THE INFLUENCE OF WATER CONTENT ON THE MINERAL CONTENT OF *URTICA DIOICA* PLANT

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Abstract
Urtica dioica is a perennial species valued for its medicinal and nutritional potential. Its development is strongly influenced by water status, both in the soil and in the plant itself. Minerals play a crucial role in plant development, supporting key processes such as photosynthesis, protein synthesis, and stress resistance. The aim of this study was to investigate the influence of water content on the development and mineral content of *Urtica dioica* under natural conditions. Moisture and mineral contents were determined through thermogravimetric methods and portable spectrophotometric analysis. The results indicate that maximum hydration was recorded in spring, when moderate temperatures and balanced air humidity created favorable conditions for plant growth. In contrast, during summer, tissue water content declined while mineral concentration increased, even though rainfall and soil moisture were higher. This pattern highlights the decisive role of atmospheric conditions, particularly temperature and air humidity, in shaping the seasonal water balance of *Urtica dioica*.

Keywords: stinging nettle, climatic factors, seasonal variation, water availability

Introduction
Urtica dioica is a perennial species widely spread across Europe, traditionally harvested as both food and medicine. One important feature of the physiology of the plant is water content. Water is required for metabolism, photosynthesis, nutrient transport as well as turgor maintenance. It has been reported that there is a decreasing water content with maturity, which results in a relative increase of the minerals and secondary metabolites concentration [5, 9]. This change has consequences for more than just the plant's nutritional value [7], but it also affects how it reacts to stress. Beyond this relative increase, minerals themselves are essential drivers of plant metabolism, as they function as cofactors in enzymatic reactions, structural components of cell walls, and regulators of osmotic balance [1].
Environmental conditions have a crucial influence on this balance. Elements such as soil water supply, rainfall, air temperature, and humidity interact closely to shape the plant's hydration status [11].
The aim of the study is to investigate how the seasonal interplay between mineral accumulation and water content shapes the developmental process of *Urtica dioica.*
A distinctive characteristic of *Urtica dioica* is its flexibility in adjusting the levels of bioactive compounds and minerals under stress or at different growth stages. Evidence suggests that when exposed to drought, nettle plants can accumulate more phenolic substances and antioxidants, which act as protective responses [4]. Such adaptive plasticity is not limited to secondary metabolites; mineral nutrients like magnesium, calcium, and potassium also fluctuate with

growth stage and environmental stress, directly influencing photosynthetic capacity and tissue resilience [3].

Experimental

2.1. Collection and preparation of samples

Nettle plants and soil samples were collected from Bazoş area, Timiş County, Romania, over a four-month period: October 2024, January, April and July 2025.

Soil samples were manually cleaned of impurities (leaves, roots, stones), then passed through a 2 mm laboratory sieve. After moisture determination, they were dried at room temperature (25°C) and prepared for further analyses.

Plant material was rinsed with distilled water to remove dust and contaminants. Roots, stems, and leaves were separated, cut, and homogenized individually to ensure uniform and representative samples.

Climatic data (temperature, precipitation, and atmospheric humidity) were obtained from local meteorological sources [12].

2.2. Analysis of samples

The moisture content [%] of the soil and nettle samples was assessed through thermogravimetric analysis, as presented by Bordean (2013), employing a Sartorius scale [2].

The total mineral content of nettle samples (roots, stems, leaves and flowers) was assessed using a portable X-ray fluorescence (XRF) spectrometer, which provided rapid and non-destructive elemental analysis [8]. The concentrations obtained were further processed and calculated to ensure accurate quantification of the mineral profile.

2.3. Statistical analysis

The experimental data were processed using Microsoft Excel 2010, which was employed for data organization, descriptive statistics, and graphical representation of the results.

Results and discussion

In Figure 1, we can observe the seasonal variability of *Urtica dioica* water status and mineral concentration, and their dependence on both soil and atmospheric parameters. Rainfall influenced mineral dynamics indirectly, since higher precipitation and soil moisture did not always correspond to lower mineral concentrations, highlighting the stronger role of atmospheric conditions in shaping nutrient balance. Temperature rises were associated with increased mineral concentration, suggesting that heat stress not only reduced tissue hydration but also enhanced nutrient accumulation as part of the plant's adaptive response.The data clearly indicate that soil water availability alone is insufficient to explain plant hydration levels; instead, the balance between precipitation, soil retention capacity, air temperature, and relative humidity exerts a combined influence [11]. The rise in mineral concentration (471 g/kg DM) indicates water stress, as dehydration concentrates solutes, a common adaptive response to drought and heat [11]. Such mineral enrichment may not only be a passive concentration effect but can also represent an adaptive advantage, since elements like potassium regulate stomatal function, calcium strengthens cell walls, and magnesium maintains photosynthetic efficiency under stress [6, 10].

