Trees, Forests and People 17 (2024) 100607

Contents lists available at ScienceDirect

Trees, Forests and People

journal homepage: www.sciencedirect.com/journal/trees-forests-and-people

Assessing water storage capacity and wettability of plants and woody fragments in post-fire environments: A case study in Los Guájares, SE Spain☆

Anna Klamerus-Iwan [a], Laura Cambronero Ruiz [b], Casandra Muñoz Gómez [c], Agata Warczyk [a], Pranav Dev Singh [a], Muhammad Owais Khan [a], Andrés Caballero-Calvo [b,*]

[a] Department of Ecological Engineering and Forest Hydrology, University of Agriculture in Krakow, Kraków, Poland
[b] Department of Regional Geographic Analysis and Physical Geography, Faculty of Philosophy and Letters, Cartuja Campus, University of Granada, 18071, Granada, Spain
[c] Escuela Nacional de Ciencias de la Tierra, Universidad Nacional Autónoma de México, Av. Antonio Delfin Madrigal 300, Coyoacán, 04510, Ciudad de México, México

ARTICLE INFO

Keywords:
Wetting contact angle
Forest fire
Water retention
Drought resilience
Post-fire recovery

ABSTRACT

Wildfires pose significant threats to ecosystems, impacting soil properties and hydrological dynamics. This study investigates the water storage capacity and wettability of ecosystem elements, especially plants and woody fragments in post-fire areas of Los Guájares (Granada, SE Spain). Wildfires alter soil acidity, water storage, and nutrient concentration, affecting the hydrological properties of the forest floor. Understanding the water cycle is crucial for preserving and harnessing ecosystem capabilities. Plant wettability, a key parameter reflecting the ability to retain water on surfaces, is integral to the hydrological and ecological functioning of ecosystems. This research employs contact angle measurements and water storage capacity assessments to explore the relationship between leaves and wood wettability in areas affected by last year's fire (B) compared to adjacent unburned areas (U). The research was conducted in Los Guájares, characterized by steep slopes and Mediterranean climate, and utilized photography and angle measurements in graphic software for the wetting contact angle measurements and a weighing method for the plant surface water storage determination. Results reveal that average water capacity (S) decreases with increasing contact angle (CA) on both burned and unburned surfaces. Woody fragments, such as dry but unburned mango branches, exhibit the highest water capacity after 24 h of water immersion (S24), 1.10 [g^{-1}] of water, emphasizing the role of dead wood as a water reservoir. Burnt pine wood and fresh mango branches show lower water retention, indicating the impact of fire on water storage. Findings suggest that while the water capacity of leaves in new plants is similar between burned and unburned areas, wettability differs. This research provides insights into species selection for landscape conservation, informs hillslope restoration planning, and identifies areas resilient to droughts.

1. Introduction

The study of water uptake by plants encompasses various dimensions, playing a pivotal role in the intricate balance of water within ecosystems and influencing soil water cycles (Raats 2007; Hueso-González et al., 2018; Klamerus-Iwan et al., 2020a). Regardless of the aspect under scrutiny, this process significantly impacts microclimatic conditions, intertwined with air humidity (Leelamanie et al., 2019). In eco-hydrological research, understanding the factors that influence changes in the water capacity of forest ecosystem elements is paramount (Chang et al., 2022; Yu et al., 2023). Plants exhibit the ability to intercept and retain rainwater across their entire surface, shaping a process known as plant interception (Belmonte Serrato and Romero 1998). The amount of precipitation reaching the forest floor is contingent upon both direct precipitation and relative air humidity, with tree morphology notably influencing water distribution in the lower layers of the forest (Rosado and Holder 2012; Klamerus-Iwan, Szymański 2017). The intricate process of water retention on plant surfaces is influenced by various characteristics, with structural features and precipitation dynamics standing out as the most critical (Dunkerley, 2000;

☆ This article is part of a special issue entitled: "Fire and environment. Issues and challenges" published at the journal Trees, Forests and People.

* Corresponding author.
E-mail address: annaklamerus.iwan@gmail.com (A. Caballero-Calvo).

https://doi.org/10.1016/j.tfp.2024.100607

Available online 27 June 2024

Rastegaripour et al., 2024). The amount of water retained is often treated as a constant value of a single precipitation event, subject to change due to successive events (Chen and Chen, 2003; Klamerus- Iwan and Witek, 2018). Therefore, it is imperative to identify factors that enhance or diminish water retention within forest stands (Muzylo et al., 2009).

The wettability of plant material, a key determinant of its hydrological properties, can be assessed by measuring the contact angle of water droplets on the material surface (Papierowska et al., 2018; Holder et al., 2020). Recent scientific research has delved analysing into understanding the intricate interactions between plant surfaces and water (Blonska et al.,2018; Leelamanie et al., 2021; Rosado and Holder, 2013; Wang et al., 2014; Holder and Gibbes, 2016), focusing on wettability, hydrophobicity, and hydrophilicity based on water contact angle measurements (Holder and Gibbes, 2016). Contact angles, considered as bioindicators of air pollution, find diverse applications extending into industries (Klamerus-Iwan and Błońska, 2018). Holder et al. (2020) conducted a detailed analysis of contact angles, to determine the wettability of a solid surface by a liquid (Weisensee et al., 2016; Whelan et al., 2014).

