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in

Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.).
Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109

2014
pages 517-521

Restoration of degraded rangeland by the use of *Cenchrus ciliaris*, a high value perennial forage grass, in Hail region (Saudi Arabia)

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Abstract. Saudi Arabia (KSA) is one of the countries that suffers from the degradation of natural rangelands aggravated by severe drought. Rangelands with wild forage species decreased and refuged in difficult accessible zones such as mountains and deep Wadi. *Cenchrus ciliaris* L., a high value pasture plant of the Saudi Arabian mountains, is one of the endangered species that becomes very rare in its natural habitats. In this work five accessions of *Cenchrus ciliaris* were collected from different zones in Hail region (North of KSA), to select the most vigorous ecotypes to be introduced in the degraded lands. In the first part of this study, the germination capacities of different accessions were estimated. The second part focuses on the study of the vegetative vigour of different accessions by the assessment of morphological parameters. In the last part of this study, a selection of the resistant accessions to overgrazing by a protocol of repeated cuts, was conducted. This study permitted to select the most productive and drought tolerant accessions of *Cenchrus ciliaris*.

Keywords. *Cenchrus ciliaris* – Overgrazing – Degraded rangelands – Forage – Mountains – Saudi Arabia.

Restauration des parcours dégradés par réintroduction de* Cenchrus ciliaris*, graminée pérenne de haute valeur pastorale dans le région de Hail (Arabie Saoudite)

Résumé. *L'Arabie Saoudite est un pays qui souffre énormément de la dégradation des terres de parcours aggravée encore par un climat désertique. Les parcours naturels contenant des espèces fourragères autochtones ont été fortement diminués et se trouvent actuellement refugiés dans quelques zones d'accès difficiles comme les sommets des montagnes ou les lits des profonds oueds.* Cenchrus ciliaris*, graminée pérenne de haute valeur pastorale, est l'une des espèces les plus menacées d'extinction. Cette espèce devient de plus en plus rare dans son habitat naturel et est supposée, selon des travaux récents, en voie de disparition dans la région de Hail, au Nord de l'Arabie Saoudite. Dans ce travail, cinq accessions de* Cenchrus ciliaris *ont été collectées dans la région de Hail en vue de sélectionner, parmi-elles, les plus productives et les plus résistantes au surpâturage pour une éventuelle réintroduction et réhabilitation des parcours dégradés. La première partie de ce travail a servi à tester les capacités germinatives des différentes provenances. Dans une seconde partie, la vigueur végétative des provenances a été évaluée en se basant sur un ensemble de paramètres morphologiques. Enfin, une sélection des accessions les plus résistantes au pâturage a été réalisée sur la base du poids de la matière sèche accumulée après 3 coupes séparées par des intervalles de 30 jours. Cette étude a permis de sélectionner les accessions de* Cenchrus ciliaris *les plus vigoureuses et les plus résistantes au pâturage.*

Mots-clés. Cenchrus ciliaris – *Surpâturage – Parcours dégradés – Fourrage – Montagne – Arabie Saoudite.*

I – Introduction

Buffelgrass (*Cenchrus ciliaris*) is one of the most important wild forage species, known by its high pastoral value (*Visser et al*., 2008). In the world, this species is known for its high diversity (Kharrat *et al*., 2004; Mseddi *et al*., 2002) and adaptability to different environments as well as by its high resistance to drought and warm climates. The high productivity of this species allows to cul-

tivate it in several regions of the world, such as Australia, the United States and Pakistan, as a primary source for animal feed (Mseddi *et al*., 2004a; 2004b).

As the Kingdom of Saudi Arabia (KSA) is suffering from a shortage of groundwater because of its frequent use in irrigated agriculture (cereal and vegetable crop) and especially the cultivation of alfalfa (livestock feed) that consume a high volume of water, this research project defined the following objectives: (1) Establishing a sustainable development system through the use of some "economic" plants, such as buffelgrass, known by its high productivity and forage quality despite its low water consumption; (2) the rehabilitation of disturbed grassland in KSA by seed dispersion of the resistant varieties of this species; and (3) the conservation of the natural resources and the genetic heritage of this area.

