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in

Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.).
Sustainable Mediterranean grasslands and their multi-functions

Zaragoza : CIHEAM / FAO / ENMP / SPPF
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 79

2008
pages 149-152

Ecophysiological survey of some perennial grass cultivars in the semi-arid region of Setif[1]

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SUMMARY – The lack of water is an issue of major concern throughout the Mediterranean, both because of population growth and of predicted increasing incidence of drought associated to climate change. In order to improve forage production in Algeria, 14 cultivars of perennial grasses (*Dactylis glomerata* L. and *Festuca arundinacea* Schreb.) were evaluated during their first establishment year under semi arid growth conditions. The results indicated that tall fescue varieties were characterized by high herbage yield, drought escaping mechanism and early heading, while cocksfoot varieties were characterized by a relatively low herbage yield and a long vegetative cycle. Proline accumulation was negatively correlated with leaf relative water content, dry matter yield was positively related to plant height and earliness, while soluble sugar accumulation did not show any relationships with the measured variables.

Keywords: Tall fescue, cocksfoot, semi-arid, herbage yield, summer senescence, solute accumulation.

RESUME – *"Etude écophysiologique de quelques cultivars de graminées pérennes dans la région semi-aride de Sétif ". Le manque d'eau constitue une préoccupation majeure dans l'ensemble de la Méditerranée, à la fois en raison de la croissance démographique et de la prédiction d'augmentation des incidences de la sécheresse associées aux changements climatiques. Afin d'améliorer la production fourragère en Algérie, 14 cultivars de graminées pérennes (*Dactylis glomerata *L. et* Festuca arundinacea *Schreb.) ont été évalués au cours de leur première année d'installation dans des conditions semi-arides. Les résultats préliminaires indiquent que les variétés de fétuque sont caractérisées par une forte production de matière verte et une précocité d'épiaison, leur permettant d'échapper à la sécheresse, alors que les variétés de dactyle ont été caractérisées par un rendement en matière verte relativement faible et un cycle végétatif plus long. L'accumulation de proline est négativement corrélée avec la teneur en eau des feuilles, le rendement en matière sèche est positivement lié à la hauteur des plantes et à la précocité, alors que l'accumulation de sucres solubles n'a pas montré de relation avec les variables mesurées.*

Mots-clés : *Fétuque élevée, dactyle, conditions semi-arides, production de fourrage, sénescence, accumulation des solutés.*

Introduction

Water stress is the main factor limiting crop production in rainfed farming systems under arid and semi arid environments. In these environments, the challenge is to increase crop production by achieving higher water use efficiency, even though the year-to-year variation in total rainfall and its monthly distribution generates a wide diversity of climatic growth conditions and intermittent water stress patterns. Selection of cultivars and species which tolerate drought is a way to adapt the crop to the target environment. The agronomic traits useful in crop breeding and selection for drought tolerance need to be identified in relation with the target environment (Dacosta *et al.,* 2004). The objective of this field study was to characterize a set of perennial grasses varieties, during their first establishment year, for dry matter production, crop height, summer leaf senescence, leaf water status, and the differential ability to accumulate proline and soluble sugars, under rainfed conditions in a semi-arid environment.

[1] Work conducted under PERMED project, contract n° INCO-CT-2004-509140.

Materials and methods

Experimental design

The field study was conducted during the 2005/06 cropping season at the Setif Agricultural Experimental Station of the Field Crop Institute, located at grid reference 36°12′N, 5°24′E and altitude 1023 m asl. The long term annual mean precipitation of the experimental site is 396.0 mm, with a winter mean temperature of 6.6°C and a spring mean temperature of 12.5°C. The soil is loamy clay, with a bulk density of 1.35 g cm^{-3}. Seven varieties of tall fescue (*Festuca arundinacea* Shreb.) and seven varieties of cocksfoot (*Dactylis glomerata* L.) were hand sown in October 2005 in a lattice design with four replicates in 10 row- plot, 2.5m long x 2m wide. Plant material was obtained via the Permed project♣ from Portugal, Italy, France and Australia. Average seeding rate was 12 kg ha^{-1}. Nitrogen fertilizer was applied at a rate of 100 kg ha^{-1} as urea 35%. Weeds were controlled chemically by application of Zoom [4.1% *Trisulfuron* + 65.9% *Dicamba*] at a rate of 120 g ha^{-1} in March 2006.

