

Wild edible plant *Urospermum picroides* as a sustainable cultivation in saline soils growing under different irrigation and fertilization regimes

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Abstract

Aims

Native edible plants such as *Urospermum picroides* (L.) have a long tradition in the Cretan diet. Their adaptation to demanding local environments makes them promising low-input alternative crops, aligned with economic, environmental, and climatic challenges. Accordingly, this study evaluated *U. picroides* performance under varying salinity, fertilization, and irrigation regimes, focusing on key physiological and agronomic characteristics.

Methods

A pot-based experiment was conducted to investigate the response of *U. picroides* to different irrigation water salinity levels (< 1, 2, 4, and 8 mS/cm), irrigation regimes (40 and 80% of water holding capacity (WHC)), and fertilization treatments (with vs without inorganic fertilizers). The study focused on plant growth, fresh biomass production, physiology (Fv/Fm and SPAD measurements), and micro- and macronutrient uptake characteristics.

Results

Salinity had little effect on plant height, leaf number, or fresh biomass, while biomass increased with higher irrigation and was unaffected by fertilization. All factors, and their interactions, showed no significant effects on physiological parameters (Fv/Fm, SPAD). Nutrient concentrations were largely unaffected by salinity, except for increased sodium and copper uptake. Irrigation and fertilization had no significant effects on nutrient content, except for higher nitrogen and magnesium at the highest irrigation level.

Conclusions

Overall, our findings highlight the strong potential of *U. picroides* as an alternative, low-input crop, supporting objectives related to climate adaptation, biodiversity conservation, and sustainable resource management in vulnerable environments. Further research, including field-scale trials under diverse soils, environments, and abiotic stresses, is needed to confirm long-term crop performance and benefits for resources and local communities.

Introduction

Global climate change affects weather patterns, infusing abiotic stressors like salinity and droughts which are two of the most significant environmental challenges to crop growth and yield worldwide (Ahmed et al., 2024; Christoforidi et al., 2022). Soil salinization and water scarcity are major and escalating threats that currently reduce crop productivity on over 20% of global agricultural land and are projected to affect more than 50% of arable land by 2025 (Ortas et al., 2021). Furthermore, low water availability can affect agricultural production in regions relying mostly on rain-fed agriculture. The Mediterranean region is suffering from droughts, occurring even during the wet season, which can have a strong impact on water resources by lowering groundwater levels and water available in dams and reservoirs (Tramblay et al., 2020). In addition, 26 countries in Europe have reported cases of salinization with higher frequency in Mediterranean coastal areas and cultivations with no proper irrigation management increasing; the progression of salinization is increasingly jeopardizing productions of irrigated lands, the most active agricultural areas of the world (Maggio et al., 2011).

Future agricultural land shortages and high food demands will fundamentally influence the food supply's safety and necessitate increasing crop yields through sustainable methods (Sharma et al., 2024). In addition, sustainable farming refers to agricultural practices that preserve, expand natural resources and protect the environment (Mina et al., 2023). Wild edible plant species traditionally gathered from the wild in the Mediterranean region are consumed as a part of the Mediterranean diet (Christoforidi et al., 2024; Guasch-Ferré & Willett, 2021; Nieto Feliner et al., 2023; Psaroudaki et al., 2015; Trichopoulou, 2012). In addition, most

of the Mediterranean flora, apart from their important nutritional and therapeutic values (Fragopoulou et al., 2012; Guarrera & Savo, 2016; Salonikioti et al., 2015), have adaptation to adverse soil, climatic conditions and irrigation limitations (Iglesias et al., 2011; Nardini et al., 2014; Salleo & Nardini, 2000; Seleiman et al., 2021).

