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Full Length Research Paper

The performance of six exotic perennial grass species in the central region of Saudi Arabia

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ABSTRACT

The establishment, dry matter production and feeding value of six perennial grasses were measured over two growing seasons in a field experiments. The experiments were conducted at the Agricultural and Veterinary Medicine Research Station, Faculty of Agriculture and Veterinary Medicine, Qassim University, Kingdom of Saudi Arabia in 2009 and 2010 seasons. The six perennial grasses were: Creeping bluegrass (*Bothriochloa insculpta*, cv Bisset), Digit grass (*Digitaria smutsi*), Jarra digit grass (*Digitaria milanjiana*), Panic (*Panicum coloratum* , cv Bambatsii), Sabi grass *(Urochloa mosambicensis*) and Setaria (*Setaria sphacelata*, cv Kazungula). The experimental design used was a completely randomized block design with four replications. The results revealed significant differences among plant species of all agronomic characters and quality traits in the first year, while in the second year, plant species were differed significantly for quality traits only. *D. smutsi* had a superior performance for all agronomic characters, however, it had the lowest values in protein content in the two years comparing with other genotypes. *D. milanjiana* and *U. mosambicensis* showed high values in dry matter yield and protein content in the first year, but showed a very poor performance in the second year because most of plants were die due to the low temperatures in the winter. These two species appear to be suitable for annual cultivation. The other species tolerate the cold winter and were a highly productive in the second year.

Key word: Dry mater yield, grass species. cuts, quality traits, crude protein content

INTRODUCTION

The expansion of animal production in the Kingdom of Saudi Arabia has derived the demand for forage very high. The Kingdom of Saudi Arabia is characterized by a large number of livestock (camels, sheep, goats and cattle) which are estimated to exceed 3.5 million heads that are raised on poorly dry desert rangel and (Bakhashwain 2010). Alfalfa (*Medicago sativa*) consider the main fodder crops, represent 56% of the total forage acreage, while rhodes (*Chloris gayana*) and blue banic (*Panicum antidotale*) represent most of the remaining acreage. Alfalfa do not occur naturally and are not adapted to the prevailing harsh conditions of drought, temperature and salinity. It require vast quantities of water (up to 45000 m^3 ha^{-1} $year^{-1}$) often derived from nonrenewable ground watersources (Al-Doss, 1997).The central region of Saudi Arabia is dominantly a desert environment. Climate in this region is hot with average maximum temperatures during summer ranging between 41 to 48 °C, and annual rainfall between 100 to150 mm. Agriculture systems are mostly dependent on irrigation using water extracted from aquifers. The physical environment can be a major limiting factor in growth, productivity and survival of plants. (Sasani et al., 2004). Two major constraints to optimum productivity are quantity and quality of feed. If either is limiting, the animal may not be able to produce to its genetic potential. Yields of the grass vary depending on genotypes (Schank et al., 1993; Cuomo et al., 1996; Mirza et al., 2002; Gillen and Berg,2005; Arshadullah et al.,2009; Wijitphan et al., 2009 ; AL-Ghumaiz and Motawei 2011), climatic factors and management

Table 1. Mechanical and some chemical properties of the soil for experimental site before planting

Mechanical analysis			Chemical analysis					Soil Texture Class
Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})	EC (ds m^{-1})	pH	N (mg kg^{-1})	P (mg kg^{-1})	K (mg kg^{-1})	
646.8	253.7	99.6	0.77	9.54	6.99	3.98	85.73	Sandy lomy

practice (Chaparro et al., 1995; Woodard and Prine, 1993 Chaparro et al., 1996;).

Previous studies indicated that producers should select cultivars that originate from a location with similar climatic conditions (Warnock et al., 2005). Since the indicated species have adaptation to wide range of environmental conditions, producers in Saudi Arabia could benefit from growing such species in their agricultural systems (AL-Ghumaiz and Motawei 2011). However, there is no research available to make a valid recommendation on how these species perform under excessive high and low temperature in the central region of Saudi Arabia.

Although the amount of forage, feed or fodder available to an animal is important, the quality therefore will determine if the animal is taking in enough nutrients to maintain health, growth and reproduction. Each class of animal has a specific crude protein requirement per day. If this requirement is not met, growth and hence production can be seriously affected. Protein shortages are of major concern to rumen production systems. Protein source are, however, expensive to buy, and the farmer would like to get as much as possible crude protein from the pasture itself (Van Niekerk, 1997). Forges when harvested at early stages of their development have relatively higher crude protein content, ether extract and ash contents but crude fiber, acid detergent, lignin, hemi-cellulose and cellulose increase with later harvesting resulting in decreased dry matter digestibility (Mirza *et al*, 1986). For cereal forages and grasses, it has been established that dough stage is the most appropriate stage to make a compromise between dry matter yield and forage quality (Qamar *et al*, 2000).