The evolution of this field is evidenced by continual modifications and contemporary theories. Recentreview , such as that by Popović & Cerdà (2023), provides a comprehensive overview of the current understanding of soil water repellency (SWR) and its relationship with plant cover. The diversity of plant surfaces, particularly in terms of polarity and non-polarity, prompts the exploration of wettability to understand its influence on the water holding capacity of plant material. Previous studies on the wettability of plant material have primarily focused on wetland plants (Papierowska et al. 2023). Leaf hydrophobicity significantly contributes to the amount of retained water, with an observed decrease in water retention with increasing average contact angle. Beyond plants, lichens are gaining attention in ecohydrology for their water holding capacity (Klamerus-Iwan et al. 2023; Thakur et al., 2024).

Advancing our understanding of water retention capacity, particularly under controlled conditions, is crucial for generating data that can inform the development of mathematical models (Doerr et al., 2005; Drelich 2019; Holos et al., 2022). The exploration of water retention capacity is a critical focus for hydrologists and researchers engaged in studying forest ecosystems (Koch and Barthlott, 2009; Doerr et al., 2006, 2004).

Against the backdrop of prevalent forest fires in Mediterranean areas, compounded by chanlenges posed by climate change and droughts, this study aims to shed light on species selection for burned areas, facilitate future hillslope restoration, especially in highly degraded zones, and characterize the most resilient territories against droughts. Despite the pressing need, the retention properties of vegetation in the mountainous areas of the arid climate of Andalusia remain undetermined. In this inaugural research effort, diverse experiments were conducted in Los Guajares region (SE Spain), characterized by steep slopes, a dry Mediterranean climate, and rural activities including agriculture (olive orchards, subtropical trees, etc.) and scattered settlements. Employing photography, angle measurements in graphic software, wetting contact angle assessments, and the weighing method for plant surface water storage determination, plant samples were collected in the spring of 2023.

The primary hypothesis guiding this research was rooted in the premise that forest fires exert significant influences on the hydrological properties of ecosystems, specifically impacting water retention capacities and wettability of plant materials. The study aimed to explore how plant responses to fire-induced alterations manifest in the Los Guájares region, focusing on understanding the relationships between wettability, water storage capacity of burned (B) and unburned (U) surfaces. The objectives encompassed a thorough investigation of the contact angles and water retention capabilities of both green plant materials and woody elements in post-fire landscapes. By comparing burned and unburned areas, the research sought to uncover patterns, if any, in the wettability and water storage dynamics of plant materials, providing valuable insights into the ecological consequences of forest fires. Additionally, the study aimed to contribute to the broader understanding of the role of wettability in fire ecology and its implications for ecosystem management and restoration in fire-affected regions. The wettability of these dry branches, particularly, may play a pivotal role in understanding and predicting future fire occurrences.

2. Methodology

2.1. Sampling location

The research was conducted in the Los Guajares area (89.25 km^2, 36.8457 N, −3.586 W), located within the Autonomous Community of Andalucía, Spain. This region spans four municipalities: Albuñuelas (36.928 N, −3.632 W), El Valle (36.929 N, −3.583 W), El Pinar (36.913 N, −3.554 W), and Vélez de Benaudalla (36.832 N, −3.516 W). The area serves as a representative case study for a significant forest fire that occurred between September and October 2022 in the Granada province, resulting in the burning of 5194 hectares within a 150-km perimeter (Junta de Andalucía, 2022). The origins and causes of this sixth-generation forest fire remain unknown.

The altitudinal range within the fire-affected perimeter varies from 360 m.a.s.l. to the heightest point at 1420 m (the Giralda peak), slopes 30–60 %. Land use in the area encompasses diverse ecosystems, including forested regions and agricultural activities related to herbaceous and woody crops, both irrigated and rainfed, as well as olive groves and subtropical trees. The landscape features a mix of *Pinus halepensis* forests, dense shrubs, scattered grasslands, rocks, and thick soil, along with dense wooded shrubs or continuous grasslands. Climatically, the region experiences a Mediterranean climate (Csa) according to the Köppen classification (Köppen and Geiger, 1930), characterized by mild, wet winters and hot and dry summers, with significant seasonal variations and some localized microclimates due to the region's topography. During summers and winters, average daytime temperatures often exceed 30 °C and range from 10 °C to 15 °C, respectively. Nighttime temperatures can drop, occasionally approaching 0 °C but rarely going below freezing. The annual rainfall average between 400 and 600 mm, though it is also characterized by big interannual irregularities. Most of the precipitation occurs from November to March and there is almost no rainfall during the summers. Rain tends to come in short, intense bursts, often linked to frontal systems from the Atlantic.

Los Guájares region experience a high number of sunshine hours. Of specially interest for wildfires is the characterization of the prevailing winds, which are of variable directions and intensity, with more frequent and stronger winds in the spring and autumn. Summer breezes often come from the sea, providing some regulation of the extreme heats. The topography of the area, including the nearby Sierra de los Guájares, can influence local wind patterns, creating microclimates and varying conditions within short distances. The varied elevation in Los Guájares contributes to microclimatic differences. Higher elevations tend to be cooler and receive more precipitation than the valley areas.