Urospermum picroides (L.) Scop. ex F. W. Schmidt (Asteraceae), common name prickly goldenfleece, is a wild edible plant, native to the Mediterranean region, rich in secondary compounds, with antimicrobial and antioxidant activity, medicinal and health-promoting properties (Alper & Güneş, 2019; Aly et al., 2008; Balboul et al., 1997; El-Amier et al., 2016; Fragopoulou et al., 2012; Strzelecka et al., 2005). The plant, as a product gathered from nature, is an integral part of the traditional Cretan dietary pattern, which are closely linked to sustainable practices across the entire agri-food system of a region (Pieroni et al. 2022; Psaroudaki et al., 2015, 2020; Trichopoulou, 2012). A prominent example is the region of Crete, where the traditional Cretan Mediterranean dietary pattern includes the consumption of a wide variety of wild edible greens (Psaroudaki 2012). The *U. picroides* could be a promising new cultivation and have adaptations in abiotic stressors (Alexopoulos et al., 2023; Salonikioti et al., 2015) however, there is a limited literature evaluation of the cultivation practices that can increase the yield of this crop while ensuring the use of salinity soils and a limited environmental footprint.

In the present study, in a pot-based experiment, we examined the response of *Urospermum picroides* (L.) growing under different fertilization, irrigation and soil salinity levels focusing on growth and plant physiological characteristics. The findings of the study provide information regarding species potential particularly under different stresses based on current and future environmental and climate challenges.

Materials and Methods

Plant development and Pot experiment

The study focuses on the growth of the plant *Urospermum picroides* (collected after permission, with specific deposition number GR1 HMUND-002), with the aim of investigating its resistance to salinity, in specific irrigation and fertilization regimes. An experimental protocol (plan) was designed and implemented that included compliance with certain cultivation conditions as well as examination of predefined variables-parameters for the plant and the soil. Initially, a substrate was prepared for the growth of *Urospermum picroides* seedlings, mixing perlite with compost in a 1:1 ratio. The mixture was placed in the seed trays, in which one seed was planted in each position. At the beginning of the process (November 23, 2023), the first watering of the seeds was done, and for the first three weeks the plants were watered daily. As plant growth progressed, irrigation frequency was gradually reduced. From the emergence of the first seedlings plants were watered four times a week for a month. At a more advanced developmental stage, irrigation was reduced to twice per week and maintained until transplanting.

On February 12, 2024, the 64 healthiest and most developed plants were transplanted into 3-liter pots in the greenhouse. The pots contained soil from the outdoor area of the Hellenic Mediterranean University of Crete (HMU), which was offered as a substrate for their growth. Soil properties are presented in Table 1. On the first day of transplanting, double watering was applied to promote plant growth, followed by irrigation every two days. In total 16 treatments were applied to the pots as follows: The pots were placed in a 16x4 arrangement (four replicates) and in each one were placed intervals containing a specific amount of deionized water, fertilizer and/or sodium chloride (NaCl), to achieve four levels of irrigation water salinity (< 1, 2, 4 and 8 mS/cm), and two fertilization (with or without chemical fertilizer addition) and irrigation (~ 40 and ~ 80% of WHC) regimes. Thus, 2x2x4x4 = 64 pots were prepared (Fig. 1). Both irrigation and fertilization rates were calculated on data collected after laboratory experimentation followed by periodic weighting of pots. Inorganic fertilizers, ammonium sulfate and monopotassium phosphate were applied (at rates of 50 kg NPK per ha) to the half of the pots with added fertilizer. The pots remained partially under controlled conditions in the greenhouse, with periodical aeration and normal temperature variation (15–30°C). In the following period, additions of the above solutions were made (1st dose 16/3/24, 2nd dose 4/4/24, 3rd dose 16/4/24 and last and 4th dose 22/4/24) and measurements were taken to determine the growth, physiology, and nutrients in the above ground part of the plant. In addition, photographs were taken for the macroscopic recording of plant growth during the experiment.

Table 1
Parameters measured in soil
used in pot experiment.

Parameters	Values
pH	7,58
EC (mS cm ⁻¹)	< 1
Clay (%)	25
Sand (%)	38
Loam (%)	38
Org. matter (%)	3,61
CaCO ₃ (%)	17

Samplings and analysis

The height of the plant was recorded; the first measurement was made on 30/3/2024 and two more measurements followed (11/4/2024 and 23/4/2024). We measured the height from where the above-ground part of the plant began up. Measurements were also taken for the number of leaves of each plant, with the 1st starting on 30/3/2024, the 2nd on 11/4/2024 and the 3rd on 23/4/2024. In addition, photographs were taken for the macroscopic recording of the growth of the plants during the experiment.