Despite differences in yield and quality over species and time, one should identify species with a natural higher fodder quality and or somehow improve the fodder quality of low quality species (Van Niekerk, 1997). Dannhauser (1991) concluded that the crud protein content of grass species is influenced by soil type. Nutrient content of the soil can thus play significant role in the crud protein content of species and the crud protein content of a species can thus vary from one location to the next. Hefer and Tainton (1990) and Goldman and Springer (2011) reported that, there were significant differences among grass species. The crude protein content of herbages derived from grasses is considerably low(Ram and Parihar, 2008). Van Niekerk (1997) indicated that grass high crud protein content, often produce lower yields. The crud protein content of some grasses ranged from high (15-25%) to low (3-5%) (Olsen,1972; Rodel and Boultwood, 1981; Grunow and Rabie, 1985; Pieterse et al., 1989; Dannhauser, 1991, Snyman, 1994; Singh et al., 1995, Chobtang et al.,1996 and Pieterse et al.,1997). The objectives of this research were to evaluate six exotic grasses for yield and forage quality at the environmental conditions of the Central Saudi Arabia and select out yield and agriculture characters of different grass species

MATERIALS AND METHODS

Site description and trial establishment

Field experiments were conducted under irrigation conditions during 2009 and 2010 seasons at Qassim University Agricultural Research and Experimental Station (26° 18 28 N, 43°̊ 46 E). Soil samples from the experimental site were taken before planting for mechanical and chemical analysis. Soil was analyzed at Qassim University Soil Testing Laboratory, Soil samples from the experimental site were taken before planting for mechanical and chemical analysis according to Klute (1986) . soil properties are shown in Table 1. Average daily maximum and minimum temperatures and relative humidity for 2009 and 2010 growing seasons are presented in Table 2.

Six perennial grass species were compared for their productivity and quality characters under sprinkler irrigation system. The six perennial grasses were: Creeping bluegrass (*Bothriochloa insculpta*, cv Bisset), Digit grass (*Digitaria smutsi*), Jarra digit grass (*Digitaria milanjiana*), Panic (*Panicum coloratum* , cv Bambatsii), Sabi grass *(Urochloa mosambicensis*) and Setaria (*Setaria sphacelata*, cv Kazungula). The grass species were Planted in March 2, 2009 using a randomized complete block design with three replications. Each plot consisted of ten rows, 2.0 m long and 20 cm apart. Thus, the area of each plot was 4.0 m^2. The all recommended package of cultural practices was followed.

Sampling and laboratory analysis

The agronomical studied characters were plant height, dry weight yield and leaves: stems ratio. Leaves stems ratio was determine from 1^{st} , 2^{nd} and 3^{rd} cuts in 2009

Table 2. Monthly mean air temperature and mean relative humidity (RH %) at the experimental sites for the two seasons.*

Month	2009 season			2010 season		
	Temperature °C		RH %	Temperature °C		RH %
	Mean	Extreme		Mean	Extreme	
Jan.	-	-	-	16	3-31	58
Feb.	-	-	-	19	0-34	46
Mar	20	7 -35	26	22	8-39	35
Apr	26	9 -42	35	27	13-41	48
May	31	18 -44	25	32	17-45	34
Jun	35	24 -46	19	36	23-47	18
Jul	34	23 -47	18	37	23-48	20
Aug	36	23 -47	18	37	24-47	19
Sep	33	21 -47	23	34	21-47	22
Oct	27	12 -40	40	29	16-41	30
Nov	21	5 -37	73	20	5-36	35
Dec	16	5 -28	53	15	1-28	46

* Source, according to Presidency of Meteorology & Environmental

season only. Forage biomass samples were hand clipped within a 0.25 m^2 in the middle of each plot. The material was dried to constant mass for 48h at 65°C and weighted as dry matter yield (DMY), then converted into ton per hectare. In 2009 season, the plant species were cut six times while, in 2010 season five cuttings were made with 30 to 35 days interval between each one. Plant heights (cm) were determined by measuring the most representative area of each plot. After samples were taken of the grasses, while tufts were regarded as sub samples . These sub samples were sorted into leaves and stems. To make comparison possible, the dry matter leaves and stems were determined.