II – Materials and methods

Plant material: *Cenchrus ciliaris* is a C4 perennial grass belonging to the family of *Poaceae*. Seed collection was undertaken at the end of the summer 2012. A total of 10 accessions were collected in Hail area and finely 5 accessions were retained because of the short distance between some accession sites. Geographic coordinates were taken by GPS. Accessions were named as: Jameen, Aja, Zaitoun, Gaed and Industrial zone. Seed Germination trials were conducted in 9-cm sterile Petri dishes lined with two Whatman No. 1 filter papers. Five salinity concentrations (0 g/l, 2 g/l, 4 g/l, and 8 g/l) were used based on a preliminary test for salt tolerance of the species. The Petri dishes were placed in an incubator for 25 days at constant temperatures of 25°C [optimal temperature for *Cenchrus ciliaris* (Mseddi *et al*., 2002)]. Physiological and morphological parameters that were assessed in this work are reported in Table 1. Data were analysed using SPSS, version 16.0.

Table 1. Parameters assessed, their codes and units

Unit	Code	Parameters
cm	PL	Plant length
cm	PD	Plant diameter
kg/m^3	DEN	Density
cm	ST	Stem length
m^3	BV	Biovolume
Numeric number	BN	Branch number
cm	LL	Leaf length
cm	SL	Spike length
g	DM	Dry matter
g	OVG	Resistance to overgrazing
Numeric number	GER	Percentage of germination

III – Results and discussion

1. Germination

Seed germination of *Cenchrus ciliaris* of all accessions was highest in distilled water (0 g NaCl/l). The highest germination rate was observed at Aja accession with 100% of germination. The increase of salt in water was followed by a decrease in germination percentage. Aja was the most tolerant accession to salt; it can fully germinate at 2 g NaCl/l after 20 days. Whereas, Jameen was the most sensitive accession to salt with a 0% germination in 2 and 4 g NaCl/l (Fig. 1).

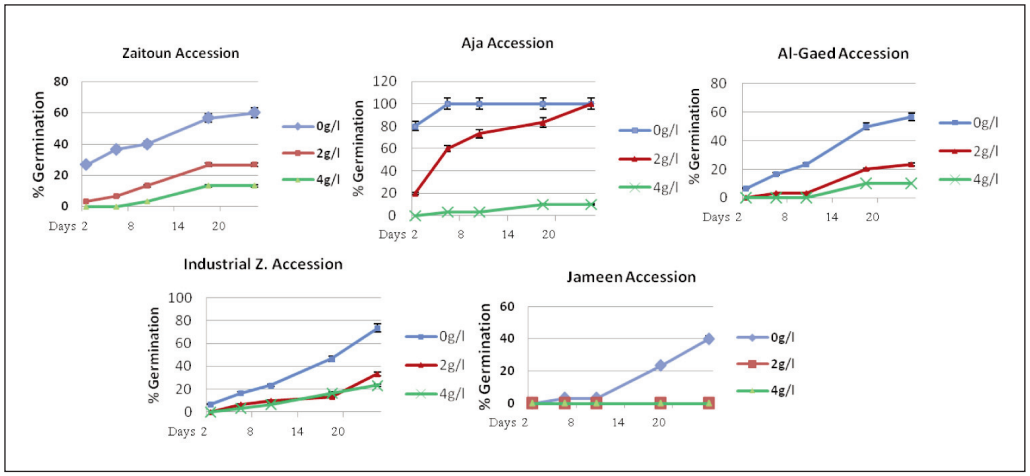

Fig. 1. Effect of salinity concentrations on the germination of different accessions of *Cenchrus ciliaris* in Saudi Arabia (Hail Region). Bars represent means + 1SE.

2. Morphological parameters

The means of all morphological parameters are reported in Table 2. Jameen Accession was the most developed accession with PL of 110 cm and PD of 86 cm. Small plants are recorded for Industrial zone accession with PL of 69.7 cm and PD of 54 cm.