Measurements

The 6 inner rows per plot were harvested in the spring when inflorescence emerged in at least 4 among the tested varieties. Dry matter yield (DMY) was determined after drying a sample of 500 g in a forced air oven at 65°C during 48 hours, Heading date (DHE) was recorded, on the outer rows, as the number of Julian days from January 1st to the date when 50% panicles fully emerged. Plant height (PHT) was measured just before harvest and water status, proline and sugars were determined at harvest, 2 and 4 weeks later, from the vegetation of the outer row. Plant water status was evaluated as relative water content (RWC, %), which was calculated based on leaf fresh weight, dry weight, obtained after 24 h at 70°C, and full turgor weight, after soaking leaves in water for 4 h at 4°C. Measurements were done on 5 fully emerged leaves, sampled from the first replicate. Proline was determined by the ninhydrine method, using pure proline as a standard (Bates *et al.,* 1973) and soluble sugars were determined according to Dubois *et al.* (1956), using glucose as standard. Senescence was estimated on a percent scale at the start of the summer season. Data were subjected to the analysis of variance. Cultivar means were separated by the least significant difference test at the 5% probability level. Correlations between pairs of traits were calculated.

Statistical analyses

The data were analysed using the appropriate analysis of variance models of the STATBOX 6 Package. Differences among the entry means were tested using the least significant difference (LSD) test at the 0.05 probability level.

Results and discussion

Plant height, earliness, dry matter yield and summer senescence

Significant differences were noted between varieties for the measured morphological variables. Averaged over entries, the mean value of PHT was 15.8 cm, and varied from a minimum of 11.0 cm for Lutine to a maximum of 20.3 cm for Fletcha^{EF}. Average number of days for heading was 133.9 and varied from 123.2 for Fletcha^{EF} to 140.0 days for Medly. DMY varied from 0.139 t ha^{-1}, mean yield expressed by Lutine to 0.656 t ha^{-1}, mean yield of Fletcha^{EF}. Summer senescence mean values varied from 31.3% to 63.8%, measured on Medly and Kasbah, respectively (Table 1). Expressed relatively to the mean values of the cocksfoot entries, tall fescue varieties were taller with an advantage of 21.0% increase in PHT; earlier with a 2.6% reduction in DHE; high yielding with 25.6% increase in DMY and senesce faster with 17.9% more leaf senescence by the start of the summer season. Compared with data of the second production year, reported by Mefti *et al.,* (2008), most entries showed a weak expression of the measured variables, leading to only one harvest during this first establishment year. However the results of the present study corroborate those of Mousset *et al*., (1992) who reported that early heading populations of perennial grasses had more DMY than the late one. Such genotypes exhibited summer dormancy characteristics, in late spring, through cessation of

leaf growth and senescence of most aboveground plant organs (Volaire and Norton, 2006). Piano *et al.* (2005) mentioned that early-flowering perennial grasses are more suited to environments with terminal abiotic stress, because they grow actively during winter and early spring.

Table 1. Mean values of plant height (PHT, cm), number of days to heading (DHE, days), dry matter yield (DMY, t/ha), summer senescence (SEN, %), relative water content (RWC, %), sugar (mg g^{-1}DM) and proline (mg g^{-1}DM) of the evaluated grass entries

Genotype	PHT	DHE	DMY	SEN	RWC	Sugar	Proline
Cocksfoot entries							
Jana	18.5	136.2	0.293	33.7	30.41	33.3	39.0
Medly	18.7	140.0	0.415	31.2	32.87	22.3	36.3
Kasbah	15.0	132.5	0.601	63.7	52.24	17.5	06.4
Delta	12.5	139.5	0.200	42.5	41.80	31.4	23.3
Currie	13.3	134.5	0.533	33.7	29.16	21.9	27.2
Porto	13.4	136.2	0.221	42.5	41.57	22.3	11.0
Ottava	12.2	132.7	0.393	40.0	41.72	37.0	33.8
Tall fescue entries							
Tanit	18.9	137.7	0.430	60.0	41.44	30.3	18.1
Sisa	16.7	133.2	0.521	47.5	60.16	35.9	21.0
Fletcha^{EI}	15.8	128.2	0.613	52.5	37.69	29.3	24.8
Centurion	17.4	127.7	0.521	56.2	52.04	30.5	16.4
Fletcha^{EF}	20.3	123.2	0.656	53.7	49.55	29.9	18.6
Lutine	11.0	140.0	0.139	35.7	41.66	35.3	20.4
Fraydo	20.2	136.0	0.587	43.7	56.94	34.8	09.8
LSD 5%	05.5	08.8	0.69	16.8	15.81	19.9	09.6