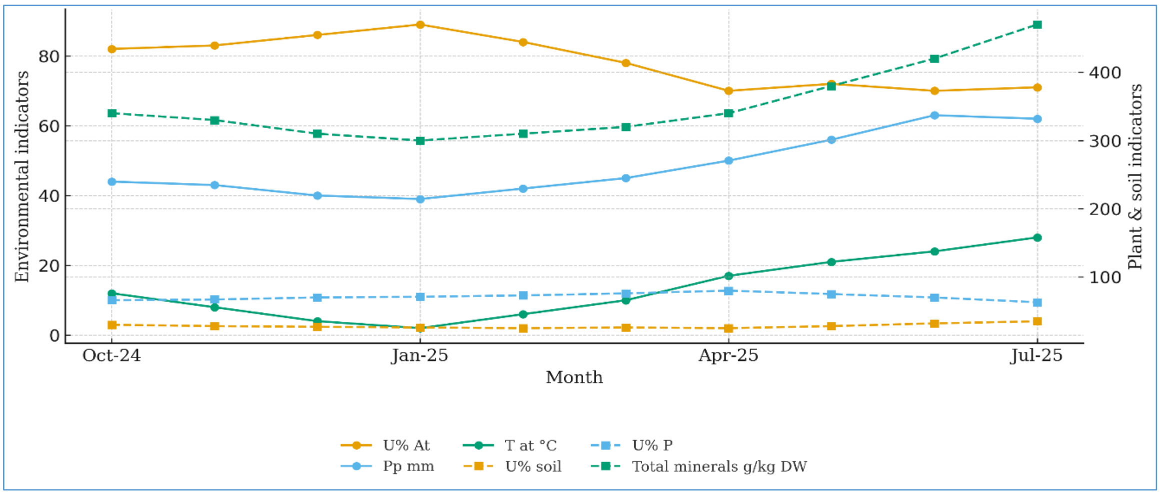


Figure 1. Seasonal Dynamics of Environmental and Plant Indicators (Oct-24 to Jul-25)

Legend: Oct-24=October 2024, Jan-25 =January 2025, Apr-25=April 2025 Jul-25=July 2025, U% soil= moisture content in the soil,U% P=Percentage of moisture content in Urtica Dioica plant, Total minerals g/kg DW=total mineral content in grams per kilogram of dry matter, U% At=Percentage of atmospheric humidity, Pp mm=Precipitation in millimeters (amount of rainfall), T at °C=Temperature in degrees Celsius.

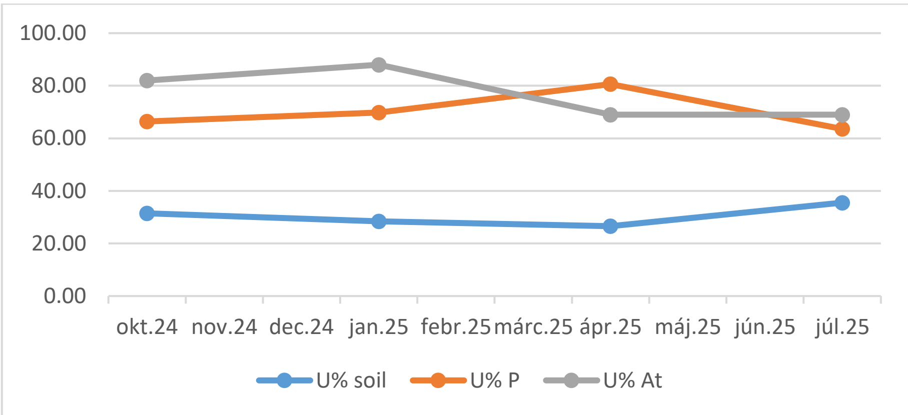
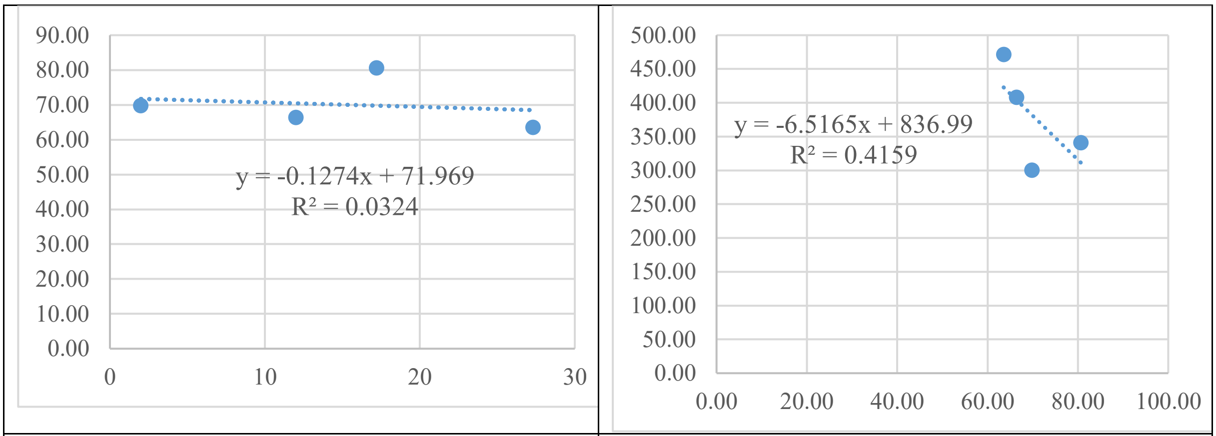