Table 2. The means of all morphological parameters

Ac	PL	PD	ST	LL	BN	SP
Indust. Z.	69.7 ± 9.1	54.0 ± 7.9	72.7 ± 7.6	16.0 ± 1.0	7.0 ± 1.0	10.0 ± 1.0
Gaed	105.0 ± 5.0	96.7 ± 2.9	71.7 ± 3.2	24.0 ± 1.0	5.3 ± 0.6	11.7 ± 0.6
Jameen	110.0 ± 17.3	86.7 ± 11.5	104.0 ± 7.9	34.0 ± 1.0	4.0 ± 1.0	11.7 ± 2.1
Aja	86.7 ± 5.8	73.3 ± 2.9	78.3 ± 7.6	25.0 ± 2.0	3.3 ± 0.6	12.7 ± 1.2
Zaitoun	67.0 ± 2.6	66.0 ± 1.0	59.3 ± 5.1	12.3 ± 2.5	6.7 ± 1.2	7.0 ± 0.0
Average	87.7 ± 19.9	75.3 ± 16.5	77.2 ± 16.3	22.3 ± 8.0	5.3 ± 1.7	10.6 ± 2.3
F	.000	.000	.000	.000	.002	.001

3. Dry matter yield and resistance to overgrazing

As reported in Table 3, Jameen was the most productive accession with accumulation of 513.3 ± 25.2 g of dry matter, whereas it's density was about 0.8 ± 0.3 kg/m^2. The lowest productivity was observed for Industrial-Zone accession with a 254.7 ± 9.5 g but followed by a high density about 1.7 ± 0.7 kg/m^2. Accumulation of dry matter after 3 cycles of cutting shows that Gaed and Jemeen accessions were the most tolerant to overgrazing with respectively 940.3 ± 37.4g and 866.7 ± 32.5 g of accumulated dry matter (Table 3).

Table 3. Dry matter yield and resistance to overgrazing (OVG) for different accessions

Ac	BV	DM	OVG	DEN
Indust. Z.	0.166 ± 0.064	254.7 ± 9.5	501.7 ± 25.6	1.7 ± 0.7
Gaed	0.772 ± 0.081	492.7 ± 8.0	866.7 ± 32.5	0.6 ± 0.1
Jameen	0.675 ± 0.299	513.3 ± 25.2	940.3 ± 37.4	0.8 ± 0.3
Aja	0.368 ± 0.052	392.7 ± 6.4	654.6 ± 14.9	1.1 ± 0.2
Zaitoun	0.229 ± 0.016	337.3 ± 22.7	580.8 ± 36.4	1.5 ± 0.2
Average	0.442 ± 0.277	398.1 ± 100.8	708.8 ± 29.3	1.2 ± 0.5
F	0.000	.000	.069	.027

4. Correlation between parameters

Dry matter yield (DM) was highly and positively correlated with plant length (PL) and plant diameter (PD). Whereas a negative correlation was observed with the number of branch per stem (BN) (Table 4). No correlation was observed between germination percentage (GER) and all the morphological and yield parameters assessed.

Table 4. Correlations between parameters assessed

	PL	PD	ST	LL	BN	SP	DM	DEN	GER
PL	1								
PD	.915**	1							
ST	.725**	0.437	1						
LL	.821**	.638*	.863**	1					
BN	-.578*	-0.478	-.566*	-.744**	1				
SP	.549*	0.411	.594*	.700**	-.568*	1			
DM	.892**	.925**	.565*	.794**	-.587*	0.454	1		
DEN	-.859**	-.902**	-.515*	-.633*	0.427	-0.512	-.783**	1	
GER	-0.21	-0.113	-0.251	-0.194	-0.343	0.062	-0.217	0.049	1

**: Correlation is significant at the 0.01 level.

*: Correlation is significant at the 0.05 level.

IV – Conclusions

Cenchrus ciliaris, a very endangered species in Saudi Arabia, showed a high diversity in germination parameters as well as in morphological and yield traits. From the five studied accessions, Aja accession has the highest percentage of germination in distilled water and in low salt concentration, so it can be introduced on moderate salty soil. Regarding dry matter yield, despite its poor germination, Jemeen is considered as the most vigorous accession with a productivity of 513g/individual. This yield was higher than reported by Mseddi *et al*., (2003). This work allows to select Jemeen and Gaed as the most tolerant accessions to overgrazing. These two accessions suggested to be introduced in degraded rangelands.

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