Annual Research & Review in Biology
5(4): 293-298, 2015, Article no.ARRB.2015.032
ISSN: 2347-565X

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Forage Quality Variations among Some Sudan Pearl Millet [*Pennisetum glaucum* (L.) R. Br] Collection

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Authors' contributions

This work was carried out in collaboration between all authors. Author SAB designed and carried out the field work, performed the statistical analysis and wrote the first draft of the manuscript. Author MAMK was involved in protocol setup, in the field work and revised the first draft of the manuscript. Author ISAT was involved in field work, revised the first draft and managed the literature searches. Author FMAE managed the proximate analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2015/12575
Editor(s):
(1) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.
Reviewers:
(1) Leila Radhouane, Agronomy, National Institute for Agricultural Research, Tunisia.
(2) Vitalis Temu, Agricultural Research Station, Virginia State University, Petersburg, VA 23806, USA.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=702&id=32&aid=6521

Original Research Article

Received 7th July 2014
Accepted 27th July 2014
Published 14th October 2014

ABSTRACT

Aims: This experiment aimed at identification of some forage-quality attributes of Sudan pearl millet (*Pennisetum glaucum* L.) collection for possible future utilization.
Study Design: Randomized Complete Block Design (RCBD) with three replications.
Place and Duration of Study: The analysis was carried out at the feed analysis laboratory, Elobeid Research Station of Agricultural Research Corporation (ARC), Elobeid, Sudan.
Methodology: The selected accessions (42 rainy sown and 38 winter sown) for proximate chemical entities were from 100 pearl millet accessions evaluated for dry matter yield in two field trials. Prior to the proximate quality analysis, the dried samples were ground and oven dried once again. The dried samples were used in 3 replicates for the proximate analysis to determine crude protein (CP), crude fiber (CF) and Nitrogen Free Extract (NFE).
Results: Among the studied accessions, nine (in both rainy and winter seasons) had Crude protein (CP%) more than 9%. Nineteen accessions (in rainy) and 36 (in winter) had Crude fiber (CF%) less than 40%, whereas 25 (in rainy) and 32 (in winter) had Nitrogen free extract (NFE%) more than

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40%. Among the CP-based top ranking 10 accessions, some combined high crude protein yield (CPY) with high quality attributes across both seasons. For instance, HSD 2243 was associated with highest CP (16.2%), high CPY (1.72 t/ha) and low CF (30.6%). HSD 2146 was associated with adequately high CP (11.1%), high CPY (1.07 t/ha), low CF (35.2 %) and high NFE (50.5%) and HSD 2231 was associated with comparatively lower CP (9.7%), but with high CPY (0.9 t/ha), low CF (29.2 %) and high NFE (49.2%).

Conclusion: Some accessions of pearl millet *viz*, HSD 2231, HSD 2243 and HSD 2146 with high forage yield and high forage quality across both seasons were identified. These accessions with their high CP% and high crude protein yield in both seasons could further be evaluated for multiple cutting over both seasons.

Keywords: Crude protein; Pearl millet [Pennisetum glaucum (L.) R. Br]; quality variations.

1. INTRODUCTION

Despite the large livestock numbers in Sudan, advancement in animal production is challenged by a huge forage gap which is comprised mostly of the concentrates. The production of the concentrates however cannot be expanded under the current farming systems in the country [1]. A possible alternative to bridge such a gap therefore, could be through the production of large quantities of high quality forages. Being a subtropical country, the climate of Sudan is virtuously conducive for year round irrigated forage production. This in turn, has popularized to the farmers the cut and carry system over any forage conservation system. Under such situations, high quality forage crops which can withstand multiple cuttings are most suitable. Alfalfa (*Medicago Sativa* L) is currently the only multiple cut forage crop in Sudan. Its production however, is far below the demand because it is limited by being mostly confined to Khartoum State and northward.

The current alternative crops to alfalfa are mostly single cut seasonal crops such as *sorghum bicolor* cv. Abu Sabeen, Maize (*Zea mays* L) and barley (*Hordeum vulgare*). Abu Sabeen is summer sown, barley is winter sown, while maize is winter sown in Khartoum State and northward and rainy season sown in the central Sudan. Some rainy season sown tropical legumes are also available.

In contrast to those seasonal crops, pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a valuable forage crop [2] due to its high photosynthetic efficiency and biomass production ability, fewer disease and insect pest problems, and tolerance to multiple environmental stresses. It is adapted to nutrient poor soil and low rainfall conditions [3] and does not lose nutritive value even in some conditions (high water salinity). It is therefore, commonly grown in the arid and semi-arid regions of Africa and India as a staple food for millions of people and animal feed [4]. In Sudan, it is indigenous to the country [5], showed to be successful in rainy, winter and summer seasons [6] and tolerant to multiple cutting [7].

Compared to other cereals, the CP% of the dry matter of maize, forage sorghum, Sudan grass, grain sorghum and pearl millet were 9.6, 9.6, 9.6, 11.3 and 15%, respectively [8]. In Australia, the CP% of four varieties of pearl millet was higher than that of Sudan grass and ranged from 13% to 19.7% [9]. Hence, the existence of similar variations in the forage quality attributes among Sudan pearl millet collections is plausible and worth of studying. Therefore, the objective of this study aimed at the exploration of quality related variations among certain rainy and winter sown pearl millet accessions of Sudan collection for possible future utilization.

