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Drought and high temperature resistance evaluation of *Dactylis glomerata* L.

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Abstract. With the aim to identify cultivars characterized by high drought and temperature resistance and high water use efficiency a study was carried out on 1 accession (Jana) and 4 Sardinian ecotypes of orchard grass (*Dactylis glomerata* L.) (Bolotana, Bonorva, Bonnanaro, Platamona). To evaluate the adaptive responses of different *D. glomerata* ecotypes, two trials were carried out in order to evaluate drought resistance under rain proof shelter and controlled water supply, and to evaluate high temperature resistance in a greenhouse where high summer temperature (daily maximum temperature > 50 °C) were monitored. On December 2010 seeds were sown in seed benches at the beginning of March the plants were transplanted at the 5th leaf stage in 45 litres pots, utilized in the drought resistance trial, and in a container (25 x 0.8 m), utilized in the high temperature resistance trial. In drought resistance trial, two water regimes were applied: 1) Control, soil humidity was kept at the field capacity, 2) W1, pots water losses were reintegrated at 80%. Above ground plant biomass, net photosynthesis, transpiration rate, stomatal conductance, leaf relative water content (RWC) were monitored throughout both trials.

Keywords. Drought resistance – Relative water content – Net photosynthesis – *Dactylis glomerata*.

L'évaluation de la résistance de *Dactylis glomerata* L. à la sécheresse et aux hautes températures

Résumé. Dans le but d'identifier des cultivars caractérisés par la résistance à la haute température, à la sécheresse et avec une grande efficacité dans l'utilisation de l'eau, on a réalisé des expériences sur 1 cultivar (Jana) et 4 écotypes sardes de *Dactylis glomerata* L. (Bolotana, Bonorva, Bonnanaro, Platamona). L'évaluation des réponses adaptatives des différents écotypes a été effectuée lors de deux expériences: la première menée à l'abri de la pluie et avec un régime d'eau contrôlé, pour vérifier la résistance à la sécheresse; la deuxième conduite dans des serres avec températures estivales élevées enregistrées (journalièrement > 50 °C), pour évaluer la résistance à la haute température. En décembre 2010 on a semé les grains dans des plateaux. Au début de mars les plantes au stade de la 5^{ème} feuille ont été transplantées dans des pots de 45 litres pour la première expérience et dans un bac (25 x 0,8 m) pour la deuxième. Pendant le test de résistance à la sécheresse, on a appliqué deux régimes hydriques: 1) Contrôle, en gardant l'humidité du sol au niveau de la capacité au champ, 2) W1, en réintégrant 80% d'eau des pots perdue dans le processus d'évapotranspiration. Lors des deux expériences on a observé aussi la biomasse aérienne, la photosynthèse nette, le taux de transpiration, la conductance stomatique et la teneur relative en eau dans les feuilles.

Mots-clés. Résistance à la sécheresse – Teneur relative en eau – Photosynthèse nette – *Dactylis glomerata*.

I – Introduction

Forage species have a strategic importance in semi-arid and arid regions. In Mediterranean areas, dry matter production of pastures and its seasonal distribution are strongly related to the meteorological pattern. The choice of suitable forage species and varieties, taking into account their

growth behaviour and their adaptation to drought conditions, represents one of the main strategies to improve forage production in semi-arid areas. Drought resistance is generally defined as the maintenance of plant production during moderate or severe water deficit. Several studies have been carried out on drought resistance in annual forage species while less experimental results are available on perennial forage grasses (Sanderson *et al.*, 1997; Ledda *et al.*, 2002; Volaire *et al.*, 2009). To identify the main ecophysiological characteristics of *Dactylis glomerata* L. conferring drought survival and high temperature resistance, as the ability to survive at low soil moisture under Mediterranean summer high temperature and drought, an experiment on one accession and four ecotypes of *Dactylis glomerata* L. was carried out.

