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Water use efficiency in grass species – *Dactylis glomerata* and *Festuca arundinacea*¹

N. Simões, I.D. Maçãs, J.P. Carneiro and M.M. Tavares-de-Sousa

Estação Nacional de Melhoramento de Plantas (ENMP), Apartado 6, 7350-951 Elvas, Portugal
nunosimoes1@iol.pt

SUMMARY – In order to evaluate water use efficiency (WUE), a field of perennial grasses –with several varieties/ecotypes of *Dactylis glomerata* and *Festuca arundinacea*– was established in Elvas, Portugal, in 2005-06. WUE, expressed in terms of dry matter yield per unit of water consumed, is important to understand the ability of plants to develop efficiently during the growing season (spring) and to define criteria to be used in plant breeding activities. The main hypothesis was to determine traits inducing high WUE during spring and earlier summer combined with traits determining high survival rates following dry summer periods. The measurement of biomass production is a possible indicator of WUE. The correlation between dry matter yield and WUE was variable and ranged from $r=0.798$ for *Dactylis glomerata* to 0.487 for *Festuca arundinacea*. Kasbah (*Dactylis glomerata*) had the lowest WUE; on the other hand, Porto was the opposite. In *Festuca arundinacea* the smallest WUE value was found in cv. Fraydo. Lutine (*F. arundinacea*) had the highest WUE. *Festuca arundinacea* had higher WUE than *Dactylis glomerata*.

Keywords: Water use efficiency, perennial grasses, *Dactylis glomerata*, *Festuca arundinacea*.

RESUME – "Efficience de l'utilisation de l'eau chez des graminées - *Dactylis glomerata* et *Festuca arundinacea*". Pour l'étude de l'efficience de l'utilisation de l'eau (WUE), un essai sur des graminées pérennes avec plusieurs variétés/écotypes de *Dactylis glomerata* et *Festuca arundinacea*, a été établi à Elvas, Portugal, en 2005-06. La WUE, exprimée en termes de matière sèche de la culture produite par unité d'eau consommée, est importante pour comprendre l'aptitude de la plante à pousser efficacement pendant la saison de développement (printemps) et pour définir les critères à utiliser dans l'amélioration des plantes. La principale hypothèse est que les caractères de la détermination de WUE élevée au printemps et en été peuvent être combinés avec des caractères de la détermination des taux de survie aux périodes sèches en été. La mesure de la production de biomasse est un indicateur possible de WUE. La corrélation entre le rendement en matière sèche et WUE a une valeur de $r = 0,798$ pour *Dactylis glomerata* et de $0,487$ pour *Festuca arundinacea*. Normalement, la WUE diminue tout au long du printemps; Kasbah (*Dactylis glomerata*), a eu la plus faible WUE, toutefois pour Porto ceci a été l'inverse. Chez *Festuca arundinacea* la plus basse valeur de WUE était pour la variété Fraydo. Lutine (*F. arundinacea*) a eu la plus haute valeur de WUE. *Festuca arundinacea* a eu une WUE plus élevée que *Dactylis glomerata*.

Mots-clés : Efficience de l'utilisation de l'eau, graminées pérennes, *Dactylis glomerata*, *Festuca arundinacea*.

Introduction

In Mediterranean, the amount of water available for agriculture is declining because of increasing population pressure and greater incidence of drought. Therefore, the efficiency of water use for agricultural production must be maximized. More efficient use of water by plants also would reduce the amount of water lost by evaporation from the soil profile (Asay, *et al.*, 1998).

According to Piano *et al.* (2007) tall fescue (*Festuca arundinacea* Schreb.) is widely cultivated as cool-season forage crop in temperate zones. It is now important to exploit the intrinsic adaptation to dry conditions of tall fescues "Mediterranean type" (Reed *et al.*, 2004)). Some ecotypes of *Dactylis glomerata* are drought resistant (García and Lindner, 1998), and some varieties are well adapted to Mediterranean conditions, as Kasbah. However it is important the demand for new varieties, also well adapted and more productive.

¹ Work performed under the project PERMED Contract: PL 509140 – "Improvement of native perennial forage plants for sustainability of Mediterranean farming systems".

