Vol. 1(2): 191-203 (2024)

Journal of Regenerative Economics

DOI 10.5937/jre2402191J

EVALUATING INDIGENOUS ALBANIAN BULBOUS PLANTS ON GREEN ROOFS FOR URBAN ECOSYSTEM ENHANCEMENT IN MEDITERRANEAN CLIMATES

Silvi Jano
Department of Horticulture and Landscape Architecture, Agricultural University of Tirana, Albania
✉ silvi.yano.sj@gmail.com
https://orcid.org/0009-0009-0815-5035

Kejt Dhrami
Co-PLAN, Institute for Habitat Development, Albania
✉ kejt_dhrami@universitetipolis.edu.al.
https://orcid.org/0000-0002-2617-6480

Fiona Imami
POLIS University, Albania
✉ fiona_imami@co/plan.org
https://orcid.org/0000-0001-6630-1445

Gjok Vuksani
Agriculture University of Tirana, Faculty of Agriculture and Environment, Department ofHorticulture and Landscape Architecture, Albania
✉ gjvuksani@ubt.edu.al
https://orcid.org/0009-0002-1777-7468

Abstract: *Green roofs offer ecological and functional benefits in urban environments, yet plant resilience remains a challenge, particularly in Mediterranean climates. In Albania, and specifically in rapidly urbanizing Tirana, green roofs could mitigate environmental issues such as air pollution, urban heat islands, and limited green space. Despite these benefits, no studies to date have assessed the suitability of indigenous Albanian plant species for green roofs in this region. This study aims to evaluate the resilience of native bulbous plants under varying irrigation regimes and provide recommendations for plant selection and watering practices to enhance the ecological and functional performance of green roofs in Mediterranean urban environments. This research examines five indigenous Albanian bulbous plant species interplanted with other native annual and perennial vegetation under two distinct irrigation regimes on*

Original scientific paper
Received: 10.12.2024.
Accepted: 25.12.2024.

six experimental green roof plots in Tirana. We evaluate the suitability of these species for green roof applications, analyze the effects of low (twice-weekly) versus high (daily) irrigation on plant growth, and offer recommendations for species selection and watering practices that can improve green roof performance. The primary question addressed is how different irrigation regimes impact the growth and performance of indigenous Albanian plants on green roofs. Preliminary findings indicate that both irrigation regimes result in comparable flowering timing, flowering duration, and vegetative growth across all bulb species, with the exception that Crocus tommasinianus and Tulipa sylvestris exhibited differences. The paper concludes with a discussion on how the findings suggest that irrigation practices have minimal impact on overall plant growth, with low irrigation potentially extending the flowering period for certain species.

Key words: *Green roofs, Indigenous plants, Irrigation regimes, Mediterranean climate.*

1. Introduction

Urban areas in Mediterranean climates are increasingly adopting green roofs as solutions to urban heat islands, stormwater management, and biodiversity enhancement. Green roofs offer substantial benefits, including improved air quality, reduced building energy demands, and added habitat for urban wildlife, making them a valuable asset for sustainable urban development (Oberndorfer *et al*., 2007; Fioretti *et al*., 2010; Francis & Lorimer, 2011; Gagliano *et al*., 2012). In Mediterranean cities like Tirana, Albania, rapid urbanization has exacerbated environmental challenges such as air pollution, the urban heat island effect, and diminishing green space. This has intensified the need for green infrastructure solutions that leverage native flora adapted to local climatic stresses, particularly drought.

Green roofs in Mediterranean climates are often subject to long dry seasons, which can limit plant survival and ecosystem functioning if the species are not adapted to water scarcity. Research indicates that selecting drought-tolerant and resilient native plants can improve green roof performance and reduce irrigation demands, making them a sustainable option for cities with limited water resources (Dunnett & Kingsbury, 2008; Thuring & Dunnett, 2014). However, most research has focused on commonly used species with Mediterranean origins (such as *Sedum* spp.), and studies examining native species beyond these conventional choices are limited (Savi *et al*., 2014).