II – Materials and methods

A study was carried out on 2010-2011 growing season at the Experimental Farm of the Agricultural Research Council in Sanluri (Sardinia, Italy, 39°31'N; 8°51'E, 60 a.s.l.). Five genotypes of *Dactylis glomerata* L. (one accession “Jana” and four Sardinian ecotypes “Ottava”, “Bolotana”, “Bonnano”, “Bonorva”) were compared in a drought resistance trial in a pot experiment under rain out shelter and in a high temperature resistance trial in a greenhouse. At the beginning of March 2011, after seed germination in seed benches, plants at the 5th leaf stage were transplanted in a container (25 x 0.8 m) arranged in a complete randomised design with five replication and utilized in the high temperature resistance trial (without water limitation). At the same time 2 plants per pot (45 litres each), utilized in the drought resistance trial, were transplanted using a horticultural substrate:soil:sand mixture (40:40:20) and well irrigated until the drought treatment started. In drought resistance trial, two water regimes were applied: 1) Control treatment, soil humidity was kept at the field capacity, 2) W1 treatment, the plants were exposed to progressive drought by restoring only 80% of soil water losses. In this second trial pots were arranged in a factorial complete randomised design with three replicates. Two times per week, pots were weighed to determine water losses and water volumes for irrigation. In greenhouse trial, temperatures (maximum and minimum) were daily recorded. Leaf Relative Water Content (RWC) were determined as the ratio between (leaf fresh weight – leaf dry weight) and (leaf rehydrated weight – leaf dry weight) expressed as a percentage; net photosynthesis, transpiration rate and stomatal conductance were monitored at leaf scale on young fully expanded leaves (one leaf x plant x pot) 4 times in pots trial and 5 five times in greenhouse trial by using a gas analyser (CIRAS-2, PP Systems International, Inc., MA, USA). Above ground plant biomass was observed too in both trials.

III – Results and discussion

Water content at field capacity was constantly maintained in the Control treatment, while W1 treatment reached the wilting point at the end of June (Fig. 1).

Inside the greenhouse the daily maximum temperature was higher than 50°C almost all days in July and August.

The above ground dry matter production results (Table 1), in drought resistance trial, showed a significant reduction due to the imposed water stress. Among genotypes, “Platamona” and “Jana” produced the highest dry matter amount.

In the high temperature resistance trial, the genotypes “Jana” and “Bonorva” showed the highest dry matter productions, while the lowest values have been observed in the ecotype “Bolotana”.

In mid-July, in pots trial, leaf RWC was about 55% in the control treatment and decreased accordingly to water stress imposition at 29% in the W1 pots (Table 1). The accessions “Jana”, “Bonnano” and “Bonorva” showed the highest RWC.

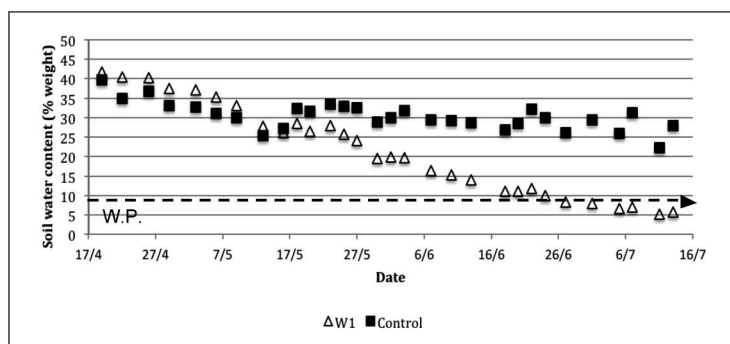


Fig. 1. Evolution of soil water content (% weight in two water regimes).

