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The water relations of two perennial grasses in a Mediterranean grassland

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Abstract. The Mediterranean zone is frequently prone to extended periods of drought, especially during the summer. Thus, water is a restrictive factor that affects the growth and the productivity of Mediterranean grass species. The aim of this study was to investigate the water relations of two perennial grasses, *Phalaris aquatica* and *Dactylis glomerata*, which are common in Mediterranean grasslands. The experiment was conducted during the growing season in a low elevation grassland in Northern Greece. The midday leaf water potential (Ψ) was measured while the leaf Relative Water Content (RWC) and the Relative Drought Index (RDI) were estimated. Different responses under water deficit conditions were evident between the two species. *P. aquatica* presented higher drought tolerance and completed its biological cycle later than *D. glomerata* under water deficit conditions. In the last phenological stages, *P. aquatica* exhibited higher values of Ψ and RWC but lower values of RDI in relation to *D. glomerata*. As it was expected, the two species presented different critical threshold points. Our results showed that, *P. aquatica* is more adapted to arid or semi-arid conditions of the low elevation Mediterranean grasslands. *P. aquatica* seems to display mechanisms that enable continue growth and giving high forage production under xeric conditions.

Keywords. Water potential – Relative Water Content – Relative Drought Index – Tolerance.

Les relations hydriques de deux graminées pérennes dans une prairie méditerranéenne

Résumé. *La zone méditerranéenne est fréquemment sujette à des périodes étendues de sécheresse, en particulier au cours de l'été. Ainsi, l'eau est un facteur restrictif de la croissance et de la productivité des espèces de graminées méditerranéennes. L'objectif était d'étudier les relations hydriques de deux graminées pérennes,* Phalaris aquatica *et* Dactylis glomerata*, très communes des prairies méditerranéennes. L'expérimentation a été réalisée au cours de la saison de croissance dans une prairie de plaine au nord de la Grèce. Le potentiel hydrique des feuilles (Ψ) a été mesuré à midi, la teneur en eau relative des feuilles (RWC) et l'indicateur relatif de sécheresse (RDI) ont été estimés. Des réponses différentes ont été mises en évidence entre les deux espèces sous des conditions de déficit hydrique. La tolérance à la sécheresse de* P. aquatica *a été meilleure que celle de* D. glomerata*. À la fin de la période de croissance,* P. aquatica *a présenté des valeurs Ψ et RWC plus élevées, mais les valeurs RDI étaient plus basses par rapport à celles de* D. glomerata*. Simultanément, comme attendu, les deux espèces ont présenté différents seuils de réponse. Il semble que l'espèce* P. aquatica *est plus adaptée aux conditions arides ou semi-arides des prairies méditerranéennes de plaine. Probablement,* P. aquatica *développe des mécanismes qui permettent son développement constant et une production de fourrage accrue en conditions de déficit hydrique*.

Mots-clés. *Potentiel hydrique – Teneur en eau relative – Indicateur relatif de sécheresse – Tolérance.*

I – Introduction

Water availability is the most essential factor that affects the growth and the productivity of Mediterranean rangelands. Thus, water deficit unsettles plant physiological processes which may have a decisive influence on the capacity of forage plant production (Rodriguez-Iturbe and Porporato, 2004). This can be better explained by the gradual increase in the average air tempera-

ture and the substantial drop in the intensity of annual rainfall, especially during summer, that is predicted to be continued even after years to come across Europe and particularly in regions of the Mediterranean zone (IPCC, 2013).

The maintenance of favourable internal water status and plant functions at low leaf water potential is the main physiological process that contributes to the maintenance of high production under drought periods (Blum, 1996). The intensity of water shortage may cause instability in the internal water balance and variations in plant growing cycles (Volaire *et al*., 2009). Several physiological and/or morphological mechanisms can be expressed by plants in order to withstand drought conditions (Gurevitch *et al*., 2006; Blum, 2011). These responses may vary among species even belonging to the same growth and/or life form or genus (Volaire *et al*., 2001; Blum, 2011; Karatassiou *et al*., 2010). Therefore, determining the most tolerant species under the prevalence of xeric conditions is obligatory, in order to improve forage plant productivity towards preventing range desertification.