Fluorimeter and chlorophyll measurements were carried out, which were made in the morning hours for more accurate results. For the fluorimeter measurements, we placed a peg on each leaf for 3 leaves per plant and left them for a quarter to twenty minutes. The 1st measurement was made on 5/4/2024 and the 2nd on 24/4/2024 (end of experiment, Table 2). For the chlorophyll measurement, we placed the device on the leaf and noted the value; this was done on 3 different leaves per plant. The 1st chlorophyll measurement was also noted on 5/4/2024 and the 2nd on 24/4/2024 (Table 2).

On April 25, 2024 (end of the experiment), the plants were cut from their base and weighed to determine the fresh biomass. Then, the leaves were separated from the central shoot, individually weighted and transferred to the laboratory for further processing. More specifically, the leaves were washed, air-dried, and weighed again. Subsequently, they were dried in a desiccator at 65°C and reweighed to determine the dry weight. Then, the dried leaves were crushed, pulverized with an electric mill and stored in paper bags until nutrient analysis. For nutrient determination, 1 gram of the material was placed to porcelain crucibles, which were placed in a combustion oven at 480°C for 7–8 hours, for complete combustion. The white ash that was obtained, was dissolved by the addition of 1 ml of concentrated HNO₃ and 5 ml of 6N HCL solution. Each sample filtered through No 1 Whatman filter paper and diluted to 50 ml volume with deionized water, capped, inverted and transferred to plastic vials, which were stored in fridge at 4°C. The stock samples, that were obtained from dry combustion, were used for determination of leaf phosphorus, potassium and micronutrients content. Measurements were carried out to determine the concentrations of phosphorus (P), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), calcium (Ca), and magnesium (Mg) in the stock solution. Phosphorus was determined according to the Vanadium molybdate procedure (Benton-Jones, 2001). Potassium was determined in the sample stock solutions using flame-photometer (Model) (Benton-Jones, 2001) and Ca, Mg, and micronutrients (Zinc, Boron and Ferrous) by using atomic absorption photometer. When necessary, appropriate dilutions performed to acquire values inside the calibration curve. Nitrogen concentration in the leaf tissue was determined in leaf tissue powder by the Kjeldhal procedure (Bremner, 1996).

In addition to plant tissues, soil conductivity was also determined at the end of the experiments. For this purpose, 20 g of soil were taken from each pot and 20 g of deionized water were added. The solution was stirred for 30 minutes and then the conductivity of the sample was measured. This procedure completed the data collection for the experiment.

Statistical analysis

For the purposes of the experiments, a three-way analysis of variance (Salinity, Irrigation and Fertilization) (3-way ANOVA) was applied. Individual comparisons (Duncan post hoc) were made for the salinity factor whereas student t test was carried out for irrigation and fertilization factors. Data were checked for homogeneity and normality, and log transformation were carried out where was necessary. The IBM SPSS statistical package (ver. 22) was used.

Results

Soil salinity

Soil salinity was examined at the end of the experimentation to determine the salinity level in pots under different treatments. The initial level (Control) was less than 1 mS/cm, while the subsequent levels 2, 4 and 8 mS/cm showed soil salinities of 2.39, 3.90, 6.43 mS/cm.

Plant growth and physiology

Salinity had a significant effect on the height of the plant ($p < 0.05$) (Table 2.). Higher values were recorded in plants with increasing soil salinity (with exception of the higher salinity) and the highest moisture levels ($p = 0.08$). Regarding the number of leaves, significant differences were also observed between the plants in relation to moisture and salinity ($p < 0.05$) (Table 2). Higher leaf numbers were observed under increased salinity and moisture treatments. Regarding the produced fresh biomass, a significant effect was observed on the irrigation factor, showing higher biomass in higher irrigation level ($p < 0.05$). Fertilization had no effect on the above parameters (Table 2). Fertilization significantly, salinity and humidity had no effect on SPAD and fluorescence values ($p > 0.05$).