2. MATERIALS AND METHODS

The accessions used for the proximate quality analysis in this study were selected from 100 accessions (obtained from the Genetic Resource Unit of the Agricultural Research Corporation, Sudan) evaluated for phenotypic traits during the rainy and winter seasons of 2008/2009 at the Gezira Research Station Farm (GRSF) of the Agricultural Research Corporation (ARC), Wad Medani, Sudan (latitude 14º 24 N, longitude 33º 29 E and altitude 406.9 m above sea level). The full text including detailed materials and methods and all relevant phenotypic traits for those experiment were thoroughly described [6]. The number of accessions used for the proximate analysis were 42 in the rainy season and 38 in the winter season. The analysis was carried out at the feed analysis laboratory, Elobeid Research Station. Prior to the proximate quality analysis, the samples were ground and oven dried. The design used was Randomized Complete Block Design (RCBD). The dried sample was used in 3

replicates for the proximate analysis [10] to determine crude protein (CP), crude fiber (CF), nitrogen free extract (NFE) and Ether extract (EE). Duplicate samples of 2.5 grams each, were dried overnight at 100ºC to determine the DM%. Crude protein was calculated from total nitrogen content. Ash content was obtained by burning duplicate samples of 2.5 grams of DM at 540 – 550ºC in a muffle furnace for three hours. Organic matter (OM) was obtained by DM less the ash. Nitrogen free extract (NFE) was obtained by subtracting the sum of CP, CF and EE from OM contents.

Statistical analysis was done by the standard analysis of variance (ANOVA) using the IRRISTAT for windows (version 5.0) software. Data for each season were analyzed separately.

3. RESULTS

The studied accessions differed in all of the parameters of the proximate quality analysis during both rainy and winter seasons (Table 1). The data on ash and EE% were utilized in the calculation of the NFE but are not shown in this paper. Taking CP at 9%, CF at 40% and NFE at 40% as yard sticks, 9 accessions had high CP% in both seasons, 19 (in rainy) and 36 (in winter) had low CF% and 25 (in rainy) and 32 (in winter) were high in NFE% (Table 1). The number of accessions that had crude protein yields more than 0.5 t/ha was 23 in rainy and 22 in winter seasons.

The top 10 (CP% based) ranking accessions of pearl millet were the same in both winter and rainy seasons (Table 2). Their CP% ranged from 8.7 to 13.8 and from 8.9 to 18.6 during rainy and winter seasons, respectively. The highest CP across both seasons viz, 16.2% was that of HSD 2243. Other accessions with high CP% were HSD2106 (11.35%), HSD 2159 (11.35%) and HSD 2146 (11.05%). Based on both seasons mean, the highest crude protein yields (1.717, 1.072, 0.900 and 0.858 t/ha) were obtained by accessions HSD 2243, 2146, 2231 and 2105, respectively.

Crude fiber (%) ranged from, 30.8 to 54.4 in rainy and from 26.5 to 39.6 in winter seasons, whereas NFE (%) ranged from 24.6 to 50.0 in rainy and from 33.8 to 50.9 in winter seasons (Table 3). Considerable variation in CF and NFE were found among the top ranking 10 accessions of both seasons, but generally lower crude fiber and high nitrogen free extract were associated with high crude protein. Based on the two seasons mean, accessions HSD 2231, 2243 and 2146 were characterized with low crude fiber (29.2, 30.6 and 35.2%, respectively), while accessions HSD 2231 and 2146 were characterized with highest NFE (49.2 and 50.5%, respectively).

4. DISCUSSION

The annual forage gap in Sudan is estimated at more than 28 million tons [1]. Eighty two percent of that however (viz 23 million ton), is in the form of production ration (i.e. concentrates). Under the current crop production system, expansion in the production of the concentrates in Sudan seems unlikely. The situation is being more aggravated by the rising tendency to export alfalfa hay. An alternative way to minimize the gap of the concentrates in Sudan, therefore, should rely on the horizontal and vertical expansion in the production of high quality forages. It is from this point of view, the significance of pearl millet in playing such a role could be appreciated.

Despite the wide quality variations among the studied pearl millet accessions, sizable number of them encompassed both high crude protein yields and good forage quality aspects. The CP% of a number of accessions was higher than that of Abu Sabeen and maize in Shambat [11], in the Gezira [12] and higher than those of Sudan grass and maize in the USA [8]. The CP of some accessions (in rainy and winter seasons) compared closely with those of four varieties of pearl millet in Australia [9], two varieties of pearl millet in Saudi Arabia [13] and one variety of pearl millet in Egypt [4]. The CP% of four accessions *viz* HSD 2243, 2146, 2231 and 2105 in both rainy and winter seasons, were as high as that in the grain of most sorghum varieties in Sudan [14]. The lowest CP% within the 10 top ranking accessions on the other hand, was higher than the lowest acceptable for a forage crop [15].