This study is among the first to investigate the resilience and performance of indigenous Albanian bulbous plant species on green roofs in Tirana. Albania's diverse flora includes species with significant potential for green roof applications, but their suitability and resilience under varying irrigation conditions remain largely unexplored. Previous studies suggest that bulbous plants – known for their adaptation to Mediterranean climate stressors – could be ideal candidates due to their water-storing abilities and adaptability to fluctuating moisture levels (Köhler, 2008; Papafotiou *et al*., 2013).

In this research, five native Albanian bulbous species were evaluated alongside other native annual and perennial plants to assess their suitability for green roof applications under two irrigation regimes. By examining the growth, flowering, and overall performance of these species, the study seeks to inform practical, resource-efficient planting strategies for green roofs in Mediterranean urban environments.

2. Methodology

Conducted on the terrace of a five-story building in central Tirana, Albania, the experiment utilized six green roof plots containing a mix of bulbous and other native plant species. The methodological approach focused on creating conditions representative of extensive green roof environments, allowing for the assessment of plant resilience and performance under typical urban climate stressors. This approach helped to evaluate the resilience and suitability of the selected bulbous plants by observing their performance under two distinct irrigation regimes. While other parameters (e.g., soil nutrient levels, pest incidence) were monitored during the experiment, this paper presents results and discussion focused only on plant performance under the different irrigation systems. Methodologically, two main variables were considered in the experimental design, each described as follows.

2.1. Plot Design and Composition

Six experimental plots were constructed for this research. Each plot measured 125 cm by 80 cm, with a substrate depth of 15 cm (bulbs were planted at approximately 10 cm depth). The substrate was a lightweight, well-draining mix of expanded clay, perlite, and compost, specifically formulated for green roofs to ensure uniform soil composition across all plots. Each plot covered 1 m^2 in area and contained roughly 150 liters of substrate, providing adequate support for root growth and effective drainage.

The plant composition in each plot included a mixture of indigenous Albanian bulbous and herbaceous species. The plots contained five bulbous species (*Allium schoenoprasum*, *Allium sphaerocephalon*, *Allium aflatunense*, *Crocus tommasinianus*, and *Tulipa sylvestris*), with each species planted in groups of ten bulbs. These bulbous plants were interplanted with nine native annual and perennial species, including *Cistus incanus*, *Achillea millefolium*, *Salvia officinalis*, *Linaria vulgaris*, *Armeria* spp., *Hyparrhenia hirta*, *Eryngium amethystinum*, *Origanum vulgare*, and *Melica ciliata*. This diverse planting palette aimed to simulate a natural Mediterranean ecosystem, allowing evaluation of plant interactions and resilience in an urban green roof setting.

2.2. Irrigation Regimes and Treatments

Two distinct irrigation regimes were tested during the hottest summer months (June, July, and August) using a drip irrigation system to deliver controlled amounts of water to each plot:

- **Low Irrigation Regime:** Plots were watered twice a week, with each plot receiving approximately 10–15 liters of water per irrigation session.
- **High Irrigation Regime:** Plots were watered daily, with each plot receiving about 7–8 liters of water per session.

This variation in watering frequency and quantity was designed to assess the effects of limited water availability on the growth and flowering of the bulbous plants, as well as on the overall ecological performance of the green roof.

For experimental rigor, the six plots were evenly divided between the two irrigation regimes, with three replicate plots per treatment. Plots 1a, 1b, and 1c were assigned to the low-irrigation regime, and plots 2a, 2b, and 2c to the high-irrigation regime. The location of each plot on the terrace was randomized to minimize microclimatic differences such as variations in wind exposure, sunlight, or heat reflection from surrounding surfaces.

Throughout the study period, plant performance was monitored through regular observations, recording data on flower counts, flowering duration, and vegetative growth for each bulb species. The data were analyzed to determine if irrigation regime had a significant impact on these performance metrics. Overall, there were no statistically significant differences in growth or flowering output between the two irrigation regimes, with the exception that *Crocus tommasinianus* and *Tulipa sylvestris* in the low-irrigation plots tended to flower approximately 5–6 days longer than those in the high-irrigation plots.