This patters conditions the agricultural uses. The climate supports the cultivation of a variety of crops, including olives, almonds, and citrus fruits, which thrive in the warm, dry summer conditions and benefit from the wetter winters. In these circumstances, irrigation is important due to the dry summers, and water management practices are crucial for sustaining agriculture.

2.2. Field sampling

Within the designated experimental plot during the spring of 2023, two different surfaces, burned (B) and unburned (U), were identified. A comprehensive sampling approach involved the collection of five

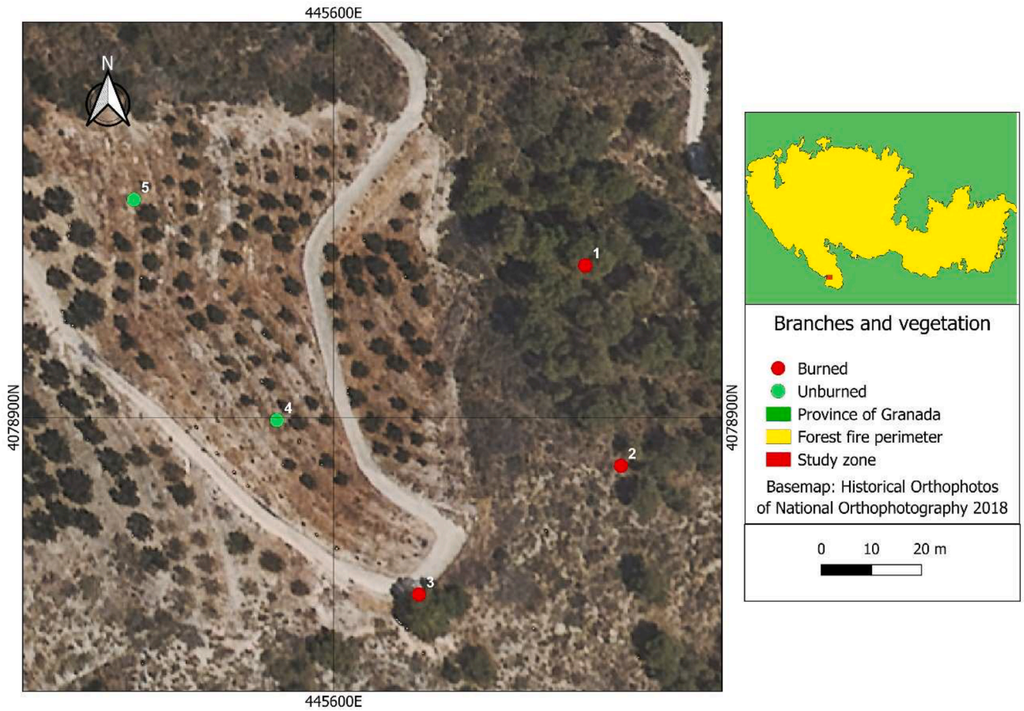

Fig. 1. Localisation of Los Guájares and forest fire extension.

Fig. 2. Example of collected plant material for further research (a and b); Visualization of the research area (c,d,e).

representative plant samples from each of the four dominant plant species on each surface (Fig. 1; Fig. 2).

For the burned area (B), the following plant species (green plant) were meticulously gathered: *Poa* sp.*; Juniperus* L.*; Carthamus lanatus; Diplotaxis muralis*. Conversely, on the unburned area (U), the collection included *Supreme cantaloupe; Magnifera indica* - leaves*; Clematis* sp.*; Pallenis spinosa*. To maintain sample integrity and prevent desiccation, each sample was carefully enclosed in plastic bags and transported to the laboratory. Contact angle (CA) tests were promptly conducted on the same day to ensure the plants retained turgor, thereby ensuring the generation of comparable results. Additionally, wood fragments, specifically branches, were collected from both surfaces.

On the B, where only pine trees (*Pinus halepensis*) were present, five branches from burned pine (woody plant elements) were sampled for subsequent analyses. In contrast, on the U hosting mango trees (*Mangifera* L.), both fresh branches and dry fragments found on the ground were collected. Five samples were taken from each plant species and woody material.

2.3. Laboratory analyses

All laboratory experiments (Fig. 3) were conducted in a controlled environment at the EGEMAP-Terra Lab (Environmental Geography and Mapping) at the University of Granada (www.egemap.eu), maintaining a constant temperature of 25 ± 1 °C and relative humidity (RH) ranging between 61 and 71 %.

