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Growth development and dry matter yield of 16 Lucerne genotypes cultivated in south Tunisia

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SUMMARY – This study aims to compare the growth and forage dry matter yield of 16 different Lucerne (*Medicago sativa*) genotypes, under the specific environmental conditions of south Tunisia. Plants were cultivated on the field and irrigated during the period (March 2005 to September 2007) and a water deficit treatment was applied, by interrupting irrigation, for 43, 56 and 65 days during the summer of 2005, 2006 and 2007, respectively. Results show significant differences between genotypes regarding forage dry matter yield, leaf-to-stem ratio and drought sensitivity index. Some genotypes show an interesting yield potential, mainly Ecotipo Siciliano, and to a lesser extent, ABT 805 and Ameristand 801S. Therefore, those varieties can provide local farmers in the region with a possibility for an alternative use.

Key words: Lucerne, forage dry matter yield, drought, South Tunisia.

RESUME – *"Développement de la croissance et rendement en matière sèche de 16 génotypes de luzerne cultivés dans le sud de la Tunisie". L'objectif de cette étude est de comparer la croissance et le rendement en matière sèche de 16 génotypes de luzerne (*Medicago sativa*) sous les conditions environnementales particulières du sud tunisien. Les plantes ont été cultivées en plein champ et elles ont été maintenues irriguées pendant la majeure partie de l'essai (de mars 2005 à septembre 2007). Les plantes ont subi un traitement de déficit hydrique, par arrêt d'irrigation, pendant 43, 56 et 65 jours durant l'été de 2005, 2006 et l'été 2007, respectivement. Les résultats ont montré des différences significatives entre les génotypes au niveau du rendement en matière sèche fourragère, du rapport feuille tige, et au niveau de l'indice de sensibilité à la sécheresse. Quelques génotypes, notamment Ecotipo siciliano, et à un moindre degré, ABT 805 et Ameristand 801S, ont montré des performances intéressantes. Ainsi, ces génotypes peuvent constituer une alternative d'utilisation par les agriculteurs dans la région*.

Mots-clés : *Luzerne, rendement en matière sèche, déficit hydrique, sud tunisien.*

Intoduction

Lucerne (*Medicago sativa*) is an important perennial legume grown worldwide. This specie presents large genetic diversity since it's cultivated in different zones in the globe with contrasting environments (Prosperi *et al.,* 1995). In South Tunisia, lucerne was cultivated mainly in the oasis where it's considered as the principal green forage available for animal feeding. Therefore, during the last 2 decades, the national policy consisting in the encouragement of cow husbandry to achieve self-sufficiency in meat and milk production has enhanced lucerne cultivation in many zones in south Tunisia outside the oasis. In theses farms, perennial lucerne was cultivated in small parcel (≤ 1 ha) in full irrigation mode, often with saline water. Common used genotypes are a local populations issued from the oasis of Gabes and considered as tolerant to salinity and frequent clipping (Seklani *et al.,* 1996). Moreover, in the seed markets of the region we can found some introduced varieties such African and Siriver. Increasing crops yield is related to the use of appropriate and adapted genotype to the particular environmental conditions of the region. In this context, the objective of this study is to determine the best adapted lucerne variety, from a pool of 16 elite genotypes to the specific environmental conditions of South Tunisia. Therefore, total forage dry matter yield, leaf to stem ratio and drought sensitivity index were used to compare genotypes. This experiment is a part of a large multi-site trial in the Mediterranean zone with the objective to analyze genotype environment interaction, and eventually to define ideotypes of plants for different types of Mediterranean environments (Work-package 3, PERMED project).

Materials and methods

The trial was conducted at the experimental station of Institut des Régions Arides (Medenine, southern Tunisia: latitude 33°.30' N, longitude 10°.38' E). The soil is sandy loam fine textured. Sixteen of Lucerne genotypes were used in this experiment. The genotypes included Rich 2, Erfoud 1 and Demnat 203 (Morocco); Magali, Melissa and Coussouls (France); Prosementi, Ecotipo Siciliano and Mamuntanas (Italy); ABT 805 and Ameristand 801S (USA); Sardi10, Siriver and African (Australia); Gabès 2355 (Tunisia) and Tamantit (Algeria).