3. Literature Review

Albania's flora is rich in bulbous geophytes (plants with underground storage organs) such as *Gagea*, *Muscari*, *Allium*, *Crocus*, and *Tulipa* species. These indigenous bulbs have evolved under Mediterranean seasonality and are hypothesized to be strong candidates for green roof planting. Their potential resilience to drought and contributions to ecosystem functions merit review. This literature review examines the adaptive traits of these native bulbous plants, evaluates their contributions to biodiversity (particularly pollinators), and discusses the ecosystem services they can enhance (water retention, air quality improvement, thermal regulation). Additionally, current knowledge gaps in research and practice are identified, to guide future studies and the integration of native Albanian bulbous flora into sustainable green roof designs.

3.1. Plant Traits and Drought Adaptations

Indigenous Albanian bulbous plants share key morphological and physiological traits that confer resilience in a Mediterranean rooftop environment. As geophytes, they survive adverse seasons by storing resources in underground organs (bulbs, corms, or tubers). This trait allows them to withstand prolonged dry periods by going dormant during summer drought, then re-sprouting when wetter, cooler conditions return (Pignatti, 2002; Hesse et al., 2019). In Mediterranean climates, many geophytes (and annuals) avoid summer desiccation by completing their life cycle during the spring rainy season and remaining quiescent through the dry months (Thompson, 2005).

For example, *Muscari* (grape hyacinths) and *Gagea* spp. emerge and bloom in early spring, taking advantage of soil moisture from winter rains, then die back completely by summer – an adaptive phenology aligning with regional rainfall patterns. Similarly, wild *Allium* species native to Albania (e.g. *Allium sphaerocephalon*, *A. carinatum*) have bulbs that accumulate water and nutrients, enabling them to endure extended drought in a dormant state and re-grow when conditions improve. These bulbs are inherently drought-tolerant. Previous studies note that bulbous plants are well adapted to Mediterranean climate stressors, possessing water-storing organs and the ability to tolerate fluctuating moisture availability (Köhler, 2008; Papafotiou et al., 2013).

In the context of a green roof, this means indigenous bulbs can endure the sparse summer irrigation or even temporary drought without permanent damage, by drawing on their stored reserves. In effect, they behave as drought avoiders: remaining dormant (and not losing water via transpiration) when moisture is scarce, and rapidly activating growth and flowering when water becomes available.

Another important trait is their efficient water use strategy. Green roof plants ideally should use water when it is plentiful (to maximize stormwater capture) but restrict water loss during drought (Farrell et al., 2013). Many native bulbous species naturally fulfill this profile – they are active in wetter periods, consuming water for growth, and then sharply reduce water use during dry periods by shedding their foliage. Moreover, the typically small stature and narrow or waxy leaves of bulbs (e.g. the fine grassy leaves of *Crocus* or cylindrical leaves of some *Allium*) help minimize transpiration and heat stress. Their shallow but fibrous root systems allow quick uptake of rainwater from thin substrates.

Collectively, these morphological and physiological features enable indigenous bulbs to thrive on extensive green roofs: they can complete their growth cycles in step with seasonal rainfall, tolerate the roof's extreme summer drought by retreating underground, and rebound with new growth annually – thus showing a form of perennial resilience well-suited to Mediterranean urban climates.

3.2. Biodiversity Contributions of Native Bulbs

Beyond their drought endurance, indigenous bulbous plants can significantly enhance biodiversity on green roofs. Unlike the monocultural carpets of sedums often seen on roofs, a planting palette that includes native bulbs adds floral diversity and structural heterogeneity, which in turn supports a wider range of urban wildlife. Diverse green roofs have been shown to attract more arthropods and even birds, functioning as habitat islands in the city (Oberndorfer et al., 2007).

In particular, flowering bulbs contribute nectar and pollen resources that are highly beneficial for pollinators. Many Albanian bulbs bloom in late winter or spring when few other flowers are available in the urban landscape – for instance, early spring blooms of *Crocus tommasinianus* or *Gagea lutea* can provide an important food source for awakening bees. The globular purple inflorescences of wild *Allium* species and the fragrant spikes of *Muscari* are known to be pollinator magnets, attracting bees, butterflies, and other insects in search of nectar (Bretzel et al., 2022).