Materials and methods

The trial is located near Elvas, Portugal, in the *Estação Nacional de Melhoramento de Plantas*:-ENMP (National Plant Breeding Station). The latitude of ENMP is 38° 53' 15"N and the longitude 7° 08' 42"W with an altitude of 208 m. The soil is a *coluviosoil* (sandy-loam) with 90 cm deep. The analysis showed the following values: P₂O₅ > 200 ppm; K₂O > 122 ppm; Mg > 125 ppm; organic matter 1.3 %; pH_(H₂O) 6.7.

Seven varieties of *Dactylis glomerata* (Ottava, Kasbah, Delta1, Jana, Currie, Medly and Porto) and six varieties of *Festuca arundinacea* (Centurion, Fraydo, Flecha NE, Lutine, Tanit and Sisa) were used in this work.

The field was sown on October 28 (I, II and III replications) and 29 (IV replication) 2005, in random blocks with 4 replications. Each plot was sown in 10 lines with 2.5 meters of length at a distance of 20 cm between lines.

Six cuts were conducted for evaluation of dry matter's production. The cuts were made at the following dates (15-11-06; 12-12-06; 27-02-07; 16-04-07; 19-06-07; 12-07-07). In each plot, the six internal lines were harvested and dried at a temperature of 65°C during 48 hours.

The evolution of soil water content was monitored by the Diviner 2000 probe. We measured the water content in the soil. The measurements take every 10 cm along 80 cm soil profiles. The real evapotranspiration (ETR, m³/ha) was calculated for each variety. The Water Use Efficiency (WUE: (kg ha⁻¹)/water consumed between cuts (ETR)/day) was calculated for each variety also. The WUE was calculated in winter, early spring and late spring.

Results

In Fig. 1 soil water content dynamics are reported, as the average of the sum for each variety.

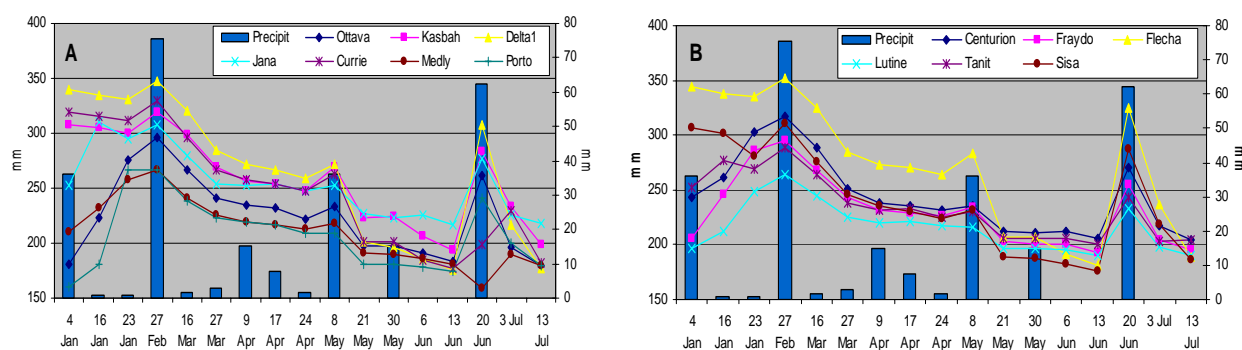


Fig. 1. Evolution of soil water content (mm) in the plots sown with *Dactylis glomerata* (A) and *Festuca arundinacea* (B) accessions throughout the second year trial.

In Fig. 2, we resume dry matter yield (kg/ha) per cut and consumed water (ETR - m³/ha) and WUE (kg/m³ha⁻¹/day) between cuts of varieties of the two species. Tables 1 and 2 present statistical analysis, coefficient correlation between dry matter and WUE and ANOVA analysis.

The measurement of biomass production is a possible indicator of WUE. For each period of calculation of WUE, the correlation between dry matter yield and WUE was almost constant in *Dactylis glomerata* with $r=0.939$ to $r=0.986$. For *Festuca arundinacea* the variation was between 0.469 and 0.852.