Table 1. Above ground dry matter production (DM) at the end of trials and relative water content (RWC) at 04/08/11 in greenhouse trial and at 14/07/11 in pots trial in relationship to ecotypes and water regimes

	DM (g pot ⁻¹)			DM (g plant ⁻¹)		RWC (%)		
	Pots		Means	Greenhouse		Pots	Greenhouse	
Genotypes	Control	W1		Means	Control	W1	Means	Means
Jana	33.4	21.7	26.7a	61.3a	59.9	38.6	49.3a	74.0a
Bolotana	25.8	19.0	21.8b	25.3c	50.1	26.5	38.3ab	44.9b
Bonnanaro	24.6	23.7	24.2ab	37.0bc	72.2	25.2	48.7a	70.6ab
Bonorva	32.9	24.3	28.6ab	49.4ab	53.7	36.3	45.0a	59.1ab
Platamona	33.4	30.7	32.0a	37.4bc	41.5	20.2	30.8b	74.8a
Means	29.9a	23.9b			55.5a	29.4b		

Means followed by the same letter within each column are not significant different at $P \leq 0.05$.

In early August, in the greenhouse trial, the genotypes “Jana”, “Bonnanaro” and “Platamona” showed the highest RWC values (> 70%).

Regarding transpiration, no significant differences were observed among genotypes in drought resistance trial (data not shown), while W1 treatment showed significantly lower values than Control treatment between water regimes.

Similarly, stomatal conductance and net photosynthesis (Table 2) resulted higher in the Control treatment. Among genotypes, “Bonorva” showed the lowest stomatal conductance and net photosynthesis values, while the other ecotypes did not showed significant differences among their, for both parameters.

In the high temperature resistance trial, the ecotypes “Bolotana” and “Platamona” showed the lowest transpiration values, 2.8 e 2.7 mmol (H₂O) m⁻² s⁻¹ respectively, with statistic differences from accession “Jana” (3.6 mmol (H₂O) m⁻² s⁻¹) (data not shown).

The genotypes “Jana”, “Bonnanaro” and “Bonorva” showed higher stomatal conductance values than 70 mmol (H₂O) m⁻² s⁻¹, whereas “Bolotana” and “Platamona” showed about 53 mmol (H₂O) m⁻² s⁻¹ values (Table 2). The lowest net photosynthesis values (4.3 μmol (CO₂) m⁻² s⁻¹) were observed in the ecotype “Platamona”.

Table 2. Stomatal conductance (GS) and net photosynthesis (PN) in both trials in relationship to eco-types and water regimes

Genotypes	GS (mmol (H ₂ O) m ⁻² s ⁻¹)				PN (μmol (CO ₂) m ⁻² s ⁻¹)			
	Pots		Greenhouse		Pots		Greenhouse	
	Control	W1	Means	Means	Control	W1	Means	Means
Jana	110.0	66.6	88.3ab	75.8a	7.9	5.5	6.7ab	6.1ab
Bolotana	92.0	77.9	85.8ab	53.0b	6.4	6.2	6.4ab	6.3a
Bonnanaro	113.8	78.9	96.3a	74.3a	8.2	5.2	6.7ab	6.5a
Bonorva	78.8	60.4	69.6b	70.6ab	6.9	4.7	5.8b	5.5ab
Platamona	105.7	88.1	97.4a	53.3b	9.4	7.1	8.3a	4.3b
Means	100.0a	73.9b			7.8a	5.7b		

Means followed by the same letter within each column are not significant different at $P \leq 0.05$.

IV – Conclusions

The drought resistance experiment allowed a complete control of the drought imposition by pots water content monitoring and by a progressive soil water deficit simulation in late spring. At the beginning of the drought, in pots trial, and with maximum daily temperature lower than 40 °C, in greenhouse trial, plants maintained a high photosynthetic activity (data not shown), in order to accumulate carbohydrates used for the autumn vegetative re-growth (Volaire and Lelièvre, 1997).

In a drought resistance experiment (Salis *et al.*, 2006) “Jana” showed a similar RWC and *Dactylis glomerata* above ground dry matter production genotypes confirming results of the present study in relation to the water imposition treatments.

Plant responses to high temperatures stresses was not always consistent with plant responses to water stresses.

Further investigations are still in progress on abscisic acid content (ABA) and on post-summer survival.

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