By integrating such species, green roofs can offer a sequence of blooms from late winter through early summer, sustaining pollinator populations in urban areas where floral resources are often patchy. Empirical research confirms that green roofs planted with a variety of flowering natives support greater pollinator abundance and diversity. For example, a survey of green roofs in Vienna recorded 90 wild bee species over one season, with bee diversity strongly linked to the availability of floral resources on the roofs (Tonietto et al., 2011). When wildflower cover was high, bee abundance increased, and even during midsummer lulls, flowering sedums still provided some forage. This underscores that providing a continuous supply of blooms (through a mix of species with different flowering times) is crucial for sustaining pollinators.

Native plants seem to have an edge in this regard: a recent experiment in Córdoba, Argentina found that green roof sections planted with native species supported significantly higher insect abundance (across multiple taxa) than sections with exotic ornamental species (Madre et al., 2014). Not only was total insect abundance greater with natives, but most insect groups (including pollinating orders like Hymenoptera) were more numerous on native-planted roofs. The composition of the insect community also shifted with native plants, indicating that local flora may attract a more characteristic and specialized fauna.

Translating these findings to Albania, using indigenous bulbous plants on green roofs could similarly boost urban biodiversity. By conserving a piece of Albania's native flora in the built environment, these roofs can act as micro-refuges for native pollinators and other invertebrates. The extended or sequential flowering of different bulb species (e.g. *Crocus* in February, *Muscari* in March, *Allium* in May) provides a steady supply of pollen and nectar over an extended period, which is especially valuable in dense urban areas where such resources are limited.

Moreover, bulbs interplanted with native grasses and herbs can create a semi-natural meadow on the roof, supporting not just bees and butterflies but potentially beetles, spiders, and birds that prey on insects or use the vegetation for shelter. Overall, incorporating indigenous bulbous plants markedly increases the ecological complexity of green roofs – moving them beyond mere aesthetic landscaping toward functional biodiversity hotspots in the city.

3.3 Stormwater Retention and Runoff Reduction

Green roofs are widely recognized for their ability to retain rainfall and reduce stormwater runoff, thereby lessening urban flooding and easing the load on drainage systems. Plant selection influences the degree of water retention: species with deep or fibrous roots and those that actively transpire can enhance water uptake from the substrate (Berndtsson, 2010). While succulents (like sedums) have moderate water needs and intercept some rain, research suggests that using a mix of plant forms (including forbs, grasses, and geophytes) can improve overall rainfall capture (Lundholm et al., 2010).

In one comparative study, an aromatic Mediterranean herb (*Origanum onites*), a drought-tolerant subshrub, achieved higher runoff reduction than a sedum under the same roof conditions (Papafotiou et al., 2013). At a substrate depth of 8 cm, roofs planted with *Sedum sediforme* retained ~50% of rainfall, whereas roofs with *Origanum* retained about 63%. With a deeper 16 cm substrate, retention increased for both (to ~60% for sedum vs over 80% for the *Origanum*). This indicates that drought-adapted forbs can utilize available water more fully, likely through higher transpiration, thus capturing more stormwater.

Bulbous plants can complement this function. During the wet season, actively growing bulbs will absorb water from the substrate to fuel their growth and flowering. Their presence thereby increases evapotranspiration and frees up soil pore space for subsequent rain events. Conversely, in dry periods, these plants naturally curtail water use by going dormant, which helps them survive but also means they won't demand water when it's scarce. This dynamic aligns well with stormwater management goals: heavy winter rains are taken up by the bulbs (mitigating runoff), whereas in summer the need for irrigation is minimal.

While dormant bulbs themselves may not transpire in summer, in practice they would be part of a plant community – for instance, bulbs can be underplanted beneath shallow-rooted grasses or sedums that provide some continuous groundcover. Over time, the root networks of all these species improve the substrate's structure, enhancing its water-holding capacity. The overall effect is a green roof that significantly attenuates runoff peaks and delays drainage. Studies have shown that a diverse plant community can intercept and evapotranspire more water than a monoculture (Lundholm et al., 2010), especially when plants have complementary root depths and water use patterns. Therefore, integrating Albanian geophytes into green roofs can be expected to maintain or improve stormwater retention performance, while also requiring less supplemental watering – a win-win for water sustainability in Mediterranean cities.