Plant nutrition

Based on the statistical analysis of the concentrations of micronutrients in the leaves of *Urospermum picroides*, significant effects on the examined factors emerge. Specifically, for the macronutrients, salinity did not have a significant effect on the concentrations of nitrogen, phosphorus, potassium, calcium and (Table 3). However, for sodium, a statistically significant effect of salinity appears, with the average values increasing from 4.29% at salinity of < 1 mS/cm to 5.89% at salinity of 2 mS/cm, 7.36% at of 4 mS/cm and 8.68 at 8 mS/cm (Table 3).

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In addition, fertilization had significant statistical effects on nitrogen concentration with an average concentration of 3.35% at fertilized versus 3.04% at non-fertilized pots. Magnesium also showed significant effects, showing higher magnesium concentrations in the leaves in fertilized pots compared to the control pots (Table 3). In contrast, fertilization had no significant statistically significant effect on phosphorus, potassium, or calcium concentrations. Likewise, irrigation appeared to have little impact on the concentrations of micronutrients in the leaves (Table 3). Finally, it is worth noting the statistically significant interaction between irrigation and fertilization, as well as the interaction between salinity, irrigation and fertilization for nitrogen concentration in leaves, indicating the complexity of the interaction of these factors in nutrient uptake.

Regarding the concentration of microelements in the leaves of the *Urospermum picroides* plant, it is observed that all factors, and their interactions, had no significant statistical effect (Table 4). In case of manganese, the effect of salinity, irrigation, fertilization on nutrient concentration in leaves was not statistically significant despite the fluctuations in their average values (Table 4). In addition, irrigation and fertilization had no significant effects on copper and zinc concentrations, whereas salinity resulted in a significant increase at higher salinity levels. For iron, neither salinity nor irrigation had a statistically significant effect; however, iron concentration showed a marginally significant trend in response to fertilization ($p = 0.09$). Finally, the interactions of the four factors did not have a statistically significant effect on the uptake of any of the microelements examined (Table 4).

Table 3

The effect of salinity, fertilization and Irrigation on macronutrient concentration in biomass of *Urospermum picroides* at the end of experiment.

		N		P		K		Ca		Mg		Na	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
Salinity (mS cm ⁻¹)	1	3.16	0.15	0.71	0.92	10.93	1.87	1.01	0.19	0.29	0.06	4.29b	0.87
	2	3.27	0.15	0.53	0.53	13.42	1.25	1.09	0.10	0.30	0.03	5.89ab	0.70
	4	3.12	0.18	0.68	0.58	15.51	2.16	1.35	0.18	0.39	0.05	7.36ab	0.92
	8	3.14	0.13	0.80	0.71	15.71	2.18	1.44	0.27	0.36	0.05	8.68a	1.38
Sig.		NS		NS		NS		NS		NS		*	
Irrigation (% of WHC)	~ 40	3.12	0.11	0.62	0.72	14.65	1.42	1.14	0.12	0.34	0.04	6.16	0.61
	~ 80	3.23	0.11	0.72	0.66	13.94	1.37	1.35	0.16	0.34	0.03	7.51	0.89
Sig.		NS		NS		NS		NS		NS		NS	
Fertilization	No	3.04b	0.08	0.59	0.71	12.34	0.87	1.22	0.13	0.28b	0.02	5.89b	0.46
	Yes	3.35a	0.14	0.78	0.65	16.81	1.84	1.29	0.16	0.42a	0.05	8.09a	1.06
Sig.		*		NS		NS		NS		**		*	
Salinity* Irrigation		0.079		NS		NS		NS		NS		NS	
Salinity * Fertilization		NS		NS		NS		NS		NS		NS	
Irrigation * Fertilization		**		NS		NS		NS		NS		NS	
Salinity * Irrigation * Fertilization		*		NS		NS		NS		NS		NS	

Table 4
The effect of salinity, fertilization and Irrigation on micronutrient concentration in biomass of *Urospermum picroides* at the end of experiment.

