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in

Porqueddu C. (ed.), Ríos S. (ed.).
The contributions of grasslands to the conservation of Mediterranean biodiversity

Zaragoza : CIHEAM / CIBIO / FAO / SEEP
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 92

2010
pages 139-143

Phenology, biomass partioning and gas exchange in droughted and irrigated seedling of two pastoral species: *Artemisia herba alba* and *Lotus creticus*

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Abstract. To study the response to drought by soils of two pastoral species *Artemisia herba alba* and *Lotus creticus* in the south of Tunisia, a pot experiment was conducted by comparing the eco-physiological characteristics of plants growing the thee water modes: 100%, 70% and 30% of field capacity. Physio-ecological indexes indicating stress level of plants such as phenology, root to shoot ratio, and photosynthetic parameters were assayed. The results show that water deficit affects the parameters studied and there is a difference between *Artemisia herba alba* and *Lotus creticus*. At the physiological level, assimilation rate "A" (µmol/m^2/s) is significantly affected (P<0.01) by water deficit for *Lotus creticus*. For *Artemisia herba alba*, the assimilation rate in favorable conditions and under water deficit are comparable. In this work, the difference in assimilation rate "A" between these species as a response to water stress could be attributed to differences in stomatal limitations to photosynthesis. This behaviour of *Artemisia herba alba* justifies the faculty of plants to maintain their growth even in very hard dry conditions. Thus, we can conclude that *Artemisia herba alba* is more tolerant than *Lotus creticus*.

Keywords. Arid areas – Photosynthesis – Phenology – Drought.

***Phénologie, répartition de la biomasse et échanges gazeux des plantules irriguées et stressées de deux espèces pastorales :* Artemisia herba alba *et* Lotus creticus**

Résumé. *Dans le but d'étudier la réponse de deux espèces pastorales du sud tunisien,* Artemisia herba alba *et* Lotus creticus*, à la sécheresse, une expérimentation en pot a été conduite en comparant les caractéristiques éco-physiologiques des plantes soumises à trois régimes hydriques : 100%, 70% et 30% de la capacité aux champs. Des index physio-écologiques indiquant l'effet du stress sur la plante tels que la phénologie, le rapport partie racinaire/partie aérienne et des paramètres photosynthétiques, ont été étudiés. Les résultats montrent que le déficit hydrique affecte les paramètres étudiés et il existe une différence entre* Artemisia herba alba *et* Lotus creticus*. Au niveau physiologique, le taux d'assimilation "A" (µmol/m^2/s) est affecté significativement (P<0,01) par le déficit hydrique pour* Lotus creticus*. Chez* Artemisia herba alba*, les taux d'assimilation dans les conditions favorables et stressées sont comparables.*

Mots-clés. *Zones arides – Photosynthèse – Phénologie – Sécheresse.*

I – Introduction

Desertification in the Mediterranean region is mainly due to vegetation cover reduction and soil erosion (Kosmas *et al.*, 2000). Mediterranean climate is characterized by hot, dry summers and cool, cold winters, which limits the use of different species for soil revegetation (Savé *et al*., 1999). Therefore, the use of native species for revegetation may be an interesting practice especially in those countries with dry climatic conditions (Sánchez-Blanco *et al.*, 1998). In this paper, we aimed to study the impact of water stress on phenology, biomass partioning and gas exchange of two pastoral species *Artemisia herba alba* and *Lotus creticus*.

II – Materials and methods

The seeds were sown on five Mai 2005 in pots (5 kg) at a rate of four seeds per pot. With ten replicates per treatment. To highlight the potentialities of adaptation of *Artemisia herba alba* and *Lotus creticus* to drought, a water constraint was induced by the application of three levels of water stress (using the method of the field capacity (F.C)). Three regimes were applied: (i) ideal (100% F.C); (ii) moderate stress (70% F.C); and (iiii) severe stress (30% F.C). The phenology is consists on the determination of the biological stages reached by the maximum of plants for each treatment. The gas exchange was measured on the well developed flag leaf of the stressed plants and of the control by using the portable photosynthesis system LCi. attached with an infrared gas analyser (IRGA; ADC Bioscientific Ltd.) and a recorder of data. The gas exchanges were determined only during the vegetative phase. At the end of the experiment, shoots and roots were dried at 80°C to a constant weight and weighed. The measured parameters were subjected to an analysis by Duncan's test using Stastical package SPSS version 12.0. The confidence interval was calculated at the threshold of 95%.