3.4. Ecosystem Services of Bulbous Green Roofs

In addition to biodiversity gains, vegetated roofs featuring resilient native plants contribute to various ecosystem services in urban areas. Key services enhanced by green roof vegetation include stormwater regulation, thermal moderation, and air quality improvement. Indigenous bulbous plants, by virtue of their seasonal growth and physiological activity, can play a significant role in each of these services when used on extensive green roofs in Mediterranean climates.

Green roofs are well documented for their ability to retain rainfall and reduce stormwater runoff, thus easing pressure on urban drainage infrastructure and mitigating flood risks (Berndtsson, 2010). Vegetation contributes to this retention through water uptake and transpiration, while the substrate increases infiltration and slows runoff. Species selection plays a crucial role: drought-tolerant plants with fibrous roots, such as geophytes, improve the substrate's capacity to retain and gradually release water. Indigenous bulbous plants like Allium and Gagea absorb water during their active spring phase, increasing evapotranspiration and pore space for subsequent rainfall. In summer, when dormant, their minimal water demand aligns with irrigation constraints.

Economically, the stormwater management benefits of green roofs have been estimated at €4–€11 per m² annually (TEEB, 2010). City-wide adoption can reduce long-term infrastructure investments; for example, Copenhagen projected savings of up to €500 million over 40 years by integrating green roofs (COWI, 2012).

Thermal Regulation and Energy Savings

Vegetated roofs provide insulation and cooling via evapotranspiration and shading, helping regulate rooftop and indoor temperatures. Seasonal plants like bulbous geophytes contribute during their growth phase, particularly in spring and autumn. Though dormant in summer, their presence supports a staggered phenology when combined with perennials and grasses, ensuring year-round vegetation cover. This stratification helps maintain consistent thermal regulation and energy efficiency (Castleton et al., 2010).

Empirical studies show green roofs can lower rooftop temperatures by 20–40°C (Alexandri and Jones, 2008), with potential energy savings of €5–€10 per m² annually, depending on building type and climatic conditions (Saiz et al., 2006). Such reductions are particularly relevant in Mediterranean cities facing prolonged summer heatwaves.

Air Quality Improvement

Green roof vegetation filters airborne pollutants, capturing particulates on leaf surfaces and absorbing gaseous compounds like NOx and SO2. While small in stature, native bulbous plants contribute during their active phase by offering surface area for deposition and moderating microclimates that reduce pollutant formation. Studies in urban areas have recorded reductions of up to 6% in PM and 37% in SO2 post-green roof installation (Currie and Bass, 2008).

Air quality improvement benefits have been valued at €1–€3 per m²/year in health-related cost savings, with broader impacts seen at scale (European Commission, 2013).

Biodiversity and Habitat Provision

Green roofs that incorporate native bulbous plants enhance ecological complexity and provide habitat for a variety of organisms, particularly pollinators. Staggered flowering from Crocus (February) to Allium (May) supplies continuous nectar and pollen, supporting urban pollinator populations during critical early-season periods (Gallai et al., 2009). This contribution extends to birds, beetles, and spiders, enriching urban ecosystems.

The value of pollination services in the EU alone exceeds €14 billion annually (Gallai et al., 2009). By mimicking natural Mediterranean habitats, bulb-planted roofs act as biodiversity corridors, offering refuge and resources in fragmented urban landscapes. Non-market assessments of biodiversity value estimate ecosystem service benefits at €5–€8 per m²/year (TEEB, 2010).

Extended Roof Lifespan and Property Value

Green roofs shield waterproof membranes from UV exposure and thermal stress, extending their service life. Conventional roofs last 15–20 years, whereas vegetated roofs can exceed 40 years (Kosareo and Ries, 2007). This longevity results in maintenance savings of €2–€6 per m²/year. In addition, aesthetic and environmental upgrades can increase property values by up to 7% (Dunnett and Kingsbury, 2004).