		Fe		Zn		Cu		Mn	
		Mean	Std. Error	Mean	Std. Error	Mean	Std. Error	Mean	Std. Error
Salinity (mS cm ⁻¹)	1	423.75	151.75	54.54	10.51	0.21	0.21	69.94	11.72
	2	406.15	35.01	61.90	5.31	3.83	1.46	56.61	5.13
	4	650.02	110.68	74.29	7.51	10.02	2.64	75.14	8.26
	8	459.99	79.32	77.20	11.65	16.52	3.95	70.30	7.47
	Sig. NS			NS		***		NS	
Irrigation (% of WHC)	~ 40	520.83	66.33	70.03	6.92	7.02	2.57	70.16	6.17
	~ 80	468.78	65.95	67.24	5.77	10.05	1.85	65.28	4.89
	Sig. NS			NS		NS		NS	
Fertilization	No	427.14	57.80	65.91	5.82	6.04	2.09	68.06	4.19
	Yes	581.13	73.57	72.08	6.98	11.83	2.26	67.18	7.22
	Sig. 0.09			NS		NS		NS	
Salinity* Irrigation		NS		NS		NS		NS	
Salinity * Fertilization		NS		NS		NS		NS	
Irrigation * Fertilization		NS		NS		NS		NS	
Salinity * Irrigation * Fertilization		.		.		.		.	

Discussion

Crop resilience and agriculture sustainability can be enhanced by exploring soil salinity, plant drought tolerance, and remediation techniques (Muhammad et al., 2024). By applying their understanding of soil functions to develop practical approaches that enhance crop performance and enable producers to evaluate the sustainability of their management practices, scientists can make a significant contribution to the global sustainability of agricultural lands (Sharma et al., 2024). In this context, in the present study, different treatments regarding irrigation water salinity, soil moisture and fertilization were examined to investigate *Urospermum picroides* response and potential. The study provides evidence of the ability of *Urospermum picroides* to grow under saline soil environments and variable irrigation regimes highlighting its potential as an alternative crop under various climate and anthropogenic driven stresses. Thus, the native edible crop cultivations, such as *Urospermum picroides*, thriving in Cretan land could be an option as an alternative crop cultivation, as a plant species well-adapted to demanding local conditions, compatible with challenging climatic and various stresses conditions.

The effect of salinity on plant growth and physiology and the role of irrigation and fertilization

Results of the study showed that the plants' growth and biomass parameters remained unaffected or were positively responded to increase in NaCl-induced salinization up to 8 mS/cm, indicating the tolerance of plant species to salinity stress. In a recent pot-study, it was found that only at the high level of NaCl (5 mS/cm) in the nutrient solution, compared to 5 mS/cm, the growth parameters of the plant were significantly reduced (Vidalis et al., 2023). Similarly, decreasing leaf number and fresh biomass have been registered under different levels of salinity (2, 6, and 10 mS/cm) particularly at the highest salinity level (Alexopoulos, 2023). It has been documented that the presence of high NaCl concentrations in the rhizosphere area creates a high osmotic potential in the soil which limits the uptake of water and nutrients by the root system (Ryu, 2015). However, *Uropsermum*

picroides may exhibit better water uptake under saline conditions (Alexopoulos, 2023) and/or may accumulate and tolerate higher Na concentrations in leaves, as shown in our pot study and previously (Alexopoulos, 2023), explaining its relatively high salt tolerance. Detrimental effect of salinity on fresh biomass yield, at various scales, has been reported in the case of different plant species indicating the importance of genetic background against salt stress (Alexopoulos, 2023; Shannon and Grieve, 1999). In line with the plant growth and biomass parameters, in our study, the physiological parameters (SPAD and Fv/Fm), were unaffected by salinity level, providing additional evidence of the tolerance of *Uropsernum picroides* to NaCl-induced salinity. Similar responses of SPAD and chlorophyll content to salinity were obtained by the above studies (Alexopoulos, 2023; Vidalis et al., 2023), indicating the tolerance of the *Uropsernum picroides* to a wide range of salt stress, probably due to effective adaptation mechanisms, such as osmotic adjustment and/or ion compartmentalization (Yang et al., 2007), needed to be elucidated.

