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in

Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.).
New approaches for grassland research in a context of climate and socio-economic changes

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 102

2012
pages 461-464

The hydrodynamic relationships of two herbaceous species in a grazed *Morus alba* L. silvopastoral system

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Abstract. In most Mediterranean areas water is one of the major determinants of plant growth. The water relations of herbaceous species was studied in a *Morus alba* L. silvopastoral system under moderate grazing. The experimental area was divided into six fenced plots in order to exclude uncontrolled grazing. Three of them were randomly assigned to be grazed (0.9 sheep/ha/year) while the other three remained ungrazed. Half of every plot was ploughed and seeded with *Trifolium subterraneum* cv Mt. Barker while the other half remained with the natural herbaceous vegetation. The water potential (Ψ) and relative water content (RWC) of *T. subterraneum* and of the dominant native grass *Poa bulbosa* were measured. Although grazing does not modify the internal water status of *T. subterraneum* and *P. bulbosa*, both species seem to have the ability to control their water balance probably by pathetic regulation of osmosis.

Keywords. Water potential – Relative water content – *Trifolium subterraneum* – *Poa bulbosa*.

Les relations hydrodynamiques de deux espèces herbacées dans un système sylvopastoral de* Morus alba *pâturé

Résumé. *Dans la région méditerranéenne, l'eau est une des déterminants majeurs de la croissance des plantes. Les paramètres hydriques de la végétation du sous-étage herbacée ont été études dans un système sylvopastoral de* Morus alba *L. sous pâturage modéré. La surface expérimentale a été séparée dans six parcelles clôturées afin d'exclure le pâturage non contrôlé. Trois d'entre elles ont été aléatoirement assignés pour être pâturées tandis que les autres trois restaient non pâturées. Dans toutes les parcelles de terrain* Morus alba *a été planté. La moitié de chaque parcelle de terrain a été labourée et semée avec* Trifolium subterraneum *L. cv. Mt. Barker tandis que l'autre moitié demeurait avec la végétation herbacée naturelle. Le potentiel hydrique (Ψ) et la teneur en eau relative (RWC) du* Trifolium subterraneum *et* Poa bulbosa *L. ont été mesurés. Les résultats ont prouvé que le pâturage ne modifie pas le statut hydrique de* T. subterraneum *et* P. bulbosa*. Cependant, ces deux espèces semblent avoir la capacité de régler leur balance hydrique probablement par règlement pathétique de l' osmose.*

Mots-clés. *Potentiel hydrique – Teneur en eau relative –* Trifolium subterraneum *–* Poa bulbosa.

I – Introduction

The analysis of hydrodynamic relationships at leaf level provides preponderant information for understanding the water economy of plant vegetation (Larcher 1980, Schopfer 1995). One of the best indicators of water balance is the changes of Ψ and RWC (Kramer 1983, Nobel 1991). These elements are crucial especially for the arid and semiarid areas where water availability is the most limiting factor for plant growth (Karatassiou *et al*., 2009). Plants in such environments have developed drought adaptation mechanisms to avoid or tolerate water stress by modifying their morphological and physiological characteristics (Arndt *et al.,* 2001, Gurevich *et al.,* 2006). Establishing a silvopastoral system in degraded Mediterranean semiarid grassland, to fill up the feed gap of the grazing animals during summer (Ainalis and Tsiouvaras 1998), should take into consideration the drought tolerance of C_3 perennial species (Sklavou *et al*., 2011). However, there is limited information regarding drought tolerance and the water relations of herbaceous species in *Morus alba* L. silvopastoral systems.

The aim of this paper was to investigate the water relations and the ecophysiological mechanisms of *Trifolium subterraneum* (seeded) and *Poa bulbosa* (natural) grown in a *Morus alba* silvopastoral system under moderate sheep grazing.

II – Materials and methods

The experiment was conducted at a low altitude Mediterranean grassland in Northern Greece. The experimental area (40^{o}41' north latitude, 23^{o}14' east longitude) was located 45 km east of Thessaloniki, at Scholari village, at an altitude of 100 m. a.s.l. The climate of the area according to the bioclimatogram of Emberger (1942) could be characterized as Mediterranean semiarid with cold winters. The mean annual precipitation is 454.5 mm and the mean annual temperature is 15.7^{o}C (Sklavou, 2002).

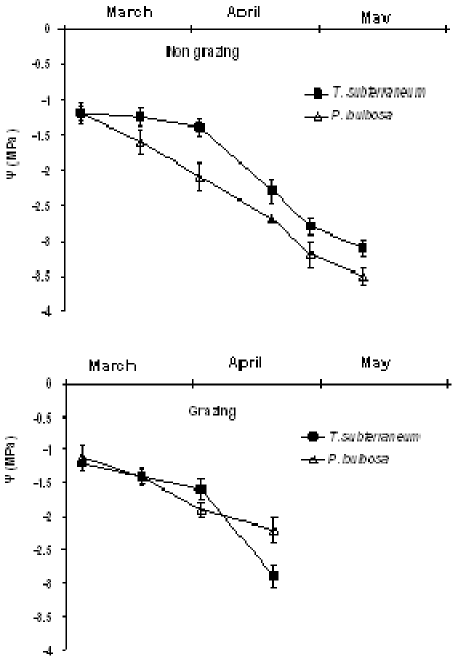
The experimental area was separated into six plots (0.141 ha each plot), which were fenced in order to control the grazing. Three of the plots were randomly assigned to be grazed by sheep at a stocking rate of 0.9 sheep/ha/year while the other three remained ungrazed (control). In all plots *Morus alba* was planted. Half of every plot was ploughed and seeded with *Trifolium subterraneum* cv. Mt. Barker (*T. subterraneum)* while the other half remained with the natural herbaceous vegetation. Leaf water potential (Ψ) and relative water content (RWC) were measured in *Trifolium subterraneum* and in the dominant native grass *Poa bulbosa* L. (*P. bulbosa*)

The measurements during the experimental period were obtained on clear sunny days at midday every 15 days. All measurements were obtained on a sample of four mature and intact, fully expanded, upper leaves in both grazed and non grazed plots. Leaf water potential (Ψ) was obtained with the pressure chamber technique (Koide *et al.*, 1991). Relative water content (RWC) was determined on 4 mm discs from leaves similar in age and orientation, and from the same plant to those used for the Ψ determination, according to the procedure described in Iannucci *et al.* (2002).