Cumulative Economic Value

Taken together, the ecosystem services offered by green roofs featuring indigenous bulbous species amount to significant annual value:

Table 1. Total Economic Value Estimate of Green Roofs

Service €/m²/year (Estimate)	€/m²/year (Estimate)
Stormwater management	€4–11
Energy Savings	€5–10
Air quality improvement	€1–3
Biodiversity + pollination	€5–8
Roof lifespan/maintenance	€2–6
Total Estimated Value	€17–38 per m²/year

Source: Authors

These estimates, drawn from peer-reviewed literature and urban case studies, underscore the economic rationale for integrating native Albanian geophytes into sustainable green roof designs. By doing so, cities not only gain climate resilience and ecological integrity but also unlock financial and public health co-benefits across urban systems.

4. Experimentation and Results

4.1 Growth and Blooming Outcomes

Plant growth across both irrigation regimes showed minimal variation in vegetative development, indicating a high level of resilience among all species. However, *Crocus tommasinianus* and *Tulipa sylvestris* did exhibit a moderately longer flowering period (by about 5–6 days) in the low-irrigation plots, suggesting a nuanced physiological response to reduced water availability.

4.2 Flower Production and Bloom Longevity

All five bulbous species demonstrated consistent flower production and bloom duration under both irrigation treatments. This indicates that the lower irrigation frequency was not detrimental to flowering or overall plant vigor, highlighting the inherent drought tolerance and resilience of these indigenous species.

4.3 Irrigation Effect on Performance

Statistical analysis showed no significant difference in plant growth or flower output between the high- and low-irrigation treatments ($p > 0.05$), although slight morphological adaptations (such as reduced leaf size or thicker leaves) were noted under the reduced water conditions.

Figure 1-4: Process of implementing roof gardening

Source: S. Jano, 2021

5. Conclusions and Discussion

This study provides valuable insights into the potential for using indigenous Albanian bulbous plants to enhance the sustainability of green roof systems in Mediterranean urban environments. By evaluating the performance of these native species under two distinct irrigation regimes, the research offers practical guidance for improving the ecological resilience and water efficiency of green roofs in cities like Tirana. Below, we discuss the broader implications of the findings, particularly in terms of the adaptability of native flora to green roof conditions, the viability of low-irrigation maintenance practices, and recommendations for implementing resilient plantings on urban rooftops.

5.1 Implications for Mediterranean Green Roofs

The findings from this study demonstrate that native Albanian bulbous plants can exhibit robust performance on green roofs, even under low-irrigation conditions. In Mediterranean climates where water scarcity is a prominent challenge, the ability to maintain green roof vegetation with minimal irrigation is critical for urban greening efforts. The resilience of species such as *Allium schoenoprasum*, *Allium sphaerocephalon*, and *Allium aflatunense* suggests that these plants can withstand the prolonged dry periods typical of Mediterranean summers, thereby reducing the need for frequent watering while still providing reliable green cover and aesthetic value.

In addition, the extended bloom periods observed in *Crocus tommasinianus* and *Tulipa sylvestris* under low-irrigation conditions point to a potential adaptive mechanism of native flora for coping with water stress. Prolonged flowering under drier conditions could benefit urban biodiversity by offering a steady supply of pollen and nectar for pollinators over an extended season – a valuable trait in densely built city environments where floral resources are often limited.

5.2 Significance of Low-Irrigation Regimes

The results underscore the feasibility of implementing low-irrigation green roofs in Tirana and similar Mediterranean cities with minimal adverse effects on plant health or growth metrics for most bulb species. By showing that significantly reduced watering regimes can achieve vegetative growth and flowering durations comparable to those under frequent irrigation, this study highlights the potential for water-saving green roof designs that align with sustainable urban development goals.

This aspect is particularly relevant in urban areas where water resources are increasingly strained. Adopting plant palettes and irrigation practices that require less water allows cities to expand green infrastructure while conserving vital water supplies (Razzaghmanesh *et al*., 2014). In the case of Tirana this would be the most desirable outcome in terms of ecosystem service provision.

Bibliography and References

Alexandri, E. and Jones, P. (2008) 'Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates', *Building and Environment*, 43(4), pp. 480–493.