Relative water content, soluble sugars and proline

During the drought period, in June, RWC mean values, averaged over entries, decreased from 83.7%, just before harvest, to 67.9% two weeks after and to 43.5% two weeks later (4 weeks after harvest). Mean values of the soluble sugars increased from 9.33, to 16.64 and to 29.44 mg g^{-1}DM, while proline content varied from 0.34 to 6.58 to 21.9 mg g^{-1}DM, for the same periods (data not shown). Four weeks after harvest, Fraydo, Centurion, Sisa and Kasbah maintained high relative leaf water content with mean values over 52.0%, while Currie showed the lowest value of 29.6% (Table 1). Lutine, Fraydo, Sisa, and Ottava increased their soluble sugar content, reaching values over 30.0 mg g^{-1}DM. Kaskah was characterised by a low increase with a mean value of 17.5 mg g^{-1}DM. Jana and Medly expressed high proline content compared to Kaskah and Fraydo (Table 1).

The analysis of the relationships between the measured traits indicated that PHT and DMY were significantly correlated (0.575, $P<0.05$). DMY was also positively correlated with leaf senescence (0.539, $P<0.05$), and negatively correlated with DHE ($r = -0.725$, $P<0.01$). These relationships indicated that entries which were taller, earlier and early senescent, were able to express a high herbage yield, because of their escaping mechanism. Sugar content showed no significant correlations with the measured traits, but proline content was negatively correlated with RWC, expressed 4 weeks after harvest ($r = -0.693$, $P<0.01$). It is commonly observed that water stress induced the accumulation of compatibles solutes, accounting mostly for osmotic adjustment (Falalou *et al.,* 2007). Volaire *et al*. (2005) found that carbohydrates accumulated during the summer enhanced the capacity of perennial grasses to recover from drought stress.

Conclusions

An understanding of the growth responses under rainfed conditions allows plant breeders to

identify stress tolerant and adapted perennial grass cultivars. Data from this research suggest that earliness, as an escaping mechanism, may be beneficial under water limited environments. This study indicates, too, that tolerance of grass cultivars to drought conditions involves a number of characteristics, among which, early summer senescence and compatible solutes accumulations. These traits are favouring high dry matter production and adaptation to water limited environments.

References

Bates, L.S., Waldren, R.P. and Tearen, J.D. (1973). Rapid determination of free proline for water stress studies. *Plant Soil*. 39: 205-207.

DaCosta, M., Wang, Z. and Huang, B. (2004). Physiological adaptation of Kentucky bluegrass to localized soil drying. *Crop Sci*., 44: 1307-1314.

Dubois, M., Gilles, K.A., Hamilton, J.K., Rebers, P.A. and Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, 28: 250-356.

Falalou, H., Zombre, G., Diouf, O., Diop, N.N., Guinko, S. and Braconnier, S. (2007). Physiological, biochemical and agromorphological responses of five cowpea genotypes (*Vigna unguiculata* (L.) Walp.) to water deficit under glasshouse conditions. *Biotechnol. Agron. Soc. Environ.,* 11: 225-234.

Mefti, M., Bouzerzour, H., Abdelguerfi, A. and Nouar, H. (2008). Morphological and Growth Characteristics of Perennial Grass Cultivars Grown under Semi-Arid Conditions of the Algerian High Plateaus. *Pakistan Journal of Agronomy* (accepted).

Mousset, C., Volaire, F. and Ghesquière, M. (1992). Caractérisation des populations corses de dactyle. Etude de l'adaptation en zone méditerranéenne. *Fourrages,* 130 : 191-209.

Piano, E., Pecetti, L. Annicchiarico, P., Carroni, A.M., Fornasier, F. and Romani, M. (2005). Combining drought tolerance and responsiveness to summer moisture availability in cocksfoot (*Dactylis glomerata* L.) germplasm grown in Mediterranean environments. *Australian Journal of Agricultural Research,* 55: 1197-1204.

Volaire, F. and Norton, M. (2006). Summer dormancy in perennial temperate grasses. *Annals of Botany*, 98: 927-933.

Volaire, F., Norton, M.R., Norton, G.M. and Lelièvre, F. (2005). Seasonal patterns of growth and water-soluble carbohydrates in genotypes of *Dactylis glomerata* varying in summer. *Annals of Botany,* 95: 981-990.