Scientific Research and Essay Vol. 2 (8), pp. 330-337, August 2007
Available online at http://www.academicjournals.org/SRE
ISSN 1992-2248 © 2007 Academic Journals

Full Length Research Paper

Potential of locally developed forage sorghum hybrids in the Sudan

Maarouf I. Mohammed

Shambat Research Station, ARC, P. O. Box 30, Khartoum North. Sudan. E-mail: ibrahimarof@yahoo.com

Accepted 4 July, 2007

The study was conducted at two locations (Shambat and Islang) during two years (2002-2003) in Khartoum State with an objective to investigate the possibility of development of local forage hybrid sorghum [*Sorghum bicolor* (L.) Moench]. The material comprised four local stocks (used as pollinators) and seven introduced genetic stocks (used as females) in A_3 cytoplasm and 'Pannar 888' as standard check. The study revealed highly significant differences among entries for all the characters studied as many hybrids excelled their parental lines in forage yield and in some of the yield-related traits. Hybrids: E-35-1 x S. 70, E-35-1 x S. 186, E-35-1 x Garawi and Dale x S.70 significantly out-yielded the check hybrid 'Panar 888' as well as the parental lines derived from the local cultivar 'Abu Sab'in'. The increase in yield of these hybrids was related to an increase in their stem diameter and plant height. The standard check, Pannar 888 excelled the newly developed hybrids in leaf: stem ratio, tillering and regrowth ability. The data obtained demonstrate the possibility of developing local hybrids having superior forage yield to both the introduced hybrids and the traditional cultivar Abu Sab'in. Apart from earliness, a potential exists for developing hybrids combining greater forage yield and desirable traits.

Key words: Hybrid, sorghum, forage, regrowth, potential, Ankolib, Rubatab, Shambat.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L). Moench] is the most important irrigated forage crop in the Sudan. A part from the natural vegetation, the sorghum straw accounts to the bulk of the animal feed in the country (Bacon, 1948). The traditional forage sorghum cultivar 'Abu Sab'in' covers the majority of the land cropped to forage in the country. Being a traditional cultivar, it is a highly mixed, with dry non-sweet stems and suffers from low forage yield during winter season.

Development of improved grain crops has been the focus of breeding efforts since the inception of research work in the Sudan with Little or no attempts made to develop improved forage types. The result was that and up to date, no locally forage hybrid was developed and released in the country. The research efforts to develop grain sorghum hybrids were, however, started more than two decades ago by the Agricultural Research Corporation (ARC) in the frame work of ICRISAT-Sudan Project. These efforts culminated in the release of the first Sudan-grain sorghum hybrid in 1983 (Ejeta, 1983). The released hybrid has poor forage value and as a result, all sorghum hybrid forages currently in use are introduced from outside. The first introduced hybrid ('Pioneer 988' from Pioneer International Co.) was released by the ARC in 1989. Few years later, Its Company ceased to operate in the Sudan and the hybrid was no longer marketed. Some introduced hybrids were later tested and released by the ARC. These were: 'Speedfeed' and 'Jumbo' from Pacific Seed Co., 'Pannar 888' from Pannar Seed Co. and 'Saf-ed Moti' from Proagro Seed Co. Although these hybrids are good forage yielders, the farmer's preference was, however, in favor of the traditional cultivar Abu Sab'in. Most of the introduced hybrids suit the grazing or silage-making systems; where as the prevailing system in the Sudan is the cut-and carry (green chopping) system. Other factors behind low adoption of introduced hybrids include unavailability and high cost of hybrid seeds as well as the lack of local multiplication of their seeds. This necessitated the development of locally adapted hybrids to enhance the adoption process and make available cheap seed. The objective of this study was to investigate the possibility of local development of forage sorghum hybrids using local stocks as pollinators and introduced genetic stocks as females.

Table 1. Genetic stock designation, recurrent parent and cytoplasm source of the seven female parents used as lines in the study.

Genetic stock	Recurrent parent	Cytoplasm source	Pericarp color	Mid-rib color
A3N166	Blue Ribbon	A3Tx 398	brown	green
A3N168	Hastings	A3Tx 398	brown	green
A3N169	E-35-1	A3Tx 430	white	green
A3N159	N 100	A3Tx 398	brown	green
A3N173	N 109	A3Tx 398	white	green
A3N154	Sugar Drip	A3Tx 398	brown	green
A3N151	Dale	A3Tx 398	brown	green

MATERIALS AND METHODS

Females (Lines): Twenty-nine forage sorghum genetic stocks in A3 cytoplasm together with their fertile counterparts were received from J. F. Pedersen, USDA-ARS, Department of Agronomy, University of Nebraska, USA. The females and their fertile counterparts were grown in the Experimental Farm of Shambat Research Station (Sh. R. S.) in July 2001. The females proved to be 100% male sterile under Shambat conditions. According to the performance of their fertile counterparts, seven male sterile lines were chosen to be used as females. The selection criteria were based on characters contributing to increased forage yield as well as quality attributes. The selected lines were: Blue Ribbon, Hastings, Sugar Drip, Dale, N100, E-35-1, and N109 (Table 1). The first five females were selected for their reasonable plant height and sweet-juicy stems. N 109 and E-35-1 were chosen for their apparent leafiness and white seed color (white seed color has seed-marketing preference).

