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Performance of some tall fescue varieties grown under Algerian semi-arid conditions

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Abstract. Within farming systems, perennial grasslands provide numerous positive environmental effects such as improvement of soil structure, erosion decrease, control of nitrate leaching and maintenance of biodiversity. In order to develop grassland crops with improved persistence and enhanced water use efficiency, 7 cultivars of tall fescue (*Festuca arundinacea* Schreb.) were evaluated for agronomic behaviour and persistence in the semi-arid region of Setif during the 2007-08 cropping season, corresponding to the third year of production. The measured traits focused on accumulated dry matter (DM), water use efficiency (WUE), plant height (PHT), relative growth rate (RGR) sward persistence (PER) and earliness (DHE). The study revealed the existence of variability for some traits, and identified cultivars having high dry matter yield and good water use efficiency. The results indicated too that the tested genotypes differed significantly for the measured traits. Fletcha, Fletcha^{EF} and Fraydo gave the best dry matter yield, RGR, PER and WUE, while Lutine, Sisa and Centurion performed poorly under semi-arid growth conditions.

Keywords. Perennial grasses – Dry matter yield – Persistence – Water use efficiency – Semi-arid climate.

Performance de quelques variétés de fétuque élevée cultivées sous conditions semi-arides d'Algérie

Résumé. Dans les systèmes de production agricoles, les prairies pérennes offrent de nombreux effets positifs sur l'environnement tels que l'amélioration de la structure du sol, la diminution de l'érosion, le contrôle du lessivage des nitrates ainsi que le maintien de la biodiversité. Afin de développer la culture des prairies avec une meilleure persistance, 7 variétés de fétuque élevée (*Festuca arundinacea* Schreb.) ont fait l'objet d'une 'évaluation agronomique du comportement et de la persistance dans la région semi- aride Sétif durant la campagne agricole 2007-08, correspondant à la troisième année de production. L'étude a porté sur la matière sèche accumulée (DM), l'efficacité d'utilisation de l'eau (WUE), la hauteur de végétation (PHT), le taux de croissance relative (RGR), la persistance (PER) et la date d'épiaison (DHE). L'étude a révélé l'existence de la variabilité pour certaines variables et a identifié des cultivars possédant par un bon rendement en matière sèche et une bonne efficacité d'utilisation de l'eau. Les résultats indiquent aussi que les génotypes testés diffèrent significativement pour les variables mesurées. Fletcha, Fletcha^{EF} et Fraydo ont donné le meilleur rendement en matière sèche, RGR, PER et WUE, tandis que Lutine, Sisa et Centurion ont donné des performances médiocres dans les conditions semi-arides.

Mots-clés. Graminées pérennes – Production de matière sèche – Persistance – Efficacité d'utilisation de l'eau – Climat semi-aride.

I – Introduction

The eastern high plateaus of Algeria have a continental Mediterranean climate with variable rainfall, ranging from 168.7 to 517.3 mm, 56 to 88% of which falls in the cold period, extending from October to March (Chennafi *et al.*, 2006). Water remains the main factor limiting crop production even though cold, late spring frost hazard and terminal heat are also frequent (Bouzerzour and Benmahammed, 2009). In these conditions the lack of forage production is a major obstacle to livestock development.

Grasslands are required as sources of good quality and healthy animal fodder, they have multi-functional requirements which include environmental, social, and cultural aspects. (Humphreys *et al.*, 2004). An increasing interest in perennial forages for Mediterranean environments is justified by the ability of these species to extend and regularise the feeding season relative to annuals, particularly when their winter yield can be expressed. They may provide earlier and more sustainable feeding possibilities than annuals due to rapid regrowth at the onset of autumn rains and delayed senescence that derives from better ability to exploit the residual moisture in summer (Piano *et al.*, 2005). The objective of the present study is to assess the performances of the seven tall fescue varieties grown under rainfed conditions in the eastern high plateaus of Algeria.

II – Material and methods

1. Experimental design

The field study was conducted during the 2007/08 cropping season at the Setif Agricultural Experimental Station of the Field Crop Institute (ITGC) located at 36°12'N, 5°24'E and 1023 m asl. The long term annual mean precipitation of the experimental site is 396.0 mm, recorded mainly from November to March with a winter mean temperature of 6.6°C and a spring mean temperature of 12.5°C. The climate is temperate continental, varying from arid to semi-arid. The soil is loamy clay, with a bulk density of 1.35 g cm⁻³. Seven perennial tall fescue (*Festuca arundinacea* Shreb.) varieties were sown in October 2005 in a lattice design with four replicates and 10 row-plots of 2.5 m long x 2 m wide.

Sowing was done by hand. The plant material originated from Portugal, Italy, France and Australia, it was obtained via the PERMED project¹. Average seeding rate was 20 kg ha⁻¹. Nitrogen fertilizer was applied at a rate of 100 kg ha⁻¹ as urea 35%. No irrigation was supplied.

2. Measurements

The 6 inner rows per plot were harvested in the spring when inflorescence emerged in at least 4 entries 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, using the average of the measurements per plot from the soil surface to the highest point of the vegetation. Variation in the ground cover percent of living grown tissue was used as measure of persistence (PER) according to Casler *et al.* (2002). The relative growth rate was calculated by the equation given by Wilhelm and Nelson (1978). Soil water measurements were made with neutron probe after each harvest and then water-use efficiency (WUE) was expressed according to Chen *et al.*, (2003). The collected data were statistically analyzed with STATBOX 6 Package. Differences among the entry means were separated by the test of Newman and Keuls.