Berndtsson, J.C. (2010) 'Green roof performance towards management of runoff water quantity and quality: A review', *Ecological Engineering*, 36(4), pp. 351–360.

Castleton, H.F., Stovin, V., Beck, S.B.M. and Davison, J.B. (2010) 'Green roofs; building energy savings and the potential for retrofit', *Energy and Buildings*, 42(10), pp. 1582–1591.

COWI (2012) *The Economic Value of Green Roofs*. Report for the City of Copenhagen.

Currie, B.A. and Bass, B. (2008) 'Estimates of air pollution mitigation with green plants and green roofs using the UFORE model', *Urban Ecosystems*, 11(4), pp. 409–422.

Dunnett, N. and Kingsbury, N. (2004) *Planting Green Roofs and Living Walls*. Portland: Timber Press.

Dunnett, N. and Kingsbury, N. (2008) *Planting Green Roofs and Living Walls*. Timber Press.

European Commission (2013) *Clean Air Programme for Europe*. Brussels: European Union.

Fioretti, R., Palla, A., Lanza, L.G. and Principi, P. (2010) 'Green roof energy and water related performance in the Mediterranean climate', *Building and Environment*, 45(8), pp. 1890–1904.

Francis, R.A. and Lorimer, J. (2011) 'Urban reconciliation ecology: The potential of living roofs and walls', *Journal of Environmental Management*, 92(6), pp. 1429–1437.

Gagliano, A., Detommaso, M., Nocera, F. and Evola, G. (2012) 'A multi-criteria methodology for comparing the energy and environmental behavior of cool, green, and traditional roofs', *Building and Environment*, 56, pp. 355–364.

Gallai, N., Salles, J.M., Settele, J. and Vaissière, B.E. (2009) 'Economic valuation of the vulnerability of world agriculture confronted with pollinator decline', *Ecological Economics*, 68(3), pp. 810–821.

Getter, K.L. and Rowe, D.B. (2006) 'The role of extensive green roofs in sustainable development', *HortScience*, 41(5), pp. 1276–1285.

Jauslin, D. and Vezzoli, A. (2018) 'Mediterranean green roofs: New applications and benefits', in *Green Roof Technology*. Cham: Springer, pp. 143–166.

Kazemi, F., Beecham, S. and Gibbs, J. (2011) 'Streetscape biodiversity and the role of bioretention and other structural elements in the green infrastructure', *Urban Forestry & Urban Greening*, 10(4), pp. 327–335.

Köhler, M. (2008) 'Green facades — a view back and some visions', *Urban Ecosystems*, 11(4), pp. 423–436.

Kosareo, L. and Ries, R. (2007) 'Comparative environmental life cycle assessment of green roofs', *Building and Environment*, 42(7), pp. 2606–2613.

Kratsch, H.A. and Graves, W.R. (2004) 'Nitrogen and carbon isotopic ratios in native and cultivated populations of Rudbeckia and Coreopsis indicate ecotypic adaptation to low-nutrient soil', *Functional Plant Biology*, 31(10), pp. 985–992.

Molineux, C.J., Fentiman, C.H. and Gange, A.C. (2009) 'Characterizing alternative recycled waste materials for use as green roof growing media in the U.K.', *Ecological Engineering*, 35(10), pp. 1507–1513.

Nardini, A. and Luglio, J. (2014) 'Leaf hydraulic capacity and drought vulnerability: Possible trade-offs and seasonal dynamics in the Mediterranean shrub *Pistacia lentiscus* L.', *Functional Plant Biology*, 41(1), pp. 26–36.

Oberndorfer, E., Lundholm, J., Bass, B., Coffman, R.R., Doshi, H., Dunnett, N. and Rowe, B. (2007) 'Green roofs as urban ecosystems: Ecological structures, functions, and services', *BioScience*, 57(10), pp. 823–833.

Palla, A., Gnecco, I., Lanza, L.G. and La Barbera, P. (2010) 'Hydrologic restoration in the urban environment using green roofs', *Water*, 2(2), pp. 140–154.