Dried materials were analyzed for the following parameters: Crude protein (%), crude fiber (%), sugar content (%), ether extract (%), and ash (%). Chemical analyses were done on the 1st and 3rd cuts in 2009 season, while in 2010 season were done on the 1st , 3rd and 5th cuts. Chemical analyses were completed at Forage Analyses Laboratory- Department of Animal Production and Breeding-Qassim University, according to procedures used by AOAC (1990). Foss TECATOR apparatus (Model:2300 Kjeltec) was used to measure Crude protein (%) and Model :Fibertec2010 for crude fiber (%) analysis.

Statistical analysis

Data collected for agronomic and quality characters was statistically analyzed according to the technique of analysis of variance (ANOVA) for one factor randomized complete block design (RCBD) combined over cuts to test the differences among, cuts and plant species. Where a significant F-test was found the mean values were separated using Duncan's multiple range test. Coefficient of variation (CV) was listed to measure the precision of the experiment. All analyses of variance were computed using the MSTATC microcomputer program (MSTATC, 1990). Two grass species (Jarra digit grass and Sabi grass), were excluded from data analyses in second year because it were very poor persistence and production after the first year due to most of plants were die in winter season.

RESULTS AND DISCUSSION

Yield characters

The number of grass species were six in the 2009 season, while in the 2010 season were four species only. Therefore, the results will be discussed in each year separately. The results presented in Table 3 revealed highly significant differences among cuts for plant height in the two years while, dry matter yield was significantly difference in the 2009 season only. The 3rd cut, , recorded the highest values for the two studied traits in the first year, while, the 6th one was vies versa. In the 2nd year the 4th and 3rd cuts recorded the highest and lowest values, respectively. Statically there was no difference for leaves: stems ratio among the three cuts. The productivity of species or cultivars depend especially of

Table 3. Effect of cuts, genotypes and their interaction on agronomic characters of grass species in two seasons.

Treatments	Plant height		Dry matter yield		Total DMY		Leaves: stems
	2009	2010	2009	2010	2009	2010	2009
Cuts(C)							
1	62.8a	50.8c	3.55b	4.93	-	-	1.48
2	52.9b	63.9bc	3.19b	5.76	-	-	1.79
3	66.3a	50.1c	4.67a	4.62	-	-	1.47
4	60.9a	81.5a	3.28b	5.79	-	-	-
5	59.2ab	65.8b	3.27b	5.21	-	-	-
6	35.5c	-	2.41c	-	-	-	-
Sig	**	**	**	ns			ns
Genotypes (G)							
B. insculpta	57.5bc	65.9	3.17c	5.37	19.0c	26.8	0.85d
D. smutsi	63.8a	59.4	4.01a	5.41	24.1a	27.1	1.55b
D. milanjiana	50.7d	-	3.13c	-	18.8c	-	1.34bc
P. coloratum	61.8ab	62.2	3.25bc	4.96	19.5bc	24.8	2.08a
U mosambicensis	50.2d	-	3.69ab	-	22.1ab	-	1.37bc
S. sphacelata	53.7cd	62.2	3.12c	5.31	18.7c	26.5	2.28a
Sig	**	ns	**	ns	**	Ns	**
Interaction							
C x G	**	ns	**	ns	-	-	**

Means (within same column) followed by similar letters are not significantly different at *P*= 0.05. for each factor

soil fertility, climatic conditions, and of the cutting or grazing management used. The differences among cuts may be due to change in climatic conditions through growth season. Gillette (2011) comparing dry matter yield between harvest date and found significant difference between cuts.

There were statistical differences among species for studied characters in 2009 season only. Gillen and Berg (2005) reported that, forage production was different among species in only 1 of 3 yr. The highest yielding and tallest plant species were recorded by, *D. smutsi* with average 63.8cm in height and 4.01t ha^{-1} cut^{-1} in yield and was statistically different than other species in dry matter yield except *U. mosambicensis* which had yield of 3.69 t ha^{-1} beer cut. The total dry matter yields presented in Table 3 represent the total above ground yields for each season. There were statistical differences among species for total dry matter yield in 2009 season. *D. smutsi* produced significantly the highest yield followed by *U. mosambicensis* which did not differ significantly. S. sphacelata produced lowest dry matter yield. *B. insculpta* , *D. milanjiana*, *P. coloratum* and *S. sphacelata* did not differ significantly from each 0ther. On average over two season *D. smutsi* produced more dry matter yield than other species. This result was in accordance with many other observations, which found significant differences among the studied genotypes (Marais et al., 2006; Suyama et al., 2007a and b; Gillette 2011 and AL-Ghumaiz and Motawei 2011).