III – Results and discussion

1. Plant height and dry matter

Mean plant height averaged over genotypes showed significant differences for both seasons: autumn 2007 and spring 2008. The mean value of PHT was 23.7 cm in autumn, and varied from a minimum of 20.7 cm for Flecha^{EF} to a maximum of 28.7 cm for Lutine, while in spring, the mean

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

value was 18.3cm, and varied from a minimum of 14.2 cm for Centurion to a maximum of 22 cm for Fraydo. The autumn and spring yields were relatively lower than dry matter yield of the previous season, and averaged 0.45 and 0.66 t ha⁻¹, respectively. No significant differences were noted between varieties for both seasons, nevertheless, the most productive cultivars in terms of annual production were Fraydo and Flecha^{EF} with 1.27 t ha⁻¹, while sisa and Lutine were the least productive with a total DMY of 0.94 and 0.89 t ha⁻¹ respectively. Spring yields are lower than expected for all cultivars due to insufficient rainfall. Duru and Ducrocq (1998) indicate that the measurement of the grass height is not sufficient to predict the amount of forage production. These authors state that for a given height, the quantity of the produced grass depends on both the horizontal structure (density of ground cover) and vertical structure (distribution of biomass in different horizons) structure of the meadow. The dry matter yield is an important characteristic in determining the choice of selected varieties. Van Wijk *et al.* (1993) mentioned that dry matter yield of the new varieties increased annually by 5%, because of greater persistence and good performance during the third and fourth years of cultivation.

2. Persistence and earliness

Row cover showed significant differences between tall fescue varieties in both seasons. Row cover means varied from 38.3 (Sisa) to 61.9 % (Flecha^{EF}) in autumn and from 29.9 (Lutine) to 53.2 % (Flecha^{EF}) in spring (Table 1). The number of days to head varied significantly between genotypes. Flecha^{EF} and Fraydo were the earliest with 98 calendar days; they headed 7 days earlier than Tanit the latest variety. According to Volaire and Lelièvre (2004) early flowering is associated with drought survival in cocksfoot. Heading spread over 30 days, clearly discriminating between the tested cultivars. Early flowering allowed a longer regrowth period, and consequently a greater allocation of assimilates to root growth before the onset of drought. Thomas, (1997) suggested that phenology interacts significantly with the plants ability to withstand drought stress. Early flowering provided an effective avoidance mechanism against summer water stress.

3. Relative growth rate and water use efficiency

The tested genotypes differed significantly for the relative growth rate based on dry matter accumulated between 14/04/2008 and 29/04/2008. The mean RGR was 22.6 g kg⁻¹ d⁻¹. Centurion and Fraydo showed the poorest RGR with 13.5 and 11.4 g kg⁻¹ d⁻¹ respectively, while Lutine and Flecha^{EF} showed the highest RGR with 30 and 29.5 g kg⁻¹ d⁻¹ respectively. No significant differences between varieties were observed for water use efficiency. Flecha endophyte free and endophyte infected (E542) showed the highest water use efficiency while Lutine had the lowest WUE (Table 1). Water use efficiency (WUE), defined as the ratio between plant dry matter yield

Table 1. Genotypic means of the traits measured during the third production year (2007/08)

Name	ADM	SDM	TDM	PHT1	PHT2	PER1	PER2	DHE	WUE	RGR
Tanit	0.53	0.63	1.16	23.7ab	17.9ab	57.7a	4803a	105a	6.9	27.9a
Sisa	0.34	0.60	0.94	20.8b	18.3ab	38.3b	34.2b	101a	6.1	25.4a
E542	0.48	0.79	1.27	23.3ab	18.0ab	55.8a	50.7a	95a	8.6	20.5a
Centurion	0.45	0.58	1.03	23.5ab	14.2b	57.5a	39.8b	104a	6.3	13.8a
Flecha ^{EF}	0.52	0.71	1.23	20.6b	17.0ab	61.9a	53.2a	98a	7.6	29.5a
Lutine	0.31	0.58	0.89	28.7a	20.4a.	39.1a	29.9b	104a	5.9	30.0a
Fraydo	0.55	0.72	1.27	25.3ab	22.0a	47.9ab	42.5ab	98a	7.4	11.4a
Sign.	NS	NS	*	*	*	*	*	*	NS	*

Autumn dry matter yield (ADM, t ha⁻¹), Spring dry matter yield (SDM, t/ha), Annual dry matter (TDM), Autumn plant height (PHTa, cm), Spring plant height (PHTs, cm), Persistence (PER1,2, %), Number of days to heading (DHE, days), Water use efficiency (WUE, kg ha⁻¹ mm⁻¹), Relative growth rate (RGR, g kg⁻¹ d⁻¹).

and transpiration is one measure of the ability of a plant to perform well under incipient drought (Thomas, 1997). The potential of breeding crop species with higher WUE to reduce water use and the approaches used have been reviewed by Condon *et al.*, (2004). Blum (2009) considers that WUE is a parameter determining the resistance of crops to drought. However, Lelièvre *et al.* (2011) suggest that WUE and drought tolerance are two distinct forms of adaptation in perennial grasses grown in semi-arid regions.

IV – Conclusion

The results of this study show that there is a quite large variability between tall fescue varieties. The drought-tolerance pattern exhibited by Flecha and Fraydo is consistent with the higher level of drought stress that characterized their selection environments relative to those of the other cultivars. In addition, there was some evidence for better drought tolerance of earlier-heading germplasm. Earliness could easily be selected for in breeding programmes, and may be useful as an indirect selection criterion especially if selection for drought-prone environments had to be performed in favourable sites or cropping years. The most adapted cultivars could now be included in our semi-arid production system in order to regenerate permanent meadows

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