III – Results and discussions

1. Phenology

Under ideal treatment and moderate stress, *Artemisia herba alba* spends eight months in the vegetative growth. It begins on the month of August and lasts until March. However, this phase begins after two months during the regime of severe stress compared to the other two treatments. The reproductive stage starts early (November) under ideal conditions compared to the two other regimes. In all three regimes, seed maturation occurred in the month of February. On the other hand, the active vegetative phase lasts almost the entire life cycle when the conditions are ideal for *Lotus creticus*. Under moderate stress, the fructification and dissemination are absent. In severe stress, the reproductive phase is totally absent (Fig. 1). *Lotus creticus* chose survival over reproduction. The results agree with those of (Chaieb, 1989). In *Artemisia herba alba*, the reproductive phase begins early under ideal conditions compared to the two other treatments. This result agree with those of Monroy-Ata (1989) which indicates that water availability alter significantly the pattern of resource allocation to reproduction in *Artemisia herba alba* that allow a greater reproductive effort. Under severe stress, *Lotus creticus* does not reach the reproductive phase, very expensive energy. This event was reported by Osorio-Barahona (1989) for *Flourensia thurifera*.

2. Gas exchange

Under ideal treatment, the photosynthetic rate and stomatal conductance were maximum (Table 1). Between both species, *Lotus creticus* showed a lower level of (A, photosintetic rate) and (gs, stomatal conductance). A higher level of this gas exchange parameters occurred in *Artemisia herba alba.* Moderate and severe stress decreased (A) and (gs) in both species when compared to control. However, this reduction is more significant for *Lotus creticus* than for *Artemisia herba alba*. In fact, beyond Ideal treatment, (A) and (gs) decreased considerably with the increase of the water deficit level. In the opposite, *Artemisia herba alba* is indifferent towards water treatment as photosynthetic activity maintains comparable values to those of ideal treatment. It shows a low reduction of stomatal conductance not confirmed by Duncan's test (Table 1).

Duncan's test show that *Artemisia herba alba* keeps a normal photosynthetic active even when water is scace. On the contrary, *Lotus creticus* is most sensitive. In response to water deficit, *Lotus creticus* closes its stomata; this is detected by the decreasing of the values of (gs). Moderate and severe water deficit influence notably the response of the stomata. It is probable that when the availability of water in the ground is low, the recovery of the plants will be slow down. This depends on the possibilities of exploration of the horizons of the ground by the roots in conditions of water deficit (Belalcazar *et al.*, 1991). *Lotus creticus* shows a conservative strategy in the use of water based mainly in the avoidance of drought stress reducing the transpiration rate, that is, reducing the stomatal conductance as it was observed in water stressed plants (Table 2). This strategy ensures a good regulation of gas exchange to arid conditions. This result is confirmed also for *Dactylis glomerata* (Jaballah *et al.*, 2007). The movement of the stomata is controlled by a hormonal message which arrives from the roots (Farquhar *et al*., 1989) which is acid abscisic ABA (Wilkinson and Davies, 2002). The reduction of the stomatal conductance is not the major cause of the reduction of photosynthesis, and the effect of the drought on photosynthesis is also allotted for non stomatic purposes like the inhibition of the activity of the mesophyll (Kirkham, 1990).