A wettability test was performed on all samples, involving the application of five drops of distilled water. The test was carried out using a manual micropipette (CLINIPET+ , PZ HTL S.A, Warsaw, Poland) with a 0.5 mm inner needle diameter and a volume range of 0.5–10 μL. Photographs for contact angle (CA) measurements were taken 1 second after the water crop landed. The equipment utilized included the Canon EOS 450D camera (Canon, Tokyo, Japan) with the EF 100 mm f/2.8 Macro USM lens. Droplet inclination angles were measured in the SigmaScan v5 software, considering the internal CA between the droplet and the leaf (Llorens and Gallart, 2000; Holder 2013). Wettability was classified based on the droplet inclination angles according to the classification proposed by Novak et al., 2009, covering superhydrophilic, well wettable, hardly wettable, and superhydrophobic properties. A contact angle of up to 40° was considered as superhydrophilic and those above 150° as superhydrophobic. Other contact angles are: 40 – 90°, highly wettable; 90 – 110°, wettable; 110 – 130°, non-wettable; and 130 – 150°, highly non-wettable.

The laboratory work also involved measuring the canopy water storage capacity (S) on all plant and tree branch samples. The current water retention capacity was determined by subtracting the weight of the sample after spraying from the weight of the fresh sample, normalized to the weight of the fresh sample (Equation 1). A scale with an accuracy of 0.01 g was employed for these measurements.

Equation 1:

$$S = \frac{Mw - Mf}{Mf}$$

S – current water retention capacity *[g/g];*
Mw – weight of the sample after spraying *[g];*
Mf – weight of the sample in the fresh state *[g].*

This methodology was extended to determine water adsorption for the branches, considering water capacity after 4 h (S4) and 24 h of full immersion in water (S24). This approach provides insights into the dynamic changes in the water supply in dead branches and their potential water storage capacity. The methodology aligns with established ecohydrological practices used in previous studies involving burnt earth or plants (Doerr et al., 2004; Papierowska et al., 2023).

2.4. Statistical analysis

The descriptive statistics was performed to show the mean and amount of variation (standard deviation) of some variables including contact angle, current water storage capacity, water storage capacity after 4 and 24 h. The ANOVA was carried out for the variables to compare the means differences among groups. After that, Tukey (HSD) test was performed to identify which specific groups are significantly different. The boxplot and linear regression plots of the selected variables were generated by using Python software. The entire statistical analysis and data visualization process were executed using Python, leveraging packages such as Pandas, NumPy, stats models, SciPy, Stats,

Table 1
Contact angles and current water storage capacity.

	CA [°]	S [g/g]	S1 [g/g]	S24 [g/g]
Mean	82.87	0.13	0.31	0.74
Std	62.92	0.12	0.22	0.38
Min	0.00	0.01	0.05	0.11
25 %	0.00	0.04	0.10	0.57
50 %	100.00	0.10	0.32	0.70
75 %	132.50	0.16	0.42	0.98
Max	155.00	0.49	0.80	1.43

Notes: CA - contact angle; S - current water storage capacity; S1 - water storage capacity of samples after 4 h in water; S24 - water storage capacity after 24 h of soaking in water.; std - Standard Deviation; 25 % = lower quartile; 75 % = upper quartile.

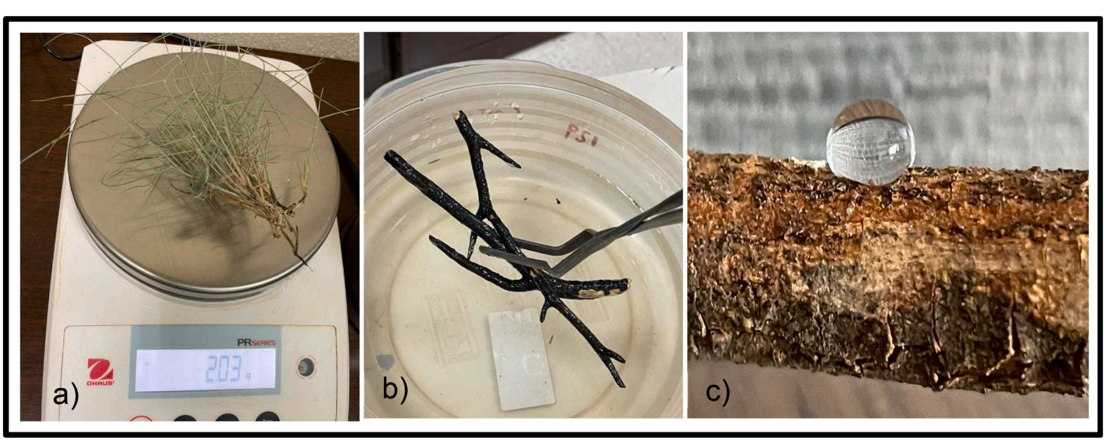

Fig. 3. Different steps during the laboratory work.
Notes: a) An example of measuring the mass of a fresh sample; b) an example of immersing a burnt pine branch in water to obtain the water capacity of the plant material; c) An example of measuring the contact angle of a water drop to the surface of a branch (mango) from the unburnt surface.

Matplotlib, and Seaborn.

3. Results

3.1. Contact angle on the tested green plants

In descriptive statistical analysis, the results for both plants and wood, critical parameters were calculated (Table 1). However, a nuanced examination of the data is essential, considering species differences and the distinction between B and U. The average CA values for all plants in the experiment was 82.87°. The current water storage capacity after a single immersion in water was 0.13 [g/g], increasing to 0.74 [g/g] after 24 h.

