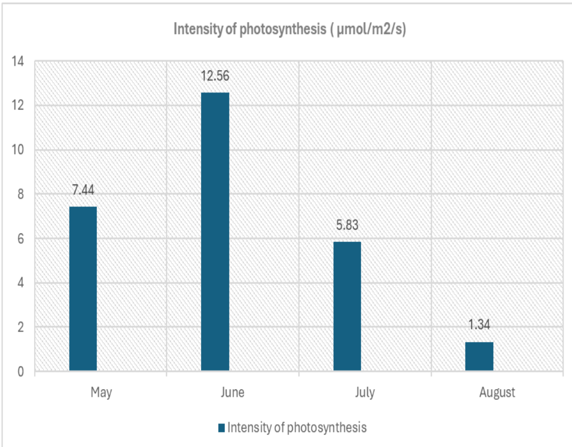

Figure 1. The intensity of photosynthesis of *Telekia speciosa* leaves (μmol/m ^{2}/s)

As drought sets in, photosynthesis in Petasites kablikianus decreases rapidly, the main causes being the closure of stomata, decreased cell turgor, and partial necrosis of the leaves. The species cannot effectively compensate for water stress. Although photosynthesis is very reduced or absent, the plant can survive until moisture returns through the reserve vegetative organs (rhizomes), but the chances are small because they have not accumulated enough reserve organic substances.

The figureical data indicate that in the case of the species *Petasites kablikianus* a stronger damage than in the case of the species *Telekia speciosa* (figure 2).

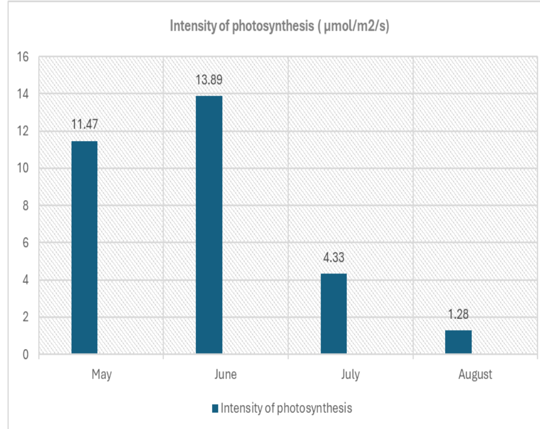

Figure 2. The intensity of photosynthesis of *Petasites kablikianus* leaves (μmol/m ^{2}/s)

The intensity of transpiration

In *Telekia speciosa*, a hygrophilous species with large and thin leaves, the intensity of transpiration as drought occurs follows a clear downward pattern, determined by the lack of adaptations to water stress.

Under normal humidity conditions, the large leaves (with thin cuticle and many open stomata) had intense transpiration, necessary for sap circulation.

In June, with the onset of drought and the decrease in soil water potential, the plant reacted by partially closing the stomata. Thus, the intensity of transpiration decreased, but remained at quite high values.

Starting with July, a loss of leaf turgor and a significant decrease in transpiration intensity were observed. Under conditions of total stomata closure, water losses were made only through the thin cuticle of the leaves.

According to figure 3, the intensity of transpiration decreases, affecting the plant's metabolism. large water losses cannot be compensated by dry soil and the plant reacts, but not quickly enough as in the case of xerophilic species.

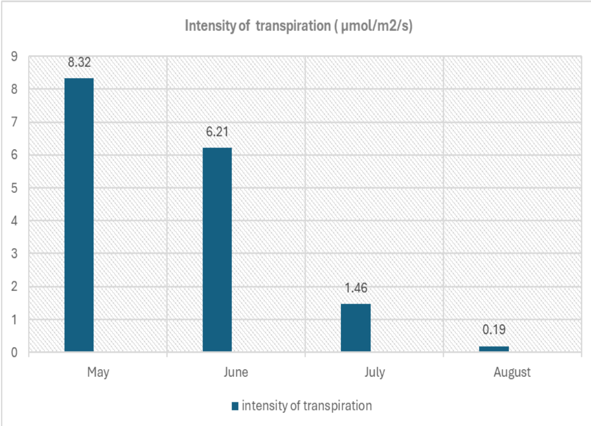

Figure 3. The intensity of transpiration of *Telekia speciosa* leaves (mmol/m ^{2}/s)

In *Petasites kablikianus*, in May the transpiration intensity values were higher than in *Telekia,* but as the drought set in they dropped sharply, reaching a minimum value of 0.08 mmol/m2/s in August (figure 4). This very low value indicates a strong damage to the plants.

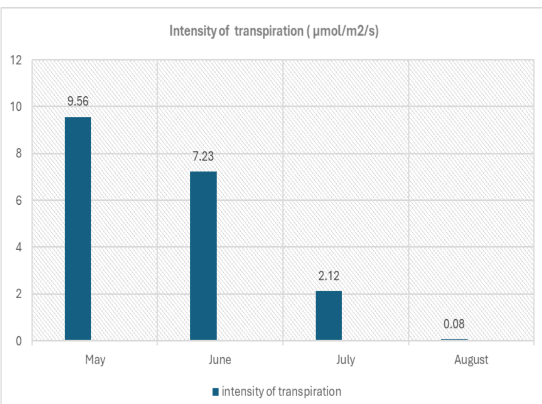

Figure 4. The intensity of transpiration of *Petasites kablikianus* (mmol/m ^{2}/s)

The water content of leaves

In *Telekia speciosa,* a hygrophilous species, the leaf has a high-water content under normal conditions, which reflects the adaptation to humid habitats and moisture-rich soils.

young and mature leaves have an average water content of 85% of the fresh mass. This gives high turgor, high transpiration and efficient photosynthesis.

