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Ecophysiological responses of perennial grasses *Stipa lagascae* and *Dactylis glomerata* under soil water deficit

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SUMMARY – Perennial herbaceous plants represent one of the most interesting resources but their persistence depends on their ability to cope with acute drought. Survival of plants under extreme conditions must therefore be studied to understand the strategies and mechanisms of perennial grasses from arid areas. The aim of the present study was to compare the adaptive responses of both species *Stipa lagascae* (cultivar Roemer and Schultz) and *Dactylis glomerata* (*cultivar* Kasbah). We analysed the impact of water deficit on phenology and growth through some physiological traits. We were particularly interested in the study of the assimilation rate "A" (µmol/m^2/s) and the stomatal conductance "gs" (mol/ m^2/s). The results show that water deficit affects the biological cycle and that there is a difference between species. At the physiological level, assimilation rate "A" (µmol/m^2/s) is significantly affected (P<0.01) by water deficit for *Dactylis glomerata*. For *Stipa lagascae*, the assimilation rates in favourable conditions and under water deficit are comparable.

Keywords: Pastoral species, *Stipa lagascae*, *Dactylis glomerata*, arid areas, phenology, photosynthesis.

RESUME – *"Réponses écophysiologiques des herbacées pérennes* Stipa lagascae *et* Dactylis glomerata *en conditions de déficit hydrique du sol". Les plantes herbacées pérennes représentent l'une des plus importantes ressources mais leur persistance dépend de leur aptitude à supporter un déficit hydrique sévère. Il est ainsi nécessaire d'étudier la survie des plantes dans des conditions extrêmes pour comprendre les stratégies et les mécanismes des herbacées pérennes des zones arides. L'objectif du présent travail est de comparer les réponses adaptatives de deux espèces* Stipa lagascae *(cultivar Roemer and Schultz) et* Dactylis glomerata *(cultivar Kasbah). Nous analysons l'effet du déficit hydrique sur la phénologie et la croissance à travers les caractères physiologiques. On s'est intéressé en particulier à l'étude du taux d'assimilation "A" (µmol/m^2/s) et de la conductance stomatique "gs" (mol/ m^2/s). Les résultats montrent que le déficit hydrique affecte le cycle biologique et qu'il existe une différence entre les deux espèces. Au niveau physiologique, le taux d'assimilation "A" (µmol/m^2/s) est significativement affecté (P<0,01) par le déficit hydrique chez* Dactylis glomerata*. Chez* Stipa lagascae*, les taux d'assimilation en conditions favorables et en déficit hydrique sont comparables.*

Mots-clés : *Espèce pastorale,* Stipa lagascae*,* Dactylis glomerata*, régions arides, phénologie, photosynthèse.*

Introduction

Drought is a widespread environmental condition leading to low water availability for plants. This constraint is considered the main environmental factor limiting photosynthesis and consequently plant growth.

The pastoral flora, characterized by an important specific and intraspecific diversity, constitutes more than 80% of livestock forage requirements (Boussaid *et al*., 2004).

The desired pastoral species should have a high productivity, a good digestibility and palatability to remain favored by animals (Hogh-Jensen *et al.*, 2006). The well searched plant species are those, which have a high productivity spread on a long period of time in the year. The primary production of ecosystems is affected by an array of interacting factors (Floret *et al*., 1982; Talamucci and Pardini, 1999). Overgrazing, rainfall deficit and soil fertility decrease are the major constraints of species productivity (Floret *et al*., 1976; Bendali *et al*., 2001; Omer *et al*., 2006). Thus, conservation and utilization of genetic resources forage and grazing has become a necessity in order to refurbish and restore degraded and vulnerable ecosystems.

In this paper, we aimed to study the impact of water deficit on phenology and growth through some physiological traits of two perennial species *Stipa lagascea* and *Dactylis glomerata*.

Materials and methods

The experiment was initiated at IRA (Medenine) on January 2006. The species studied are *Stipa lagascae* with sufficient seeds of good germination rates and one cultivar cocksfoot cv. Kasbah, from Moroccan origin and bred in Australia. Through the experiment, two irrigation regimes simulating two types of year were considered: the first, normal year and the second, rainy year, in what from spring until the first autumn supplemental watering is required to ensure correct establishment. These two treatments are designed: (i) Ideal treatment: T1 with 180 mm of water per year and (ii) Observed treatment: T2 with 94 mm of water per year (Table 1).

Table1. The amounts of water supplied at each time to each treatment

Water supplied (mm)	January	February	March	April	May	June	July
Ideal treatment: T1 (180)	40	30	30	20	20	20	20
Observed treatment: T2 (94)	15	14	13	13	13	13	13

For each water regime four subplots were sown and each contained eight randomized plots. Every plot is divided by two lines.