The aim of the current study was to investigate the water relations at leaf level of two common perennial grasses, under moderate drought conditions, in a low elevation Mediterranean grassland.

II – Materials and methods

The experiment was carried out in the farm of the Aristotle University of Thessaloniki, Northern Greece (longitude: 40º31'91'', latitude: 22º59'58''), 6m a.s.l. The climate of the area is characterized as Mediterranean semi-arid with cold winters. The monthly average precipitation (mm) and the minimum temperature (ºC) during the experimental period ranged from approximately 17.2 to 55.6 mm and from 9.6 to 24.1ºC respectively.

Measurements were taken in two perennial grass species: *Phalaris aquatica* L. and *Dactylis glomerata* L. These species are widespread in grasslands of the low zone of Northern Greece and their contribution to the grassland production is essential. All measurements were taken during the growing season (April-June), in approximately 10-day intervals, on clear sunny days at solar noon (12:00-14:00h) on five mature and intact fully expanded upper leaves per species. The Vapor Pressure Deficit (VPD) was evaluated by five replicates that have been taken over the canopy with a portable thermohygrometer (Novasina ms1, Novasina AG, CH) on the same date and time that the plant physiological parameters were measured (Fig. 1). Leaf water potential (Ψ) was measured using the pressure chamber technique (Koide *et al*., 1991) while the leaf Relative Water Content (RWC) and the Relative Drought Index (RDI) were estimated. 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, following Iannucci *et al.* (2002) and Blum (2011). Meanwhile, leaf RDI was calculated as the ratio of actual leaf water saturation deficit (WSD_{act}=100-RWC) to the critical water saturation deficit (WSD_{crit}=45%): RDI=WSD_{act} / WSD_{crit} (Larcher, 2003).

To determine differences in the responses of the two species during the growing season we performed a two way analysis of variance (ANOVA) on all parameters studied (Steel and Torrie, 1980). T-test was used to compare two means. All statistical analyses were performed using the SPSS statistical package v. 20.0 (SPSS Inc., Chicago, IL, USA).

III – Results and discussion

The seasonal changes of Ψ showed differences between the two species (Fig. 2). *P. aquatica* maintained higher Ψ compared to *D. glomerata* except for the period from end March to the middle of April and probably better internal water balance. This assumption is supported by the seasonal patterns of RWC and RDI (Fig. 3, 4). *P. aquatica* presented significantly ($P<0.05$) higher

RWC in relation to *D. glomerata* from the most part of the growing season (Fig. 3). In the first phenological stages, under no water deficit conditions, both species presented the same high value of Ψ but different RWC (Fig. 2, 3). Nevertheless, from late May up to the end, under water deficit conditions, *P. aquatica* maintained higher values of Ψ and RWC than *D. glomerata*. During the growing season, RWC and Ψ showed in both species a constant declining trend against the increased values of VPD (Fig. 1) and temperature (Prenger and Ling, 2006). It seems that the gradual increase of VPD from 3.3 to 4.1 KPa over the canopy, during mid to late phenological stages (May-June), induced different ecophysiological responses in plants (Volaire *et al.,* 2009).

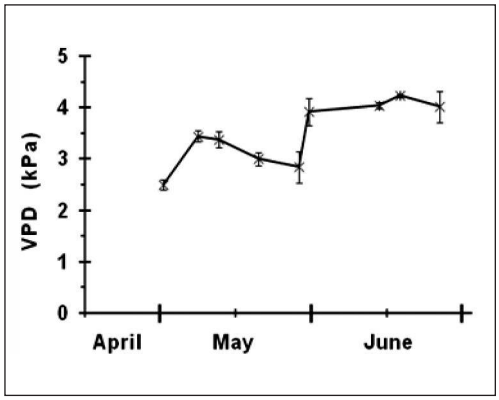

Fig. 1. Midday Vapor Pressure Deficit (VPD) during the experimental period. Values presented means ± SE.