The statistical analysis of the CA revealed significant variation among plant species. However, the effect of different surfaces (B and U) was not significant on CA. Analysis of CA for plant species reveals a trend of higher values (average 107°) for plants in area B and lower values (average 83.55°) for plants in area U (Fig. 4). The plant species Poa sp. and Juniperus showed higher contact angles, demonstrating that these two plant species have hydrophobic surfaces. Higher CA correlates with decreased moisture retention, suggesting that vegetation in the fire-affected area may naturally retain less water, potentially rendering it more susceptible to combustion during a fire. Plants in area B exhibit higher contact angles, suggesting that the surface of their leaves or other plant structures is less wettable. A higher contact angle typically indicates that water beads up and rolls off the surface, demonstrating hydrophobic properties. In contrast, plants in area U have lower contact angles, denoting that the surfaces are more wettable. Water is likely to spread and adhere to the plant structures, suggesting hydrophilic properties.

3.2. Water storage capacity of the analyzed green plants

The current water storage capacity (S) was significantly different among all plant species. The lowest S was noticed in plant species Poa sp. as compared to other plant species. The Diplotaxis muralis showed higher variability in S between all plant species. Comparing current S for plant species on B and U surfaces yields very similar values (Fig. 5). The average S for plants on B is 0.325 g^{-1}, and for U, it is 0.309 g-1. This indicates that the current water retained during immersion does not necessarily reflect CA and, in this context, CA better portrays the rainwater retention situation.

Diplotaxis muralis is a plant that occurs quite commonly in various regions of Europe, including urban areas, indicating its non-demanding nature. Our study exhibited a fairly wide range of S, suggesting a relatively stronger adaptation of this plant to challenging conditions, including its presence in areas following wildfires. Its ability to survive and thrive in challenging conditions makes it an important species for studying plant responses to environmental stress and strategies for habitat restoration after disturbances such as wildfires.

3.3. Contact angle and water capacity for woody plant elements

The statistical analysis depicted significant differences in CA for woody plants. As woody plant elements differ from green plants, they are analyzed separately. On B, only pine branches with clear signs of burning were collected. On U, mango trees were present, and both fresh branches and dry branches on the ground were collected. Water drop tests on burnt pine branches did not yield measurable values as water immediately soaked into the wood. The plant Pinus halepensis showed very low (close to zero) contact angle in the burned surface. The dry sample of Mangifera indica exhibited higher contact angle, have higher hydrophobicity compared to the fresh Mangifera indica sample (Fig. 6). Differences in water retention after single immersion (S) and in S1 and S24 are more pronounced for all types of branches (Fig. 5).

CA for woody mango branches, both fresh and dry, falls in the wettability class between 110 – 130°, defined as 'wettable' (Fig. 5).

The statistical analysis of the S, S4, and S24 showed significant variations among woody plants. S, resulting from water immersion, indicates the maximum water holding capacity during prolonged rainfall. These values for all branches (burned pine, fresh and dried mango) exhibit the lowest values (Fig. 7). S4 was measured to capture the dynamics of filling the retention reservoir represented by the tree branches. In all analyzed cases, it demonstrates intermediate values between S and S24. S24 is the maximum water capacity that the analyzed branches can achieve. Mango branches dry from U have, by far, the greatest potential, followed by burnt pine branches. However, in the case of burnt pine branches, it is essential to acknowledge the potential impact of both physical and chemical changes that occurred during the burning process.

The linear regression plot demonstrates the relationship among contact angle and current water storage capacity of B and U samples of plant and wood species. The relationship between these two parameters is slightly negative, which shows that increasing contact angle tend to decrease the current water storage capacity (Fig. 8). The R2 value illustrates the 30.2 % of variance in current water storage capacity can be explained by CA, showing moderate relationship among CA and S. The findings confirmed that as the contact angle of water droplets on the surface increases, the water capacity decreases (Fig. 8).

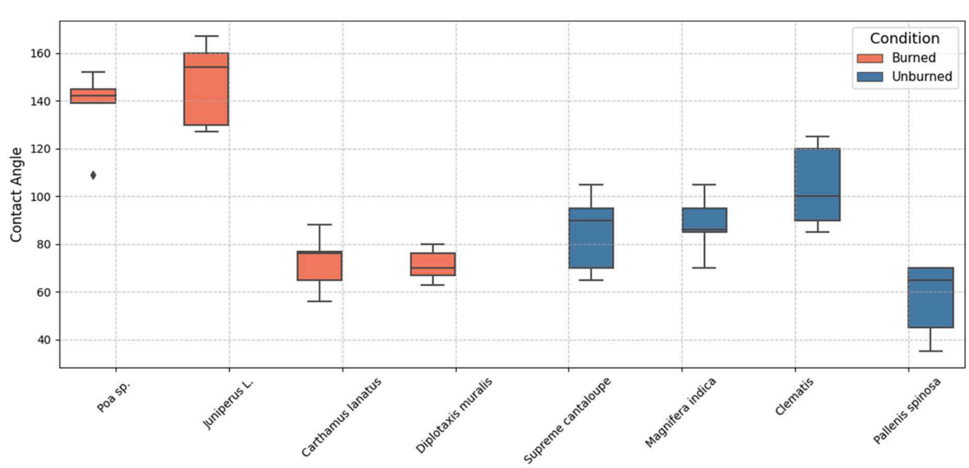

Fig. 4. Results of the contact angle test per species (burned and unburned).