Measurements

We study the effect of water stress on the growth of the two species through: (i) phenology: (determination of the biological stages reached by the maximum of plants for each treatment); (ii) physiological descriptors: throughout the experiment gas exchanges were measured on leaves for the two species using the portable infrared gas analyzer *LCi*. The assimilation rate "A" (µmol/m^2/s) and the stomatal conductance "gs" (mol/ m^2/s) were monitored. The gas exchanges were determined only during the vegetative phase and in young leaves, not fully deployed and senescing. The measurements were carried out on the 3 July 2006 between 10 h and 12 h in the morning under light saturating conditions and 30.5ºC of air temperature.

These parameters were measured on two plants for each line (in the middle) in a total of four measurements per plot (64 replicates).

Data analyses

The results obtained were analyzed through two methods: (i) graphic method that permits us to compare plants within the same species and between species of the relative position of every phenophase under two water regimes applied; and (ii) the statistic method: the analysis of variance was carried out using the SPSS programme.

Results and discussion

Effect of drought on biological cycle

A large variability between species was highlighted in response to water stress (Figs 1, 2). This diversity of phenological behaviour results in a shift more or less pronounced of their different phenophases over time depending on the species and water regime applied.

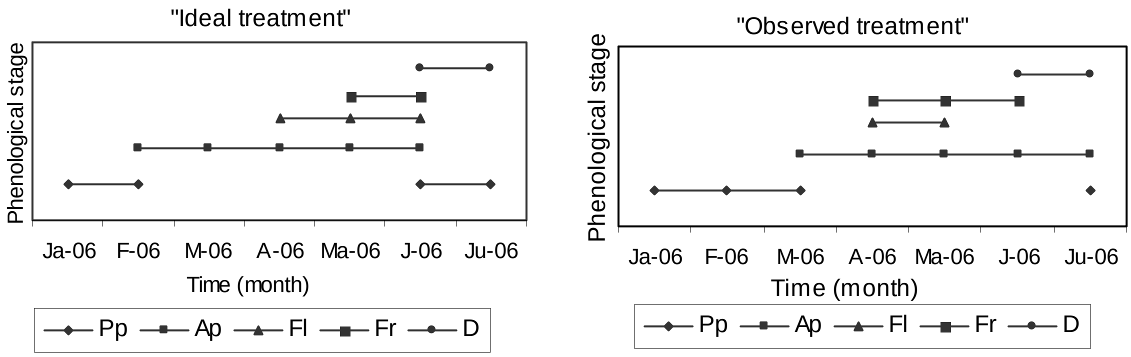

Fig. 1. Biological cycle of *Dactylis glomerata* (Pp: passive phase; Ap: active phase; Fl: flowering; Fr: fructification; D: dissemination).

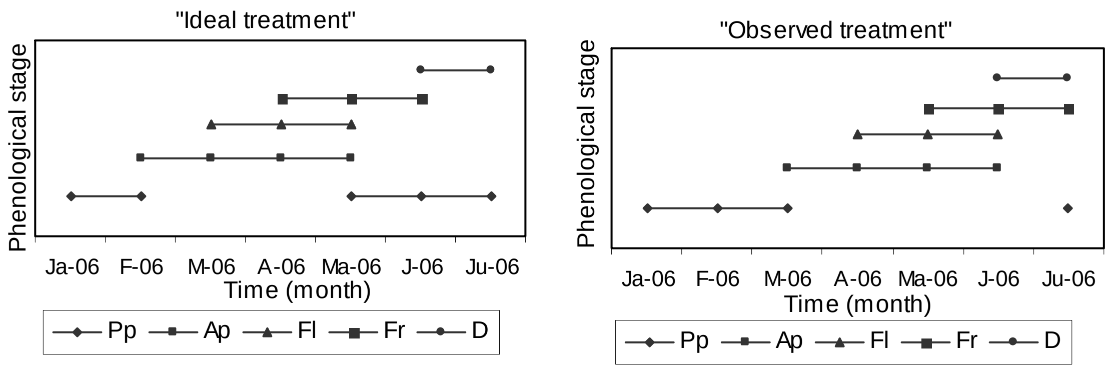

Fig. 2. Biological cycle of *Stipa lagascae* (Pp: passive phase; Ap: active phase; Fl: flowering; Fr: fructification; D: dissemination).

Under ideal treatment, *Dactylis glomerata* spends five months in the vegetative growth from February to June. Thus, under the water regime observed this phase starts one month after the ideal treatment. The reproductive phase (flowering and fructification) seems to be indifferent to the water scarcity. For *Stipa lagascae*, the vegetative phase is longer under limiting conditions than in favorable conditions. Under observed treatment, the reproductive phase starts one month after the ideal treatment. In favorable conditions, there is a difference between species. The active vegetative phase is longer for *Dactylis glomerata* than for *Stipa lagascae*. In addition, the reproductive phase is earlier for *Stipa lagascae* than for *Dactylis glomerata*. Under observed treatment, the reproductive phase is longer for *Stipa lagascae* than *Dactylis glomerata*.