Irrigation level favored leaf number and fresh biomass production indicating that soil moisture is important parameter of the *Uropsernum picroides* growing under various soil conditions. Both water availabilities allowed adequate nutrients' supply, showed by similarities regarding their content in leaves, however, increase of irrigation water favored growth rather than physiological characteristics that remained unaffected. Positive relationship between irrigation level and biomass has been reported in a wide range of crops, showing interaction with fertilization level in some cases (Amer, 2010; Shani and Dudley, 2001; Chen, et al., 2018); However, here, no remarkable interaction between irrigation and fertilization levels was recorded. In fact, no effect of fertilization on performance of *Uropsernum picroides* was observed, suggesting that soil supplied adequately plants with nutrients, regardless of fertilization. Overall, in contrast to irrigation, fertilization was not critical for *Uropsernum picroides*, which may demonstrate the plant's autonomy and potential under the examined soil regime. In contrast, positive effects of different foliar fertilizations on leaf number and fresh biomass and Fv/Fm have been reported in a field experiment (Christophoridi et al., 2024), which may suggest that *Uropsernum picroides* response to fertilization is matter, besides soil conditions, of the application of fertilization method (foliar vs soil). Unfortunately, no relevant data is available in literature, suggesting future work.

Leaf nutrient dynamics

With exception of Na, Mg and Cu, all macro and micro-nutrient concentrations in leaves were unaffected by salinity, irrigation and fertilization regimes. These suggest that plants of *Uropsernum picroides* remain unaffected and adequately supplied by the soil with the nutrients needed under the established experimental soil conditions. Interestingly, plants increased Na uptake with increasing salinity level in soil, indicating an adaptive mechanism of the plants over salinity stress. Similar results have been provided recently showing, however, parallel decrease in K and Ca leaf concentrations under increasing salinity level (Alexopoulos, 2023). In the present study increase of salinity, in addition to Na, led to increase in Cu content, which was not the case in the latter study (Alexopoulos, 2023). Moreover, variations regarding other micro or even macronutrient contents were recorded between our study and the previous studies (Alexopoulos, 2023; Christophoridi et al., 2024). These inconsistent results may be due to genetic potential of plants, root/shoot allocation and nutrient partitioning, plant handling (salinity level, duration of stress and plant adaptation period) and experimental conditions (e.g., soil properties and nutrient content, temperature and light period etc.) shaping plant response and micro and macronutrient competitions and availabilities (Shang et al., 2020; Cheng et al., 2019). For example, regarding Cu in our study, the increased uptake may be favored by elevated Na concentration and ionic strength in soil that favored Cu displacement from exchange sites of soil particles and/or prevented its sorption onto clay and organic matter (Acosta et al., 2011), increasing its availability in soil. Moreover, possible damages due to increased salinity facilitating Cu uptake aren't excluded (Zhou et al., 2024). Fertilization increased leaf N content reflecting the addition of inorganic N addition and the higher N availability in soil. Similarly, Mg leaf content was increased by inorganic fertilization that could be attributed to increased dissolution and availability in soil. No other effect of fertilization in leaf contents was recorded in our study, similar to a field *Uropsernum picroides* cultivation, where leaf micro and macronutrient contents remained unaffected by foliar fertilization (Christophoridi et al., 2024). Finally, irrigation level did not affect the leaf nutrients' concentration, suggesting that irrigation up to 40% of WHC was adequate for plants.

Implications for sustainable crop cultivation, biodiversity and Mediterranean diet systems

The present study demonstrates the ability of *Urospermum percroides* to sustain adequate growth, physiological performance and nutritional balance under saline and moderately dry soil conditions exhibiting in parallel low reliance on fertilization. These characteristics make plant species a promising candidate for low input farming systems particularly in marginal and saline soils, of the Mediterranean region, given the current and future environmental, climate and food security challenges of the area (Tzanakakis et al., 2020; Paredes et al., 2020). Apart from its agronomic performance under various stresses, *Urospermum picroides* may also contribute to preservation and strengthening of biodiversity in agroecosystems supporting parallel the traditional Mediterranean food diet prototype along with the cultural and nutritional heritage (Christophoridi et al., 2024).

Plants gathered from nature are an integral part of the traditional Cretan dietary pattern, which is closely associated with sustainable practices throughout the regional agri-food system. In the Mediterranean region, traditional food (environmental knowledge, encompassing practices, beliefs, and ecological understanding) still survives in certain areas, with Crete standing out as a prominent example, where the traditional Cretan Mediterranean diet includes the consumption of a wide variety of wild edible greens.