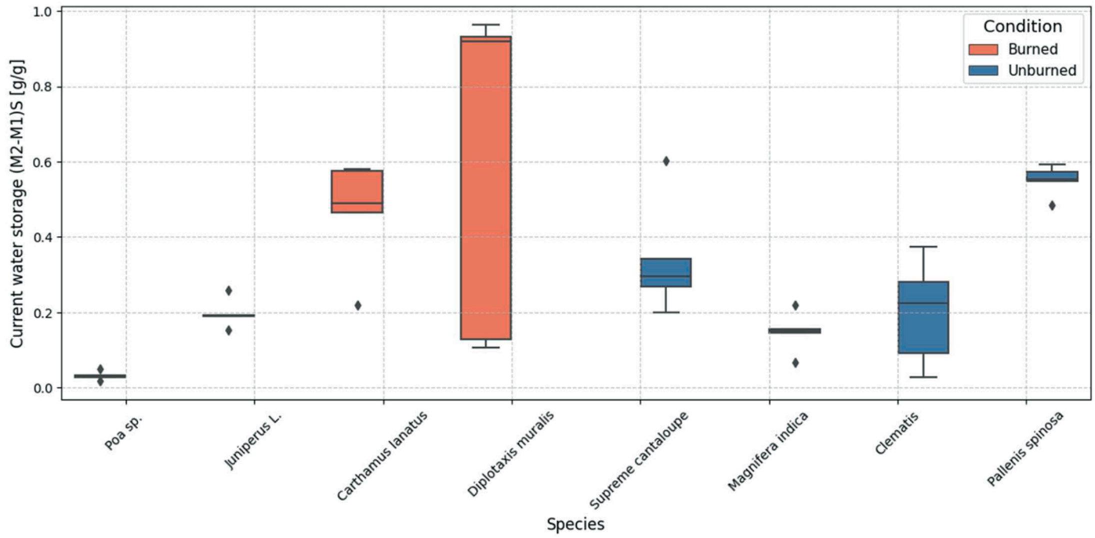

Fig. 5. Current water storage capacity for burned and unburned areas.

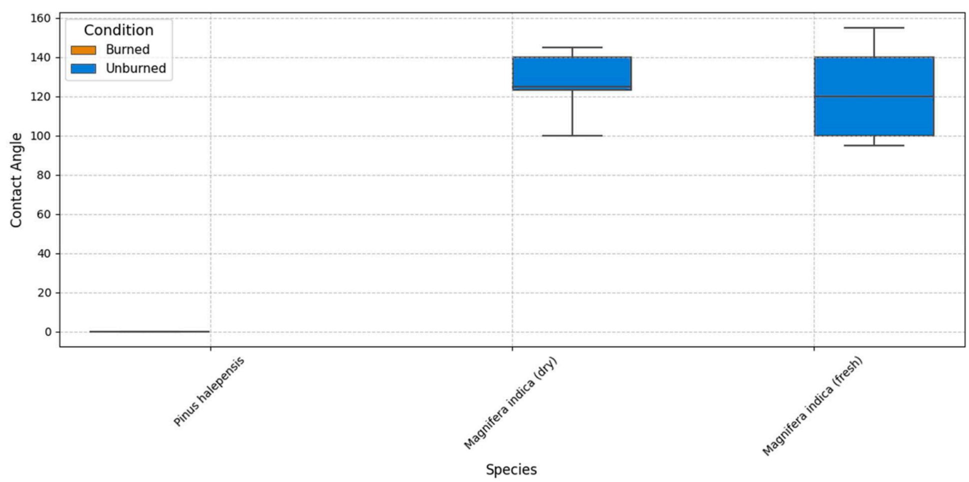

Fig. 6. Contact angle for woody parts of plants.