Males (Testers): A source population comprising the two major types of the traditional cultivar 'Abu Sab'in' viz., 'Alyab' and 'Rubatab' was established in October 2000. About 200 single plant selections were made based on vigor, tallness, juiciness (green mid-rip), healthiness, early and late flowering plants. The progeny of each plant was tested in a breeding nursery established in July 2001. Of these, S. 70 of Alyab and S. 186 of Rubatab type were chosen to be used in this study. The other two testers were: 'Garawi', a cultivated forage type of Sudan grass (*Sorghum sudanense* (Piper) Stapf) and 'Ankolib', a local sweet sorghum cultivar, grown mainly for chewing the sweet stalks. Garawi and Ankolib are heterogeneous land race cultivars with broad genetic base, desirable for providing information about the general combining ability of a line. Abu Sab'in selections, on the other hand, are expected to show good performance in specific hybrid combinations with the selected lines.

Standard check: The introduced hybrid Pannar 888 was used as a standard check. It was characterized by combining earliness with high yield levels compared to other introduced hybrids.

The experiment: The experiment was grown for two years (2002 and 2003), at two locations in Khartoum State viz., Shambat (Experimental Farm of Sh.R.S. lat.15˚39' N; long. 32˚31'E) and Islang (lat. 15^{o} 53' N; long. 32^{o} 32' E). The soil at Shambat site is heavy clay with pH 8.5. The physical properties of Islang soil varies from silty clay to silty loam. The growing season of the year 2002 compared to that of 2003 was characterized by increased maximum temperature, reduced total rainfall and low relative humidity. In the year 2002, sowing date was on the 12th and 25th of July at Shambat and Islang respectively, while in the year 2003, it was on the 24th of June and 11th of July at Shambat and Islang respectively. Apart from that, the following methods and materials were similar across different environments.

The 28 hybrids together with their 11 parents plus the introduced hybrid 'Pannar 888' were arranged in RCB design with three replicates. The plot size was 7.5 x 0.7 m ridge. Three to four seeds were sown in holes spaced at 10 cm along the ridge. Nitrogen (urea) was applied two weeks after sowing at a rate of 55 kg N/ha. The experiment was weeded twice and watered every 7 to 10 days. Harvesting was carried out 15 days after each entry had completed 50% flowering, which simulates the local practice of harvesting forage sorghum in the country.

Data collection: Green matter yield (GMY): Recorded from 6.5 m harvested from each plot leaving 0.5 m at each side. Cutting was done at 5 to 7 cm above the ground level. Dry matter yield (DMY): Recorded from a random sample of 0.5 kg taken from the harvested plot after determining GMY and oven-dried at 75°c for 48 h. Days to flower: Recorded when 50% of the plants in the whole plot started to shed pollens. In each plot, plant height, stem diameter and number of tillers per plant was determined before harvest from five randomly chosen plants. Leaf: stem ratio (on dry matter basis) was recorded from three plants randomly selected from the harvested plot. Regrowth (g/m row) was evaluated after 15 days from the date of cutting for each treatment. Newly emerging shoots in three-meter row, randomly chosen from each plot were harvested, air-dried and the average dry weight per meter row was determined.

Statistical analysis: Before combined analysis, single analysis of variance was performed for all characters following the standard procedure of analyzing RCB design. The test of homogeneity of variance (Steel and Torrie, 1960) indicated that error variances over years were heterogeneous for three characters, namely: stem diameter, number of tillers per plant and regrowth. However, since their error variances over locations were homogeneous, a combined analysis over locations was carried for the three characters. The error variances of the remaining characters were homogeneous across years and locations; therefore, they were subjected to combine analysis over years and locations. Duncan multiple range test was used for mean separation.

RESULTS AND DISCUSSIONS

Mean squares from combined analysis (Tables 2 and 3) were large and highly significant for all characters studied; indicating that a considerable portion of the variability observed was due to entries. The entry x year interaction, unlike that with location, was highly significant for all characters, suggesting the need for testing over years rather than over locations. A number of hybrids showed significant improvement in forage yield and other desirable forage traits and excelled their parental lines and the check hybrid Pannar 888. In Table 4, the GMY of hybrids ranged from 29.8 to 50.1 t/ha and that of their parents from 16.5 to 38.6 t/ha. The DMY of hybrids ranged from 3.86 to 6.68 t/ha and their parents from 2.08 parents from 16.5 to 38.6 t/ha. The DMY of hybrids ranged from 3.86 to 6.68 t/ha and their parents from 2.08 to 4.91 t/ha

Table 2. Mean square of combined analysis over years (2002-2003) and locations (Shambat, Islang) for 5 characters in forage sorghum of the hybrids, their parents and the check hybrid.