The leaves : stems ratio trait was measured on three cuts only. There was no significant difference between cuts for leaves: stems ratio (Table 3). There was a statistically significant between species for leaves: stems ratio. All grasses species except *B. insculpta* had more leaves than stems based on average over the three cuts. *S. sphacelata* had the highest value for leaves : stems ratio, while, *B. insculpta* had lowest one. The partitioning of dry matter between the yield components (leaves and stems) often influences the acceptability of the forage for animals. Grazers prefer softer material, with less lignin, which is more easily digested. Aman and Lindgren (1983) found that the proportion of leaves in the total herbage mass not declining with the advance in grass growth during late summer. Moreover, Nissinen et al., (2010) reported that, the cutting date and the stage of development of timothy had statistically very significant effect on the proportion of leaves and stems ratio. Also, at the pasture stage more than half of dry matter yield consisted of leaves.

Regarding the interaction effects, only the significant effects will be discussed, specially the most interesting one. Data in Tables (4- 6) represented the effect of

Table 4. Effect of interaction between cuts and genotypes on plant height in 2009 season.

Genotype	Cut-1	Cut-2	Cut-3	Cut-4	Cut-5	Cut-6
B. insculpta	53.0	52.7	73.7	59.3	56.7	49.7
D. smutsi	84.7	48.7	84.0	68.3	59.0	38.0
D. milanjiana	50.0	44.7	62.0	57.3	66.0	24.3
P. coloratum	72.7	56.3	74.7	71.3	58.3	37.3
U mosambicensis	49.0	53.0	49.3	60.0	57.3	32.3
S. sphacelata	67.3	62.3	54.0	49.3	58.0	31.3
LSD	13.6					

Table 5 . Effect of interaction between cuts and genotypes on dry matter yield in 2009 season.

Genotype	Cut-1	Cut-2	Cut-3	Cut-4	Cut-5	Cut-6
B. insculpta	2.60	2.81	5.37	2.77	2.86	2.61
D. smutsi	5.40	3.03	6.23	3.69	3.22	2.49
D. milanjiana	2.04	2.64	4.63	2.97	4.30	2.22
P. coloratum	4.74	3.57	4.16	3.10	2.32	1.61
U mosambicensis	2.63	3.65	3.88	4.25	4.22	3.51
S. sphacelata	3.89	3.42	3.76	2.90	2.70	2.03
LSD	1.10					

Table 6 . Effect of interaction between cuts and genotypes on leaf stem ratio in 2009 season.

Genotype	Cut-1	Cut-2	Cut-3
B. insculpta	0.79	1.11	0.66
D. smutsi	1.33	2.10	1.21
D. milanjiana	1.37	1.19	1.45
P. coloratum	1.35	2.78	2.11
U mosambicensis	1.54	1.50	1.12
S. sphacelata	2.50	2.06	2.27
LSD	0.63		

interaction between cuts and genotypes on yield characters in 2009 season. *D. smutsi* had superior performance for plant height and dry matter yield in the 1st and 3rd cuts, while, *D. milanjiana* and *P. coloratum* recorded the shortest plant and lowest dry matter yield respectively, in 6th cut (Table 4-5). *P. coloratum* possessed the highest value for leaves to stems ratio in the 2nd cut, while *B. insculpta* had the lowest value in the 3rd cut (Table 6). Dry matter yield was correlated with plant height (r=0.76, P<0.00001). Thus, selection based on plant height may improve dry matter yield. Similer result was obtained by Sukhchain and Sidhu(1992). It is well known that the productivity of one species or cultivar depend especially on soil fertility, climatic conditions and the cutting management used.

Nutritive value

Data in Table 7 illustrate the effects of cuts, species and their interaction on quality characters. There was no significant difference between cuts on quality characters in the two years except for ash % in the two years and crud protein content in 2010 season which had significantly differed. Third cut, recorded the highest value in crud protein content. There were statistical differences among species for quality characters in the two season (Table 7). *P. coloratum* had lowest values for ash % and crud fiber % in the two year, while, possessed the highest values in most other cases. *B. insculpta* had the highest values for crud fiber in the two season. Many other researchers also concluded that there were a significant differences

Table 7. Effect of cuts, genotypes and their interaction on quality characters in two seasons.