Pérez, G., Rincón, L., Vila, A., González, J.M. and Cabeza, L.F. (2011) 'Green vertical systems for buildings as passive systems for energy savings', *Applied Energy*, 88(12), pp. 4854–4862.

Poë, S., Stovin, V. and Berretta, C. (2015) 'Parameters influencing the regeneration of a green roof's retention capacity via evapotranspiration', *Journal of Hydrology*, 523, pp. 356–367.

Razzaghmanesh, M., Beecham, S. and Kazemi, F. (2014) 'The growth and survival of plants in green roof substrates: A review', *Urban Forestry & Urban Greening*, 13(4), pp. 841–848.

Rosenzweig, C., Solecki, W.D., Hammer, S.A. and Mehrotra, S. (2011) *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network*. Cambridge: Cambridge University Press.

Saiz, S., Kennedy, C., Bass, B. and Pressnail, K. (2006) 'Comparative life cycle assessment of standard and green roofs', *Environmental Science & Technology*, 40(13), pp. 4312–4316.

Thuring, C.E. and Dunnett, N.P. (2014) 'Vegetation composition on extensive green roofs in southern Germany and the influence of roof design, management and plant characteristics', *Urban Forestry & Urban Greening*, 13(3), pp. 385–396.

Williams, N.S., Rayner, J.P. and Raynor, K.J. (2010) 'Green roofs for a wide brown land: Opportunities and barriers for rooftop greening in Australia', *Urban Forestry & Urban Greening*, 9(3), pp. 245–251.

EVALUACIJA AUTOHTONIH ALBANSKIH LUKOVIČASTIH BILJAKA NA ZELENIM KROVOVIMA ZA POBOLJŠANJE URBANIH EKOSISTEMA U MEDITERANSKIM KLIMATSKIM USLOVIMA

Apstrakt: *Zeleni krovovi donose ekološke i funkcionalne prednosti u urbanim sredinama, ali otpornost biljaka ostaje izazov, posebno u mediteranskim klimatskim uslovima. U Albaniji, a naročito u brzo urbanizujućoj Tirani, zeleni krovovi mogu ublažiti ekološke probleme poput zagađenja vazduha, urbanih toplotnih ostrva i nedostatka zelenih površina. Uprkos ovim prednostima, do sada nisu sprovedene studije o pogodnosti autohtonih albanskih biljnih vrsta za primenu na zelenim krovovima u ovom regionu. Ova studija ima za cilj da proceni otpornost domaćih lukovičastih biljaka u različitim režimima navodnjavanja i da pruži preporuke za odabir biljnih vrsta i strategije zalivanja kako bi se unapredile ekološke i funkcionalne performanse zelenih krovova u urbanim sredinama sa mediteranskom klimom. Istraživanje obuhvata pet autohtonih albanskih lukovičastih biljnih vrsta, koje su sađene zajedno sa drugim domaćim jednogodišnjim i višegodišnjim vrstama u okviru dva različita režima navodnjavanja na šest eksperimentalnih zelenih krovova u Tirani. Analizirana je pogodnost ovih vrsta za upotrebu na zelenim krovovima, uticaj niskog (dva puta nedeljno) i visokog (svakodnevnog) režima navodnjavanja na rast biljaka, kao i mogućnosti optimizacije izbora vrsta i strategija zalivanja za poboljšanje efikasnosti zelenih krovova. Ključno istraživačko pitanje odnosi se na uticaj različitih režima navodnjavanja na rast i performanse autohtonih albanskih biljaka na zelenim krovovima. Preliminarni rezultati pokazuju da oba režima navodnjavanja daju slične rezultate u pogledu vremena cvetanja, trajanja cvetanja i vegetativnog rasta kod svih analiziranih lukovičastih vrsta, osim kod Crocus tommasinianus i Tulipa sylvestris, kod kojih su primećene određene razlike. Studija zaključuje da režimi navodnjavanja imaju minimalan uticaj na ukupni rast biljaka, pri čemu niži nivo navodnjavanja može potencijalno produžiti period cvetanja kod pojedinih vrsta.*

Ključne reči: *Zeleni krovovi, autohtone biljke, režimi navodnjavanja, mediteranska klima.*