In the case of drought, the water content decreases progressively. In June, with the onset of drought, 76% water and the leaf begins to lose its turgor slightly. In July, when there are still water reserves in the soil, 69% water, and in August, the water content is 63% (figure 5).

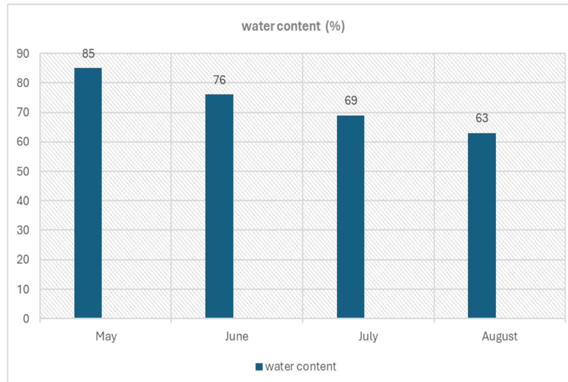

Figure 5. The water content of *Telekia speciosa* leaves
(%)

In *Petasites kablikianus* in May the total water content was 89%. In June the water content decreased to 69%, in July it reached 65% and in August the water percentage decreased significantly, reaching 58%.

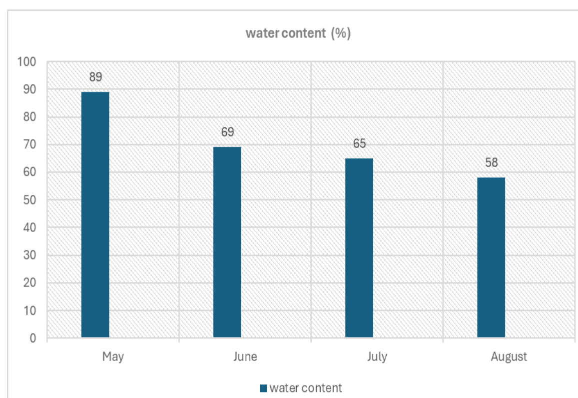

Figure 6. The water content of *Petasites kablikianus*
(%)

The chlorophyll content of leaves

Chlorophyll content decreases because stress induces partial degradation of chlorophyll and inhibition of pigment biosynthesis (figure 7,8). As chlorophyll content decreases, the leaf becomes

yellow-green or brown. The response is faster and more pronounced than in mesophilous or xerophilous plants.
The decrease in chlorophyll reflects the sensitivity of hygrophilous plants to water stress.

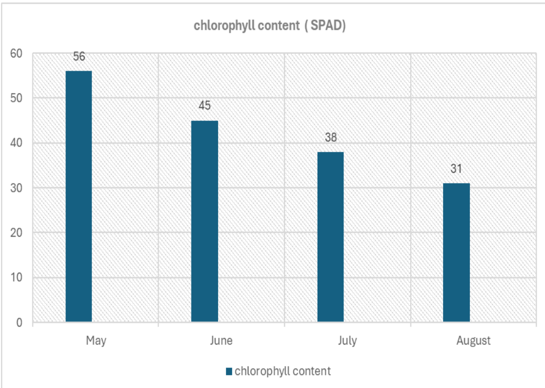

Figure 7. The chlorophyll content of *Telekia speciosa*

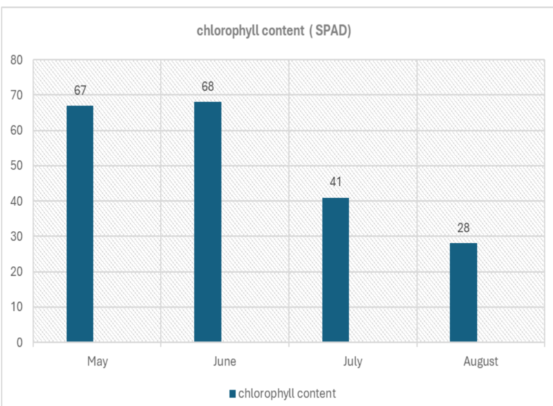

Figure 8. The chlorophyll content of *Petasites kablikianus*

CONCLUSIONS

The observed physiological responses of *Telekia speciosa* and *Petasites kablikianus* confirm their strong dependence on stable water regimes.
Drought and lowered river levels significantly reduce photosynthesis in both *Telekia speciosa* and *Petasites kablikianus*, primarily due to limited water availability and stomatal closure.
Reduced CO_2 diffusion into the leaves leads to decreased carbon assimilation and impaired biomass accumulation.
Lower soil and atmospheric water availability suppress transpiration, disrupting leaf cooling and nutrient transport. This reduction reflects an adaptive response aimed at minimizing water loss, but it also limits physiological activity.
Both species exhibit reduced stomatal conductance under drought stress, indicating a conservative water-use strategy.
Prolonged stomatal closure may lead to photoinhibition and oxidative stress due to reduced CO_2 availability in chloroplasts.
Drought stress decreases total water content in tissues, affecting cellular turgor and metabolic processes.
The shift in the free/bound water ratio with a relative increase in bound water suggests stress-induced stabilization of cellular structures but reduced physiological flexibility.
As moisture-dependent species, both *Telekia speciosa* and *Petasites kablikianus* show limited tolerance to prolonged hydrological disturbances.
Their physiological responses indicate vulnerability to climate-induced drought and river regulation.
Drought and declining river levels compromise their photosynthetic efficiency, water balance, and survival potential, emphasizing the need for integrated hydrological management and targeted conservation strategies under increasing climate variability.
Knowing the degree of adaptability of hygrophilous species is essential for protecting biodiversity, maintaining ecosystem balance, and developing effective strategies for adapting to climate change, in the context of increasing drought and reduced water resources

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