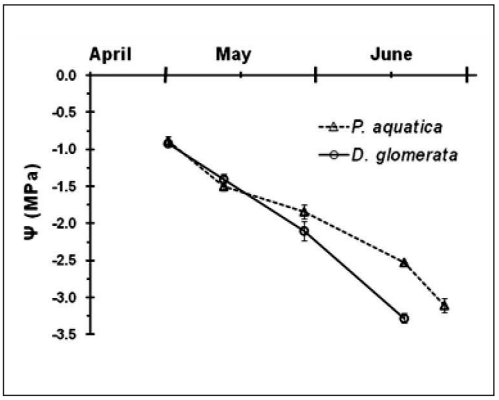

Fig. 2. Seasonal patterns of leaf water potential (Ψ) in two perennial grasses. Values presented means ± SE.

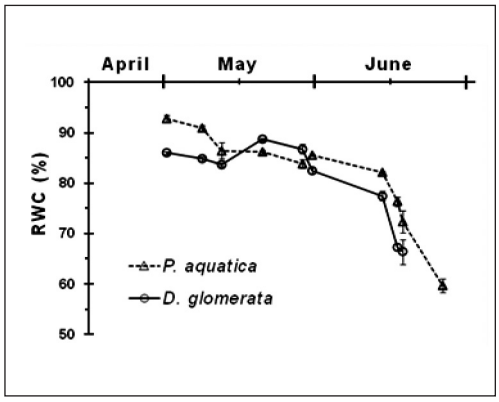

Fig. 3. Seasonal patterns of leaf Relative Water Content (RWC) in two peren-nial grasses. Values presented means ± SE.

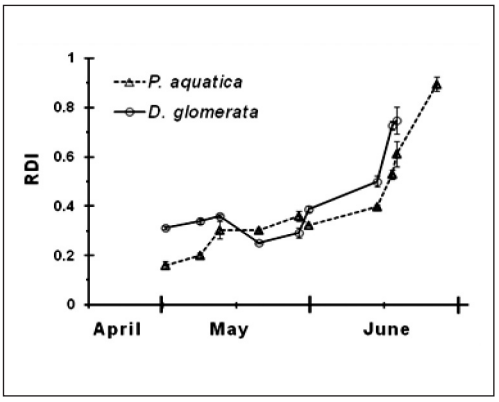

Fig. 4. Seasonal patterns of leaf Relative Drought Index (RDI) during the expe-rimental period. Values presented means ± SE.

The critical threshold point (CTP) accounts for early termination of growth and plant desiccation and is defined as the value of RWC below which turgid is lost (Larcher, 2003; De Diego *et al.,* 2013). As it was expected, the CTP was different between the two species (Fig. 3). *D. glomerata* was desiccated earlier (middle of June) than *P. aquatica* (end of June) in a value of CTP 66.4%

and 59.6% respectively. The hydrodynamic differences between the two species are also obvious from the changes of RDI thoughout the growing season (Fig. 4). Under the same environmental conditions, *P. aquatica* presented lower values of RDI in relation to *D. glomerata* and, therefore higher resistance to water deficit conditions (Larcher, 2003).

Consequently, the favourable inernal water balance of *P. aquatica* compared to that of *D. glomerata*, probably implies a higher photosynthetic capacity probably because of efficient regulation of the stomatal apparatus and/or osmotic adjustments or morphological chara-cteristics (e.g. bulbs) (Volaire *et al.,* 2001; Chaves *et al.,* 2003). Similar results have been obtained by Karatassiou and colleagues (2012) who have also demonstrated high productivity and growth of *P. aquatica* under water deficit conditions. On the other hand, *D. glomerata* higher sensitivity under drought conditions, which may be related either to its inability to maintain cell turgor under low Ψ and relative high vapor deficit conditions or to reduce transpiration losses and/or to absorb larger amounts of water (Jones, 1992; Blum, 2011).

IV – Conclusions

Our results demonstrate that perennial grasses express differential capacity to regulate the internal water balance under water deficit conditions in the low elevation Mediterranean grasslands. It seems that P. aquatica exhibits lower sensitivity to desiccation than *D. glomerata*. Hence, *P. aquatica* should be considered as a suitable species for semi-arid pastures.

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