As a matter of fortune, the 10 top ranking accessions (based on CP%), were the same in both rainy and winter seasons. The presence of winter adapted high yielding and high quality pearl millet accessions offer a good option for farmers to grow forage during the winter in the central Sudan. This is particularly important as the winter yields of Abu Sabeen and maize [12], Abu Sabeen [16] and Abu Sabeen and maize in Shambat [17] were suboptimal. Accessions such as HSD 2243 with high CP%, low CF% and high crude protein yields, HSD 2146 with high CP%, high NFE% and high crude protein yield and

Table 1. The frequency distribution of CP% (A), CF% (B), NFE% (C) and CPY (D) of pearl millet accessions grown during rainy and winter seasons of 2008

Season	Mean	SD	Frequency distribution						
			A						
			>3-<5	≥5-<7	≥7-<9	≥9-<11	≥11-<13	≥13-<15	>15
Rainy	7.064	2.548	13	10	10	5	3	1	-
Winter	7.345	3.015	9	10	10	5	3	-	1
			B						
			<30	≥30-<40	≥40-<50	≥50-<60			
Rainy	40.9	7.52	2	17	17	6			
Winter	32.526	5.457	14	22	2	-			
			C						
			<30	≥30-<40	≥40-<50	≥50-<60	>60		
Rainy	40.886	7.978	5	12	20	5	-		
Winter	48.121	6.924	-	6	14	17	1		
			D						
			<0.2	≥0.2-<0.5	≥0.5-<0.8	≥0.8-<1.1	≥1.1		
Rainy	0.275	0.475	-	19	14	8	1		
Winter	0.588	0.421	2	14	12	7	3		

SD: Standard Deviation

Table 2. Crude protein (%) and crude protein yield (t/ha) of the top ranking 10 accessions[§] of pearl millet grown in rainy and winter seasons in the Gezira Research Farm 2008/2009

Accessions	Crude protein (%)			Crude protein yield (t/ha)		
	Rainy	Winter	Mean	Rainy	Winter	Mean
HSD 2243	13.8	18.6	16.2	1.101	2.332	1.717
HSD 2106	11.5	11.2	11.4	0.462	0.887	0.675
HSD 2159	11.4	11.3	11.4	0.915	0.581	0.748
HSD 2146	11.0	11.1	11.1	0.843	1.301	1.072
HSD 2027	10.8	9.6	10.2	0.924	0.196	0.560
HSD 2105	10.3	10.8	10.6	0.796	0.920	0.858
HSD 2144	9.8	9.4	9.6	0.795	0.622	0.709
HSD 2231	9.7	9.7	9.7	0.757	1.042	0.900
HSD 2121	9.6	9.3	9.5	0.613	0.541	0.577
HSD 2221	8.7	8.9	8.8	0.219	0.981	0.600
Mean	10.7	11.0	10.8	0.743	0.940	0.842
SE±	0.45	0.28		0.132	0.243	

[§]*Accessions were ranked according to the CP% in Rainy season*

Table 3. Crude fiber (%) and nitrogen free extract (%) of the top ranking 10 accessions of pearl millet grown in rainy and winter seasons in the Gezira Research Farm 2008/2009

Acessions	Crude fiber (%)			Nitrogen free extract (%)		
	Rainy	Winter	Mean	Rainy	Winter	Mean
HSD 2243	30.8	30.4	30.6	44.7	33.8	39.3
HSD 2231	31.6	26.7	29.2	47.8	50.6	49.2
HSD 2121	34.5	39.6	37.1	45.4	39.7	42.6
HSD 2105	35.0	39.3	37.2	42.6	37.7	40.2
HSD 2146	43.5	26.8	35.2	50.0	50.9	50.5
HSD 2027	46.3	36.9	41.6	28.8	40.3	34.6
HSD 2144	46.3	29.7	38.0	32.1	49.1	40.6
HSD 2106	47.1	32.2	39.7	30.4	44.6	37.5
HSD 2159	47.6	39.5`	43.6	29.1	36.5	32.8
HSD 2221	54.4	33.4	43.9	24.6	45.4	35.0
Mean	41.7	32.8	37.6	37.6	42.9	40.2
SE±	0.90	0.38		2.92	0.84	

HSD 2231 with low CF%, high NFE%, high CPY, but with comparatively lower CP% in both rainy and winter seasons, offer materials for seasonal production or/and pan seasonal production of forage. Furthermore, as pearl millet can withstand multiple cutting [7] these three accessions could be tested for multiple cutting across both seasons. Pearl millet with such high quality attributes together with its suitability for growing under irrigation during rainy and/or winter is almost all central Sudan, offers a highly likely solution to bridge the big concentrated forage gap in Sudan.

5. CONCLUSION

In conclusion, some accessions of pearl millet *viz*, HSD 2231, HSD 2243 and HSD 2146 with high forage yield and high forage quality across both seasons were identified. These accessions with their high CP% and high crude protein yield in both seasons could further be evaluated for multiple cutting over both seasons

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=702&id=32&aid=6521