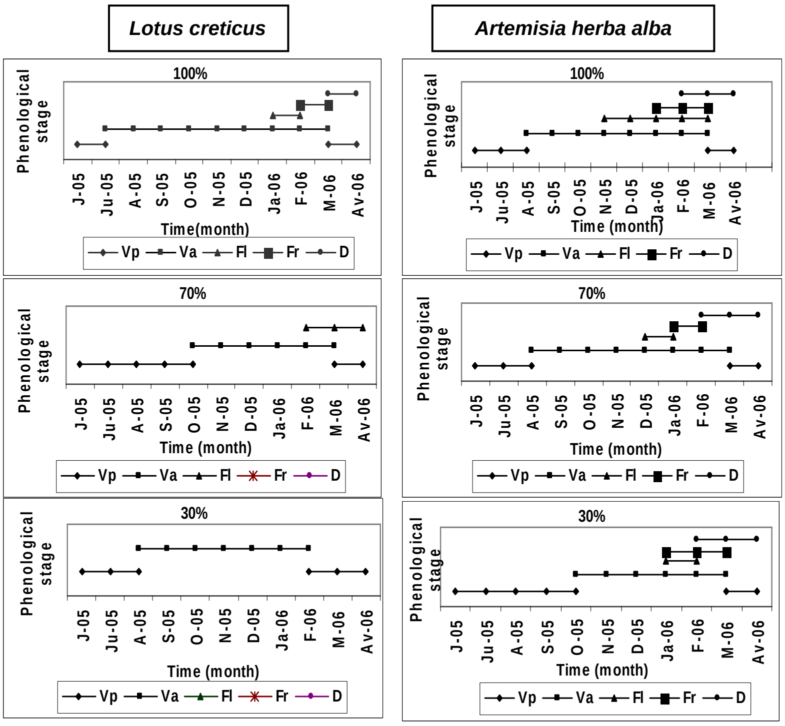

Fig. 1. Biological cycle of *Artemisia herba alba* and *Lotus creticus* (Vp: passive phase; Va: active phase; Fl: flowering; Fr: fructification; D: dissemination).

Table 1. Changes in photosynthetic rate (A) and stomatal conductance (gs) in *Lotus creticus* and *Artemisia herba alba* in response to drought stress

Species	Parameters	Water treatment (field capacity)		
		100%	70%	30%
Lotus creticus	A (μmol $m^{-2}s^{-1}$)	11.53^a	7.91^b	5.39^b
	gs (mol $m^{-2}s^{-1}$)	0.16^a	0.08^b	0.04^b
Artemisia herba alba	A (μmol $m^{-2}s^{-1}$)	16.03^a	15.28^a	15.2^a
	gs (mol $m^{-2}s^{-1}$)	0.38^b	0.36^b	0.33^b

Values that are not sharing a common superscript (a, b) differ significantly at p<0.05.

Table 2. Effect of water stress on root to shoot ratio (R/S) for *Artemisia herba alba* and *Lotus creticus*

Species	Water treatment (field capacity)		
	100%	70%	30%
Artemisia herba alba	0.630[a]	0.603[a]	0.790[b]
Lotus creticus	0.293[a]	0.443[b]	0.663[c]

Values that are not sharing a common superscript (a, b, c) differ significantly (Duncan's test at $\alpha = 0.05$).

3. Biomass partitioning

Table 2 shows that the ratio R/S of *Artemisia herba alba* is affected significantly by severe water deficit. These results are verified through Duncan's test. In *Lotus creticus*, the results showed that the elevation of the level of water stress deficit induces an increase in the ratio R/S. Thus, the highest ratio was observed in plants subjected to severe water deficit. The water deficit is reflected in resource allocation to roots. In fact, these ratios are 0.293, 0.443 and 0.663 respectively under ideal conditions, moderate stress and severe stress. These results are confirmed by the Duncan's test (Table 2). The ratios obtained for all species varied from 0.3 to 0.8. These results agree well with those conducted in certain arid regions. Thus, Chaieb (1989) found for *Digitaria nodosa*, *Stipa lagascae*, *Plantago albicans* and *Argyrolobium uniflorum* a ratio between 0.3 and 0.9.

IV – Conclusions

The two studied species showed a high resistance under water deficit. Gas exchange is relatively insensitive for *Artemisia herba alba.* However, the effect of water stress is highly significant on assimilation rate by reduction of the stomatal conductance for *Lotus creticus*. This strategy ensures a good regulation of the gas exchange under arid conditions.

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