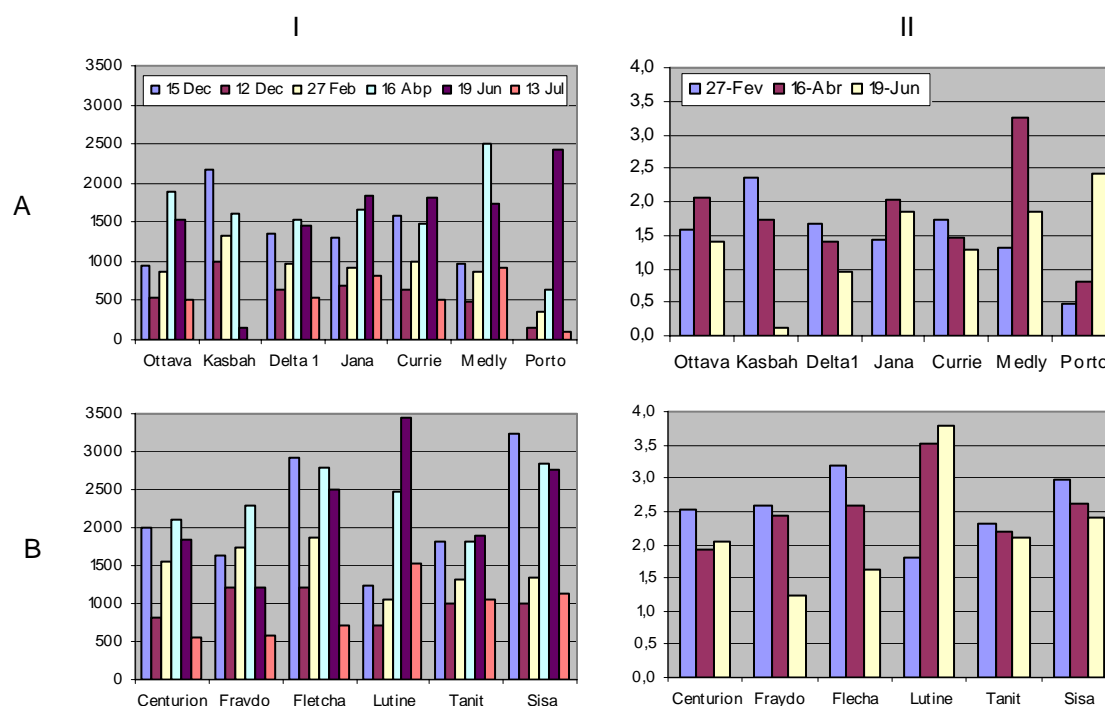


Fig. 2. Dry matter (kg ha^{-1}) produced in each cut (I) and water use efficiency (WUE) in $\text{kg per m}^3\text{ha}^{-1}$ between cuts (II); *Dactylis glomerata* (A) and *Festuca arundinacea* (B) accessions.

Table 1. Coefficient correlation between dry matter and WUE, between varieties

Cut	<i>Dactylis glomerata</i>	<i>Festuca arundinacea</i>
3 rd cut (27 Feb)	0.986	0.746
4 th cut (16 Apr)	0.951	0.469
5 th cut (19 Jun)	0.939	0.852

Table 2. ANOVA analysis

	<i>Dactylis glomerata</i>			<i>Festuca arundinacea</i>		
	MS (kg ha^{-1})	WUE	Degrees of freedom	MS (kg ha^{-1})	WUE	Degrees of freedom
Cut's	***	**	2	***	n.s.	2
Varieties	***	**	6	***	*	5
Cut x variety	***	***	12	***	*	10
Error	-	-	42	-	-	36
Mean	1361	1.641	-	2046	2.494	-
CV(%)	23.84	38.39	-	20.15	27.83	-

The water use efficiency (WUE), expressed in terms of dry matter yield of the crop produced per unit of water consumed, was determined by the ability to grow efficiently at higher soil moisture levels during the growing season (autumn to spring) and to define criteria to be used in plant breeding activities (field or controlled conditions, individual plant or plot scale). The main hypothesis is that in the same plant of perennial grass, traits determining high WUE during spring (16 April and 19 June) and late spring (12 July) can be combined with traits determining high survival rates following dry summer periods.

On the entire year, in *Dactylis glomerata*, Kasbah add the lowest WUE ($0.12 \text{ g DM/kgH}_2\text{O}$ in the 5th cut). In *Festuca arundinacea* was Fraydo and Flecha (1.24 and $1.63 \text{ g DM/kgH}_2\text{O}$) in the 5th cut. In

contrast, Porto (*D. glomerata*) and Lutine (*F. arundinacea*) has the highest WUE (2.41 and 3.80 g DM/kg H₂O respectively).

Final considerations

The measurement of biomass production is a possible indicator of WUE. *Festuca arundinacea* had higher WUE than *Dactylis glomerata*.

The correlation between dry matter yield and WUE was variable from $r=0.798$ for *Dactylis glomerata* to 0.487 for *Festuca arundinacea*.

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