General linear model procedure of the SPSS statistical software v. 17.0 (SPSS, Chicago, IL, USA) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980). Non-linear regressions of varying Ψ in respect to RWC were fitted per species and grazing treatment using a quadratic function at $p<0.05$.

III – Results and discussion

Seasonal changes of Ψ, in the non grazing treatment were significantly different between *T. subterraneum* and *P. bulbosa* (Fig. 1). So, on the same date during the growing season Ψ was higher in *T. subterraneum* in relation to *P. bulbosa*. Therefore, *T. subterraneum* seems to have the ability to maintain internal water balance (Karatassiou *et al.*, 2009). Nevertheless, seasonal changes of RWC between *T. subterraneum* and *P. bulbosa* were rather similar except for the period from middle March to the end of April (Fig. 2). During this period the VPD (Vapor pressure deficit) was relatively low (1.3 kPa) and seems to be related with higher RWC values in *T. subterraneum* compared to *P. bulbosa* (Medrano *et al.*, 2002, Karatassiou *et al.*, 2009). In the grazing treatment, seasonal changes of Ψ in the two species were similar for most part of the growing season. It seems that grazing tends to diminish the hydrodynamic differences between *T. subterraneum* and *P. bulbosa*. Seasonal changes of Ψ for the two species differentiated in middle April, with higher values recorded in *P. bulbosa* compared to *T. subterraneum*. Seasonal changes of RWC in the grazing treatment were proportional, showing that RWC was different between the two species after middle April, which was expected from the corresponding difference of Ψ. Also, fluctuation of Ψ in relation to RWC (Fig. 3) in the two treatments (non grazing, grazing) was similar for the two species. Thus, assuming that the water use is an important factor for herbaceous production the *T. subterraneum* introduction to silvopastoral system can efficiently work.



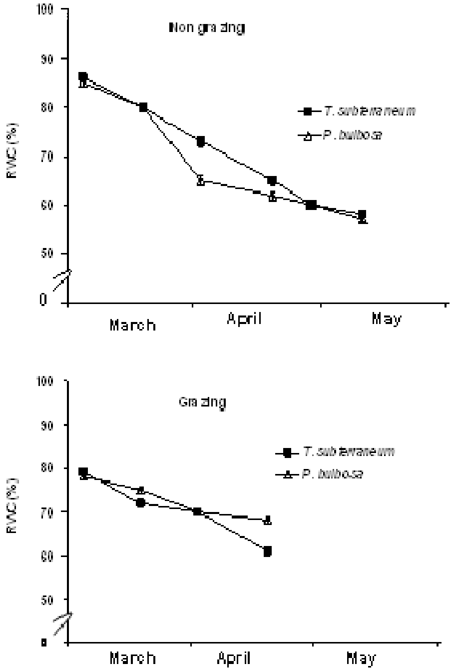


Fig. 1. Seasonal changes of water potential (Ψ) in *T. subterraneum* and *P. bulbosa* at non grazing and grazing treatment. Values present means ± SE of four replicates per species.

Fig. 2. Seasonal changes of relative water content (RWC) in *T. subterraneum* and *P. bulbosa* at non grazing and grazing treatment. Values present means ± SE of four replicates per species.

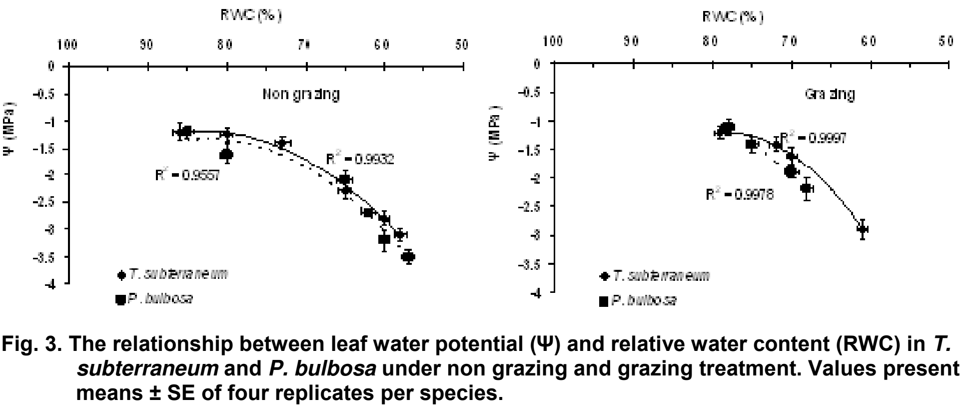


Fig. 3. The relationship between leaf water potential (Ψ) and relative water content (RWC) in *T. subterraneum* and *P. bulbosa* under non grazing and grazing treatment. Values present means ± SE of four replicates per species.

IV – Conclusions

These results suggest that *T. subterraneum* establishment can be implemented in such silvopastoral system, since the differences observed at the two species are not so much considerable. The fact indicates that the two species use water resource at different soil deep. Additionally the slow decrease of Ψ in respect to RWC in both treatments makes us think about a pathetical regulation of osmosis.

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