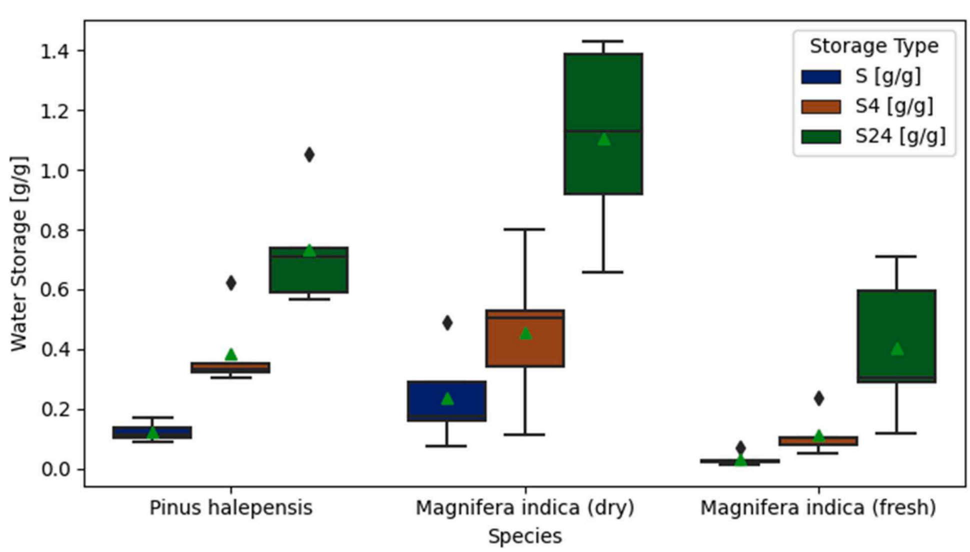

Fig. 7. Current water capacity (S) after 4 and 24 h in water for woody parts of plants.

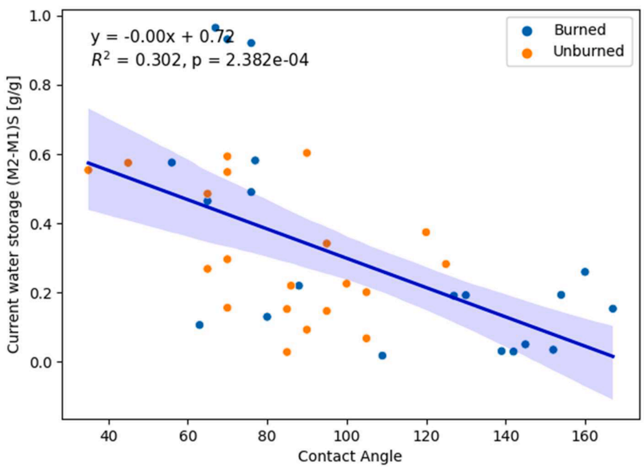

Fig. 8. Relationship between CA and water capacity.

4. Discussion

The results of this study provide valuable insights into the complex interplay between water retention properties, wettability, and ecological dynamics in the aftermath of a forest fire. The findings are consistent with established research on plant material water retention, extending our understanding of the specific context in the Los Guájares region following the 2022 fire. Moreover, the study illuminates universal dependencies on how these factors may contribute to the susceptibility of certain plant groups to fire but they should be interpreted with caution when applied to different settings or broader management and restoration practices. The sample size in this study was relatively small, which may affect the generalizability of our findings. Nevertheless, the results can be considered as preliminary research that lays the groundwork for a broader analysis of the impact of physical and physiological characteristics of plants on their wettability.

Fires have a well-documented impact on hydrological properties, influencing factors such as soil structure and water repellency (Lichner et al., 2007; Kupka et al., 2022; Perera et al., 2023). However, our findings suggest an intriguing dimension to this impact - certain plant groups appear to be less wettable and possess lower water capacity, potentially rendering them more prone to fire. While fire-adapted ecosystems often necessitate periodic burning to rejuvenation (Cerdà, et al., 2022), this study prompts consideration of how specific plant traits may influence the likelihood of ignition and spread.

The relationship between leaves and wood wettability, assessed through contact angle measurements, provides a nuanced perspective on the post-fire landscape. By comparing areas affected by the previous year's fire (B) with unburned regions (U), we discerned a consistent pattern: as the contact angle of water droplets increased, indicating reduced wettability, the water capacity of both branches and leaves decreased. This inverse correlation aligns with prior studies (Holder 2020; Papierowska et al., 2022) and underscores the role of wettability in governing water retention dynamics.

Laboratory experiments allowed to measure the amount of water absorbed by the woody elements from both surfaces after 4 and 24 h. These analyses, initially applied to soil, are increasingly informative regarding the water retention capacities of dead wood (Błońska et al., 2020) as well as plants (Papierowska et al., 2022).

The examination of woody fragments and branches of dry but unburned mango showed the highest water capacity after 24 h of immersion (S24), 1.10 [g^{-1}] of water. This highlights the significance of dead wood as a substantial water store, crucial for post-fire ecosystems. In stark contrast, burnt pine wood exhibited minimal water retention at 0.07 [g^{-1}], emphasizing the impact of fire-induced changes. Fresh mango branches, with 0.40 [g^{-1}] water retention, showcased the advantage of dry branches in holding water. Burnt pine wood's non-hydrophobic side surface, coupled with rapid water absorption (0.12 g^{-1}), hints at complex interactions during burning, necessitating further investigation.

The comparison of leaf water capacity between B and U revealed no statistical difference (average 0.31 g^{-1}). However, CA measurements indicated highly wettable leaves in U and wettable leaves in B. This discrepancy suggests a potential adaptation mechanism in plants for B, exhibiting traits that enhance water absorption despite having wettable surfaces. This nuanced response emphasizes the resilience and adaptability of plant species to fire-induced changes in their environment. The observed trends in contact angle and moisture retention have significant implications for fire ecology in the respective areas.

Vegetation with higher contact angles (area B) may dry out faster, creating a drier fuel source that is more prone to ignition and sustaining fire. Vegetation with lower contact angles (area U) may retain more moisture, acting as a natural barrier to fire spread and potentially reducing the intensity of wildfires.