Seeds of the 16 Lucerne genotypes were sown in 31 March 2005 at the rate of 25 kg.ha^{-1}. The experimental unit is a plot of 5 m², consisting of 11 rows, 2.5 m length and 0.17 m apart. Plants were maintained well watered throughout the growing season and irrigated with canal water (EC = 4 dS/m). A drought treatment by withholding irrigation during summer was applied for 43 days in 2005 (27/07 to 08/09), 56 days in 2006 (04/07 to 29/08) and for 65 days in 2007 (09/07 to 12/09). The experimental design was a simple lattice with 4 replications giving a total of 64 plots.

During 30 months of experiment, all cultivars were harvested 14 times, except for African which is harvested 13 times due to a low growth rate during the winter 2006. All plants were cutted in the same date, when at least 10 genotypes have reached 50 % flowering. Measurements were concerned time of 50% flowering, dry forage matter yield and leaf:stem ratio. Forage dry matter yield was determined by cutting of central 2 m² of each plot. A sample of fresh plants were dried at 80°C for 3 days and then weighed and dry matter percentage used to determine total yield (t ha^{-1}). Dried material was separated into stem and leaves to calculate leaf/stem ratio, this parameter was measured at 8 harvests. Drought sensitivity index (DSI) was calculated following Fischer and Maurer (1978) as DSI = (1 – (Ys/Yp))/SI, where Ys is the genotype mean yield after summer drought (average of 3 years) and Yp is the genotypes mean yield during the non stressed period. SI is the stress index SI = 1 – (XYs/XYp), XYs is the all genotypes average yield after summer stress and XYp is the all genotypes average yield during the non stressed period.

Result and discussion

The data presented in Table 1 show significant differences between genotypes for measured parameters at the 3 years of experiment. The general mean of forage dry matter yield during the 30 months of trial is 36.783 t ha^{-1}. The highest yield was produced by Ecotipo Siciliano (41.704 t ha^{-1}) followed by ABT 805 (40.736 t ha^{-1}), Ameristand (39.775 t ha^{-1}), Siriver (39.691 t ha^{-1}) and Mamuntanas (39.278 t ha^{-1}). The lowest yields were registered by Tamantit (29.193 t ha^{-1}) and African (29.585 t ha^{-1}). The average dry matter produced by cut varied between 3.557 t ha^{-1}cut^{-1} and 2.695 t ha^{-1}.cut^{-1} in 2005, between 3.167 t ha^{-1}.cut^{-1} and 1.763 t ha^{-1}.cut^{-1} in 2006, and between 2.838 t ha^{-1}.cut^{-1} and 1.952 t ha^{-1}.cut^{-1} in 2007. Water deficit stress during summer reduces plant growth and consequently dry matter harvested was low. Average dry matter of all genotypes was 0.799 t ha^{-1} in 2005, 0.405 t ha^{-1} in 2006 and 0.530 t ha^{-1} in 2007 (data not shown).

The significant difference in forage dry matter produced by year is related to the number of mowing applied: 3 cuts in 2005, 6 cuts in 2006 and 5 cuts in 2007. However, no significant genotype x year interaction was detected. Genotype comparison indicate that Ecotipo Siciliano was the best yielder (in 2005 and 2007), and Tamantit was the less yielder in 2 years (2006 and 2007).

Results show differences in time of 50% of flowering from 9 to 14 days between early and late genotypes. Significant and negative correlation was detected between total forage dry matter (sum of 3 years) and the first flowering in spring, r = -0.48** in 2006 and r = -0.38** in 2007.