The results agree with those of other authors (e.g Chaieb, 1989; Monroy-Ata, 1989; Neffati, 1994; Ferchichi, 1997; Jaballah, 2007) who showed that the life cycle of plants is very much related to environmental factors in particular rainfall.

Under water deficit (observed treatment), these two species complete their biological cycle. This result reflects their water stress resistance. Indeed, Chaieb (1989) reported the fact that *Plantago albicans* complete its cycle of reproduction under dry regime reflects the resistance of this taxon to drought and particularly its ability to extract water from the soil water potential below -16 bars.

Effect of drought on the assimilation rate "A" and stomatal conductance "gs"

Water deficit significantly affects assimilation rate "A" (µmol/m^2/s) (P<0.01) for *Dactylis glomerata*. This result is confirmed by Duncan's test. *Stipa lagascae* is indifferent towards water regime as photosynthetic activity maintains similar values to those obtained in favorable conditions. These results are confirmed by statistical analysis through Duncan's test (5%).

For the same regime, the differences of assimilation rate between species are significant (Duncan's test at 5 % level). In fact, *Stipa lagascae* (C3 plant) has higher assimilation rate than *Dactylis glomerata*.

Stomatal conductance is decreasing with the increasing of water deficit; this decrease can be significant or not according to the species (Fig. 3). In fact, *Dactylis glomerata* has a very sensible stomatal conductance to water deficit (the percentage of reduction is about 75.67%). On the other hand, *Stipa lagascae* shows a low reduction of stomatal conductance that is not confirmed by Duncan's test (the two-water regime are classified as a one group).

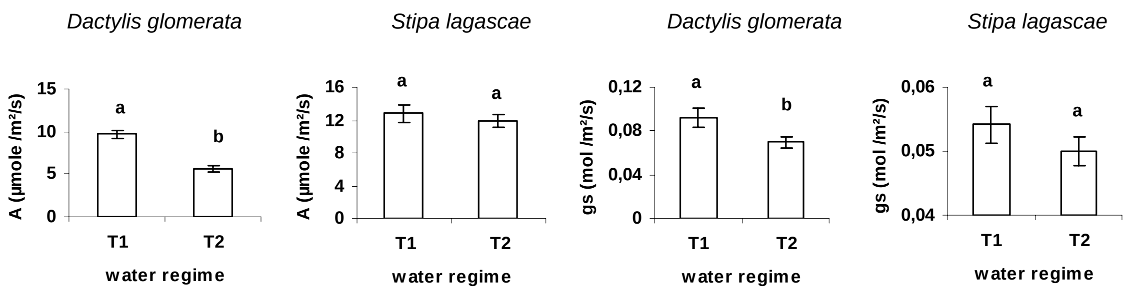

Fig. 3. Effect of water regime on CO_2 assimilation rate "A" (µmol/m^2/s) and stomatal conductance "gs" (mol/m^2/s) for leaves of *Dactylis glomerata* and *Stipa lagascae* (values represent the means of 64 replicate). Means with the same letter are not significantly different at $P<0.05$.

Therefore, *Dactylis glomerata*, as well as many other Mediterranean perennial grasses, shows a conservative strategy in the use of the water, based mainly in the avoidance of drought stress reducing the transpiration rate by reducing stomatal conductance. This result is confirmed also for *Rosmarinus officinalis* (Blanco *et al*., 2004). On the other hand, *Stipa lagascae* keeps a normal photosynthetic activity even when water is scarce; its stomatal conductance is lower than that of *Dactylis glomerata* in both situations of tested water regime. The result agrees with that of Jaballah (2007) who find the same results for the same species and Ourcival (1992) who showed that *Anthylis henoniana* reduces its stomatal conductance as soon as soil water slightly declines, but maintains its gas exchanges.

The photosynthetic assimilation decreases under water deficit. This reduction can be explained by a reduction in the stomatal conductance, which reduces the diffusion of CO_2. The reduction of photosynthesis under severe water stress, can also be ascribed to non stomatal limitations (Lawlor and Cornic, 2002). Generally, the intensity of the stress appears to be important in the determination of the nature of the factors which affect photosynthesis (stomatic factors or different), like the inhibition of the activity of the mesophyll (non stomatic inhibition of photosynthesis).

Conclusions

The knowledge of the biological cycle of pastoral species under drought is of very important utility for assessment of the rangeland productivity. The two species showed a high resistance under water deficit. At physiological level, *Stipa lagascae* presented lower stomatal conductance and higher CO_2 assimilation rate than *Dactylis glomerata*, under both water regime, what leads to a greater efficiency in the use of water. *Dactylis glomerata* showed high sensivity to water deficit reducing both stomatal conductance and net photosynthesis. The ability of *Stipa lagascae* to keep photosynthetically active tissues can suggests that it has a higher rooting rate, with a tendency to extract the heavily retained water from the ground. However, these results are to be qualified as Kasbah became dormant from late May, so it is obvious that its photosynthetic capacity declined. This is mostly due to its endogenous dormancy. These strategies ensure a good regulation of gas exchanges in arid conditions.

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