Figure 2. Comparison of Soil, Plant, and Air Moisture (Oct-24 to Jul-25)

In Figure 2, the seasonal changes of soil, plant, and air moisture in *Urtica dioica* are illustrated. Soil moisture dropped from autumn to spring, with the lowest point in April, then increased in July with higher rainfall. Plant water content followed another pattern, reaching its maximum in April under moderate temperature and balanced humidity. The plant was able to store more water even though the soil was relatively dry. By July, higher temperatures and lower air humidity reduced plant water content despite increased soil moisture. Atmospheric humidity peaked in winter but declined steadily with rising temperatures.



a) Relationship between temperature and plant water content

b) Relationship between plant moisture and mineral content

Figure 3. Association between investigated parameters

In Figure 3 a), the temperature trend and water content in the plant *Urtica dioica* are illustrated. The points show that as temperature rises, the plant contains less water in its tissues. The trendline reinforces a declining trend with slight slope but not greatly steep. The very low R^2 indicates that temperature cannot explain much of the variation in water content on its own. Other environmental factors, such as soil and atmospheric humidity, must play a larger role.
The scatter plot reveals that as plant moisture increases, mineral content in *Urtica dioica* actually decreases (Figure 3 b). High tissue water in April (80.6%) corresponded to low mineral levels (340.9 g/kg SU), while reduced hydration in July (63.6%) coincided with the maximum (471.5 g/kg SU). This inverse pattern reflects both passive concentration through dehydration and active adjustment, as mineral accumulation aids osmotic balance and stress tolerance. Potassium, for instance, regulates stomatal aperture and water balance, calcium strengthens membranes and cell walls, while magnesium ensures chlorophyll stability and photosynthetic efficiency under fluctuating hydration [6,10].

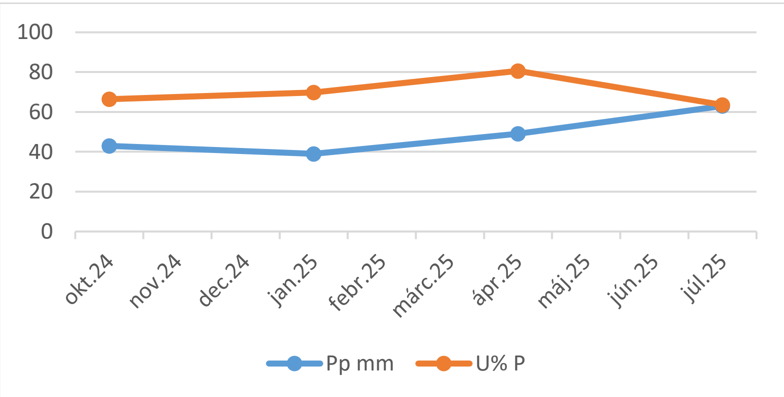


Figure 4. Effect of rainfall on plant moisture in *Urtica dioica*

Figure 4 shows that plant water content does not correlate with more rain. In April, *Urtica dioica* reached its maximum hydration (80.6%) with moderate rainfall, while in July, despite the highest rainfall (63 mm), plant moisture content dropped to 63.6%. This suggests that things like temperature and how much moisture is in the air have a greater impact on the water status of the plant than how much rain falls.

Conclusions

The analysis revealed that that the growth of *Urtica dioica* is influenced by a variety of factors, such as soil conditions, climate, and plant physiology, rather than by rainfall alone. Spring was the most favorable period for hydration and growth, while summer imposed significant stress from high temperatures and low air humidity, even when soil moisture was plentiful. Minerals such as potassium, calcium, and magnesium play active roles in this adjustment by regulating stomatal behavior, reinforcing cell structure, and sustaining photosynthetic capacity, thereby enhancing the plant's tolerance to environmental stressors.

The inverse relationship between water content and mineral concentration reflects natural seasonal changes and the species' adaptive strategies under heat and drought stress. These results highlight the nettle's resilience and its ability to adapt its biochemical profile in response to environmental variations, providing valuable insights for ecological research and the sustainable use of this resource.

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