Forage quality (protein and fiber content) is mainly influenced by leaf to stem ratio (Rotilli *et al*. 2001). Therefore, high alfalfa forage quality is associated with leafy, fine stemmed plants and then high leaf to stem ratio (Mueller and Orloff, 1994). Results show leaf:stem ratio variation from 0.87 for Melissa to 1.08 for Coussouls and Magali (Table 1). These values are higher than sited in other experiment. Those high values indicate a good quality of the harvested forage. The typical environmental conditions of the experiment were characterized by high temperature, dry air and high radiation level during long period of the year, and associated to the saline water used for irrigation. All of these factors lead to reduce plant growth and plants were shorter, finer stemmed and leafier and

Table 1. Mean forage dry matter produced by year and by cut, Ranking of genotypes from early to late flowering, leaf to stem ratio ($g.g^{-1}$) and drought sensitivity index (DSI)

Genotype	Forage dry matter yield (t ha^{-1})				Forage dry matter yield (t $ha^{-1}.cut^{-1}$)				50% Flowering (DOY*)		Leaf/stem ($g.g^{-1}$)	DSI
	2005	2006	2007	3 Years	2005	2006	2007	3 Years	2006	2007		
ABT 805	8.695	19.003	13.038	40.736	2.898	3.167	2.608	2.910	104	84	0.92	1.04
Africaine	8.315	11.047	10.224	29.585	2.772	1.841	2.045	2.113	110	85	0.94	0.94
Ameristand	10.557	16.647	12.570	39.775	3.519	2.775	2.514	2.841	103	80	0.97	1.04
Coussouls	9.982	14.103	13.004	37.090	3.327	2.350	2.601	2.649	110	86	1.08	1.05
Demnat 203	8.086	13.962	10.298	32.346	2.695	2.327	2.060	2.310	112	87	0.91	0.95
E. Siciliano	10.671	16.843	14.189	41.704	3.557	2.807	2.838	2.979	107	84	0.99	1.01
Erfoud 1	8.466	17.111	12.821	38.397	2.822	2.852	2.564	2.743	107	83	0.97	0.97
Gabes 2355	10.309	13.646	10.778	34.732	3.436	2.274	2.156	2.481	113	89	1.00	0.95
Magali	8.022	15.584	13.737	37.343	2.674	2.597	2.747	2.667	109	86	1.08	1.01
Mamuntanas	10.632	15.532	13.115	39.278	3.544	2.589	2.623	2.806	106	83	0.94	1.00
Melissa	9.914	16.043	12.836	38.793	3.305	2.674	2.567	2.771	109	83	0.87	1.00
Prosementi	8.738	13.840	13.516	36.094	2.913	2.307	2.703	2.578	106	83	0.98	0.92
Rich 2	10.140	13.580	11.181	34.900	3.380	2.263	2.236	2.493	109	83	0.96	1.02
Sardi 10	10.037	16.684	12.159	38.880	3.346	2.781	2.432	2.777	105	81	0.90	1.07
Siriver	9.863	15.761	14.068	39.691	3.288	2.627	2.814	2.835	107	85	0.89	1.04
Tamantit	8.855	10.576	9.762	29.193	2.952	1.763	1.952	2.085	110	87	1.03	0.94
Grand mean	*9.455*	*14.997*	*12.331*	*36.783*	*3.152*	*2.499*	*2.466*	*2.627*	*108*	*84*	*0.96*	*0.99*
LSD (5%)	1.913	3.505	2.737	6.160	0.637	0.584	0.547	0.440	2.8	4.4	0.11	0.06

*Day of the year from 1 January.

then increase the leaf to stem ratio. These results go with the observation of Mueller and Orloff (1994) which indicates that yield and forage quality are inversely related, and any factor that retards plant development tends to promote the maintenance of forage quality.

Significant differences were observed between DSI (Table 1), which is the indication of different levels of drought tolerance between genotypes. Also, significant and negative correlation was observed between DSI and forage dry matter yield produced during stressed period (r =- 0.79**).

Conclusions

This trial show significant differences between tested genotypes according to their forage dry matter yield in the specific environmental conditions of south Tunisia. Some genotypes have revealed interesting yield potential, mainly Ecotipo Siciliano, and with lesser extend, ABT 805 and Ameristand 801S. These genotypes surpass the productivity of the Gabes 2355 which is issued from the most cultivated Lucerne population in Tunisia. Therefore, these varieties can provide a possibility for an alternative use by farmers in the region.

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