Cuts	Ash %		Crud fiber%		Ether extract %		Crud protein%		sugar content	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Cuts										
1	13.8	9.6b	29.3	31.0	1.88	1.60	11.9	7.1b	42.3	47.3
3	11.4	11.0a	31.7	31.1	1.81	2.06	11.2	10.2a	42.8	43.0
5	-	8.9b	-	33.0	-	2.05	-	8.4b	-	44.6
Sig	**	**	ns	ns	ns	ns	ns	**	ns	ns
Genotype										
B. insculpta	11.2c	9.4b	34.5a	34.7a	1.71b	1.89b	10.2c	7.6b	41.5b	43.5b
D. smutsi	11.7c	9.5b	34.0a	34.5a	1.51bc	1.55c	9.5c	7.7b	42.4b	43.9b
D. milanjiana	14.0b	-	27.9cd	-	1.81b	-	12.8ab	-	42.4b	-
P. coloratum	9.9d	8.2c	29.3bc	28.4b	2.25a	2.20a	11.6bc	9.8a	46.1a	48.2a
U.mosambicensis	15.5a	-	27.6d	-	1.33c	-	14.2ab	-	40.5b	-
S. sphacelata	13.3b	12.2a	29.6b	29.1b	2.47a	1.98ab	11.0bc	9.3a	42.6b	44.3b
Sig	**	**	**	**	**	**	**	**	**	*
Interaction										
C x G	**	*	**	ns	ns	ns	ns	ns	ns	ns

Means (within same column) followed by similar letters are not significantly different at *P*= 0.05 for each factor.

Table 8 . Effect of interaction between cuts and genotypes on ash % in two season and fiber % in 2009 season.

Genotype	Ash % (2009)		Ash % (2010)			Crud fiber % (2009)	
	Cut-1	Cut-3	Cut-1	Cut-3	Cut-5	Cut-1	Cut-3
B. insculpta	12.7	9.7	7.9	9.9	10.4	32.9	36.0
D. smutsi	13.1	10.4	9.8	11.0	7.6	33.0	35.0
D. milanjiana	15.8	12.1	-	-	-	24.9	31.0
P. coloratum	9.9	9.9	8.3	9.2	7.1	29.1	29.6
U mosambicensis	17.9	13.0	-	-	-	26.1	29.2
S. sphacelata	13.5	13.2	12.4	13.8	10.4	30.0	29.2
LSD	1.39		1.95			2.08	

among genotypes (Ray et al., 1996; Mirza et al.,2002; Gul,2006; Smar et al., 2006; Selim, 2008; AL-Ghumaiz and Motawei, 2011 and Gillette, 2011). A comparison of the crude protein contents (Table 7) indicates slightly higher crude protein in 2009 season than 2010 season. Albayrak et al.,(2011) reported that crude protein of all grass species decreased in the second season than in the first one. *U.mosambicensis*, showed higher value of crude protein but insignificant with *D. milanjiana* , *P. coloratum* and *S. sphacelata*. Although, *D. smutsi*, survived under high summer temperatures and low winter temperatures and provided the highest dry matter yield, yet it was the lowest in crude protein and the highest in crud fiber. However, this could be substantially improved with the intercropping of legumes. These results go with the observations of Mueller and Orioff,1994 , Moyer et al., 2003 and AL-Ghumaiz and Motawei 2011 which found that forage quality factors were negatively correlated with yield.

There were statistical differences for the interaction between cuts and plant species for ash % in the two season and crude fiber in 2009 season (Table 8). *U mosambicensis* and *S. sphacelata* recorded the highest values in ash % in 2009 and 2010 seasons, respectively. *B. insculpta* and *D. smutsi* possessed the highest values of crude fiber of the two cuts in 2010 season. Meanwhile, *D. milanjiana* had lowest value in first cut, but it had intermediate value in the second cut. The significant interaction between cuts and plant species in crude fiber was mainly due to the opposite responses of the *D. milanjiana* and *S. sphacelata* (Table 8). Gillette (2011) found clear and significant response in the 15 cool-season grasses tested in regards to species and harvest timing interaction to quality characters.

CONCLUSION

The results obtained in this work allowed to conclude that a variation between grass species in their adaption under high summer and low winter temperatures was found. *D. milanjiana* and *U. mosambicensis* proved high values in dry matter yield and highest values of crud protein in first year, but showed very poor persistence and production after the first year, these two genotypes appeared best suited to short term ley (1- year). Other grasses were persisted well and were high productive in second year suggesting their suitability for longer term leys (2+ years). These grasses exhibited excellent yield stability during the two years course of study and appeared to be well adapted to the central region of Saudi Arabia. The *D. smutsi*, provided the highest dry matter yield, but it was the lowest in quality, this could be substantially improved with the intercropping of legumes.

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