

Effect of water stress on different origins of *Argania spinosa*

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1. Introduction

The Argane tree (*Argania spinosa* (L.) Skeels) is an endemic essence of southwestern Morocco, and the only tree representing the tropical family of Sapotaceae listed in the flora of Morocco. This species is a national resource with a strong ecological and socio-economic impact (Chakhchar et al., 2022). However, the sustainability of this ecosystem is threatened by the effect of global climatic changes such as the successive chronic drought which considerably reduces its natural spread. Tree species cannot escape drought like annuals. Indeed, they have developed several mechanisms of tolerance against this abiotic constraint. Drought conditions cause a wide range of physiological and biochemical reactions in the Argane tree (Chakhchar et al., 2017, 2018, 2019).

In this perspective, our objective is to study some physiological and biochemical mechanisms of drought tolerance in four contrasting provenances of the Argane tree in order to discriminate the most tolerant provenances that could be exploited rehabilitation of degraded Argane forests.

2. Materials and Methods

Argane seedlings (6-month-old) from the germination of seeds of four contrasting provenances (Essaouira (Ess), Agadir (Agd), Bouizakarne (Bzk) and Berkane (Brk)), were subjected to severe water stress by cessation of irrigation for 25 days.

Physiological and biochemical measurements were collected every five days interval from 3 replications per treatment/provenance. For physiological parameters, we determined basic (Ψ_b) and minimum (Ψ_m) leaf water potential using a Schoanderl-type pressure chamber and the relative leaf water content (RWC). For the biochemical parameters, we determined total sugars according to the method of (Dubois et al., 1956), at 485 nm. The proline content is quantified according to the method described by Monneveux and Nemmar, (1987) at 528 nm.

All the results obtained were statistically analyzed by analysis of variance (ANOVA) with SPSS software, version 25. The Tukey post-hoc test is used to compare the means at the 5% significance level.

3. Results and Discussion

Physiological parameters

Table 1. Analysis of variance (ANOVA) showing the effect of provenance, observation time, and drought stress and their interaction on the physiological parameters studied in the four contrasting provenances of the *A. spinosa* (Berkane, Essaouira, Agadir, and Bouizakarne).

	Ψ_b	Ψ_m	RWC
Berkane (Brk)	-0.50b	-1.41b	62.82a
Essaouira (Ess)	-0.41a	-1.19a	56.54b
Agadir (Agd)	-0.38a	-1.42b	65.26a
Bouizakarne (Bzk)	-0.47b	-1.11a	50.70c
ANOVA ($p \leq 0.05$)			
Provenance (P)	≤ 0.05	≤ 0.05	≤ 0.05
Time (T)	≤ 0.05	≤ 0.05	0.15
Stress (S)	≤ 0.05	≤ 0.05	≤ 0.05
P x S	≤ 0.05	≤ 0.05	0.18
P x T	≤ 0.05	≤ 0.05	≤ 0.05
T x S	≤ 0.05	≤ 0.05	0.78
P x S x T	≤ 0.05	≤ 0.05	≤ 0.05

Biochemical parameters

Table 2. Analysis of variance (ANOVA) showing the effect of provenance, observation time, and drought stress and their interaction (ANOVA) on the biochemical parameters studied in the four contrasting provenances of the *A. spinosa* (Berkane, Essaouira, Agadir, and Bouizakarne).

	Proline content	Sugars content	Proteins content
Berkane (Brk)	32.41b	103.29a	214.37b
Essaouira (Ess)	28.76c	97.89ab	266.61a
Agadir (Agd)	42.42a	96.43c	229.89b
Bouizakarne (Bzk)	34.05b	101.44ab	273.25a
ANOVA ($p \leq 0.05$)			
Provenance (P)	≤ 0.05	≤ 0.05	≤ 0.05
Observation time (T)	≤ 0.05	≤ 0.05	≤ 0.05
Stress (S)	≤ 0.05	≤ 0.05	≤ 0.05
P x S	≤ 0.05	≤ 0.05	0.74
P x T	≤ 0.05	≤ 0.05	≤ 0.05
T x S	≤ 0.05	≤ 0.05	≤ 0.05
P x S x T	≤ 0.05	≤ 0.05	≤ 0.05

The results obtained revealed significant differences depending on the Water Treatment, Time and Provenance factors for all the physiological and biochemical parameters studied.

The cessation of irrigation during the experimental period significantly reduced the leaf relative water content (RWC) as well as the basic and minimal foliar water potential in the stressed Argane plants compared to the control in the four provenances (Table 1). Bouizakarne revealed the most marked decrease in RWC, while Berkane and Agadir showed the strong decrease in Ψ_m compared to the other provenances. The decrease in RWC and water potential by reaching very negative values in the Argane tree under drought stress conditions has been reported in different argane provenances (El Aboudi et al., 1991; Chakhchar et al., 2018; 2019).

Nonetheless, stopping irrigation induced a significant accumulation of proline, total proteins, and total soluble sugars in argane stressed plants compared to the control (Table 2). The marked accumulation of osmolytes (proline and total sugars) in the leaves of the argane tree under water stress conditions has also been reported by Chakhchar et al., (2018). These osmolytes are considered as one of the adaptive strategies triggered by the plant in the face of environmental constraints. Agadir and Berkane respectively showed the strong accumulation in proline and total sugars, compared to the other provenances.

Provenance x water stress x time interaction was significant for all physiological and biochemical parameters studied (Tables 1 and 2)

4. Conclusion

The present study highlighted the inter-provenance variation in the adaptation mechanism of Argane tree to drought stress. The four contrasting provenances of Argane tree showed, under drought conditions, a significant decrease in water potential, as a strategy of water conservation, as well as a significant accumulation of certain osmolytes related to osmoregulation and homeostasis maintenance. These physiological and biochemical responses varied significantly according the provenance of the Argane.

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