Conclusions

Under the experimental conditions of this study, *Urospermum percroides* demonstrated: (a) remarkable tolerance to irrigation with saline water (up to 8 mS/cm), (b) reduced water needs (lower as 40% of WHC) and (c) minimal dependence on inorganic fertilizations; highlighting its high potential as a resilient wild edible species suitable for in marginal and/or saline soils, commonly found in many areas of the Mediterranean region. Specifically, saline irrigation water up to 8 mS/cm did not reduce fresh biomass or plant physiology, represented by Fv/Fm and SPAD measurements, while moderated irrigation sufficiently supported the overall plant performance and nutrient dynamics. The relatively limited response of *Urospermum percroides* to fertilization, along with moderate water demands, indicates its high potential as a crop under low-input conditions, which can service both environmental or economic viability purposes, in agreement to climate adaptation, biodiversity preservation and sustainable resources management for vulnerable areas of the planet. Future work should focus on field-scale experimentation under diverse soil types, environmental conditions, and abiotic and biotic stresses to confirm long-term crop production and the potential benefits for resources and local communities.

Declarations

The authors declare that no specific funding was received for this study. In addition, the authors declare that they have no known financial or non-financial competing interests that could have appeared to influence the work reported in this paper. This study did not involve human participants or animals. Therefore, approval by an ethics committee was not required. All data generated and analyzed during this study supports the findings of this manuscript. The datasets are available from the corresponding author upon reasonable request. *Urospermum picroides* collected after permission “ΑΠ.ΥΠΕΝ/ΔΠΔ/128940/7615,ΥΠΕΝ/ΔΠΔ/96505/5717/25.09.2023”, with specific deposition number GR1 HMUND-002.

Ethics and consent to participate

The plant specimen was collected in compliance with Greek Law 3937/2011 (Government Gazette Α' 60/2011) on biodiversity conservation. The specimen was identified by Dr. Eleftheria Antaloudaki, Curator of Botany at the Natural History Museum of Crete (NHMC), using *Atlas of the Hellenic Flora* (Strid 2024) and *Flora Europaea* (Tutin et al. 1964–1980, 1993), while *Flora Cretica* (Muer et al. 2024) was also consulted. Nomenclature follows the *Flora of Greece Web*, the continuously updated online version of *Vascular Plants of Greece: An Annotated Checklist* (Dimopoulos et al. 2013, 2016). A voucher specimen has been prepared and deposited in the NHMC Herbarium under the code NHMC 42.13642.

The taxonomically identified seed samples used in this study belong to the species *Urospermum picroides* (Asteraceae) and were collected from natural populations of the species in the area of eastern Crete using special research permits (YPEN/DPPD/128940/7615/26.05.2023 and YPEN/DPPD/96505/5717/25.09.2023). The collection was carried out by Associate Professor of Nutrition and Food Hygiene Antonia Psaroudaki of the Department of Nutrition and Dietetics Sciences of Hellenic Mediterranean University (HMU). The collected seeds were transferred to the “ΤΕΔΔ”, which has a recognized seed

bank of wild edible plants (member of the Botanic Gardens Conservation International (BGCI) network) and were registered in the special collection registers of the aforementioned unit outside the place of conservation of genetic material (reference codes IPEN – International Plant Exchange Network). The seed lot from which the plants of the present experimental procedure originated has the IPEN code GR-1-HMUND-002. An MTA (Material Transfer Agreement) was drawn up for the transfer of the seed lots to the AGRICULTURE department of HMU for the conduct of the experiment.

Moreover, Prof. Dr. Antonia Psaroudaki identified the plant/plant part. She has Ph.D. in agricultural science and collection was done after collection permission was received. Dr. Antonia Psaroudaki is the manager of the short-term seed bank of native edible plants of the department of Nutrition Sciences and Dietetology of HMU.

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Table 2

Table 2 is available in the Supplementary Files section.

Figures



Figure 1

Schematic presentation of the experimentation.

Supplementary Files

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