To contextualize our findings, we compared them with wetland plants (Klamerus-Iwan et al., 2020b; Papierowska et al., 2023), revealing diverse CA and water capacities. The results obtained by us are lower than those presented in the literature for herbaceous species 0.12–1.26 g –1 (Xiong et al., 2019) and lower than those obtained by Garcia-Estringan et al. (2010) for Mediterranean shrubs 0.23–2.26 g·g–1 (average 0.66 g·g–1).

Pine wood water capacity emerged as a correlate ofwood density , reflecting an intermediate value between soft fir and hard ash wood (Błońska et al., 2018). Fresh mango branches, exhibiting higher CA and lower (S, S1, and S24), indicated a trade-off between nutrient-rich fresh branches and the hydrophobicity associated with higher waxes. This physiological insight into water retention strategies contributes to a broader understanding of plant adaptation to varying environmental conditions.

Understanding the relationship between contact angle and fire susceptibility aid in wildfire management and prevention strategies. Areas with vegetation exhibiting higher contact angles may require more proactive fire management approaches, such as controlled burns or fuel reduction measures, to mitigate the risk of intense wildfires. Monitoring plant species and their contact angles can contribute to targeted management efforts, helping to protect ecosystems and communities from the impact of wildfires (Popovic and Cerda, 2023; Rodrigo-Comino et al., 2024).

In the study delves into leaf wettability variation among species, suggesting adaptive strategies for diverse environments, including drought-prone regions or those experiencing prolonged rainy seasons (Rosado and Holder, 2013). The prevalence of hydrophobic leaves in marshy environments, albeit with variations in degree among species, underscores the ecological significance of leaf wettability in waterlogged ecosystems (Sikorska et al., 2017; Tellechea-Robles et al., 2020). Additionally, our observations of powdery mildew infection on young oak leaves highlight a specific strategy where hydrophilic mycelium benefits from leaf moisture, emphasizing the multifaceted role of wettability in ecological interactions (Klamerus-Iwan and Witek 2018).

In practical terms, these insights hold relevance for conservation and ecosystem restoration efforts. Understanding the water dynamics of different plant species aids in selecting appropriate species for diverse hydrological regimes. This knowledge is instrumental in restoring degraded post-fire ecosystems, ensuring the resilience of plant communities, and ultimately preserving the ecological functions of these areas (Cerda et al., 2022). The analysis of contact angle provides valuable insights into the water-repellent or water-retaining properties of plant species in different areas, shedding light on their potential susceptibility to combustion during a fire.

5. Conclusions

The comprehensive exploration of water retention properties and wettability of plant materials in the aftermath of a forest fire in the Los Guájares region yields valuable insights and implications. The study highlights alterations in water retention capacities and wettability in plant materials in post-fire areas, with plants in burned zones exhibiting higher contact angles, indicative of reduced wettability and diminished water retention. This observation suggests that certain plant species in fire-affected regions are inherently predisposed to retain less water, potentially rendering them more susceptible to future fires. The nuanced relationship between wettability and water storage capacity contributes to a deeper understanding of ecological dynamics post-fire.

The study emphasizes the differential water storage capacities in woody elements, particularly in dry, unburned mango branches, which emerge as significant reservoirs of water, showcasing their potential ecological role. In contrast, burnt pine wood exhibits lower water retention, underscoring the impact of fire on wood hydrological properties. The distinction in hydrophobicity between fresh and dry branches, attributed to higher waxes and nutrients in fresh branches, reflects the adaptive strategies of plant species in response to environmental conditions.

In summary, the study sheds light on the complex dynamics of water retention and wettability in the context of forest fires, offering practical insights for ecological management and restoration efforts in fire-affected regions like Los Guájares.

CRediT authorship contribution statement

Anna Klamerus-Iwan: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Laura Cambronero Ruiz:** Writing – original draft, Investigation, Data curation. **Casandra Muñoz Gómez:** Writing – original draft, Visualization, Data curation. **Agata Warczyk:** Writing – original draft, Visualization, Investigation, Conceptualization. **Pranav Dev Singh:** Writing – original draft, Validation, Methodology. **Muhammad Owais Khan:** Writing – original draft, Visualization, Validation. **Andrés Caballero-Calvo:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Anna Klamerus-Iwan reports financial support was provided by COST ACTION CA18135 (FIRElinks), which funded the Short Term Scientific Mission (STSM). Andres Caballero-Calvo reports financial support was provided by University of Granada which funded Plan Propio de Investigación y Transferencia (PP2022.PP-12). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

This research was funded by the Plan Propio de Investigación y Transferencia granted by the Universidad de Granada, 2022. Programa 1. Proyectos de Investigación Precompetitivos: Caracterización de propiedades clave en la relación agua-suelo para el estudio de la influencia del fuego en el balance hídrico y el carbono para el planteamiento de estrategias de restauración (PP2022.PP-12). Moreover, we want to thank the COST ACTION CA18135 (FIRElinks), which funded the Short Term Scientific Mission (STSM) grant of Dr Anna Klamerus-Iwan at the University of Granada.

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