Source of variation	d.f	Green matter yield (t/ha)	Dry matter yield (t/ha)	Days to flower	Plant height (cm)	Leaf: stem (%)
Locations (Lo)	1	1052.2**	15.7**	220.9**	19053.7**	1646.2**
Years (Yr)	1	459.3**	1.61 ^{NS}	2169.2**	1634.7*	204.0**
Blocks in Lo x Yr	8	64.0*	2.17**	65.1**	9680.2**	116.5**
Lo x Yr	1	17.0 ^{NS}	0.737^{NS}	47.9**	4624.0**	21.7 ^{NS}
Entry	39	843.9**	15.0**	718.2**	8660.7**	182.7**
Yr x Entry	39	69.8**	1.20**	29.7**	746.0**	19.2*
Lo x Entry	39	3.86 ^{NS}	0.053^{NS}	0.985 ^{NS}	60.2 ^{NS}	3.09 ^{NS}
Yr x Lo x Entry	39	3.59 ^{NS}	0.072^{NS}	1.18 ^{NS}	53.4 ^{NS}	4.38 ^{NS}
Error	312	30.6	0.651	6.35	255.4	12.0

*, **, = significant at 0.05 and 0.01 probability level respectively.
N.S. = non-significant at 0.05 probability level.

Table 3. Mean square of combined analysis over locations (Shambat, Islang) for three characters in forage sorghum of the hybrids, their parents, and the check hybrid, grown in 2002 and 2003.

Source of Variation	d.f.	2002			2002		
		No. of tillers/ plant	Stem diameter (cm)	Regrowth (g/m row)	No. of tillers/ plant	Stem diameter (cm)	Regrowth (g/m row)
Locations (Lo)	1	2.210*	0.944**	8833.1^{NS}	0.027 ^{NS}	0.843**	7392.6 ^{NS}
Blocks in Lo	4	9.891**	0.038**	62808.9 **	0.828**	0.016 ^{NS}	15055.1**
Entry	39	2.166**	0.317**	108782.8**	1.122**	0.187**	52845.4**
Lo x Entry	39	0.017 ^{NS}	0.007 ^{NS}	1227.6 ^{NS}	0.009 ^{NS}	0.003 ^{NS}	1406.0 ^{NS}
Error	156	0.265	0.018	10163.3	0.134	0.015	4320.0

*, **, = significant at 0.05 and 0.01 probability level respectively.
N.S. = non-significant at 0.05 probability level.

(Table 5). The multiple range test (Tables 4 and 5) showed that four of the newly developed hybrids significantly out-yielded the introduced hybrid Pannar 888 and the male parents derived from the traditional cultivar Abu Sab'in (S.70 and S.186) in forage yield. Three of these hybrids involved the female parent E-35-1 with S.70, S.186, and Garawi, while the fourth hybrid was Dale x S.70. The four hybrids performed consistently. The increase in for a-ge yield of these hybrids over Pannar 888 may be due to an increase in stem diameter and plant height (Tables 6 and 7). Stem diameter and plant height are reported to be among the main forage yield determinants in forage sorghum (Dharampal and Singh, 1973; Ibrahim and Orfi, 1996). The introduced check Pannar 888 excelled the four hybrids in stem diameter (fine stem), leaf: stem ratio, tillering and regrowth abilities (Tables 6 and 7). Such characters meet the requirements of grazing and hay making systems predominating in countries other than Sudan, whereas the locally adopted system here is green chopping (cut and carry). One of the four hybrids, namely, Dale x S.70 was significantly earlier than Pannar 888 (Table 6). Earliness is a desirable character under forage production system in the Sudan. Hybrids less productive than Pannar 888, but with comparable or sometimes better values for regrowth and leaf: stem ratio could be noticed (Tables 6 and 7) indicating the potential of the material in improving these traits. Some of the hybrids outyielding the parental lines derived from Abu Sab'in (S. 186 and S. 70) were also significantly better in leaf: stem ratio, tillering and regrowth abilities (Tables 6 and 7). These results confirm the possibility of developing hybrids excelling the traditional cultivar Abu Sab'in in forage yield and some desirable forage traits, however, earliness may be the only exception. When breeding for forage yield improvement, the choice for developing late or early flowering variety is determined largely by the system adopted for forage production. Late flowering varieties are usually preferred under grazing system to allow for prolonged utilization of pasture before the nutritive value is lowered by flowering. On the other hand, in Tables 4 and

Table 4. Green matter yield (GMY) of hybrids (entry no: 1-28), their parents, and the hybrid check (Pannar 888) averaged over years (2002-2003) and locations (Shambat, Islang).

Entry no	Name	Rank	GMY (t/ha) #	
1	E-35-1 x S.70	1	50.1	A
2	E-35-1 x S.186	2	48.8	AB
3	E-35-1 x Gerawi	3	48.3	AB
17	Dale x S.70	4	45.6	ABC
28	Sugar Drip x Ankolib	5	45.2	ABCD
5	Hastings x s.70	6	44.6	BCDE
4	E-35-1 x Ankolib	7	43.3	CDEF
12	Blue Ribbon x Ankolib	8	43.3	CDEF
21	N 100 x S.70	9	41.6	CDEFG
40	Pannar 888 (check)	10	40.3	DEFGH
16	N 109 x Ankolib	11	39.6	EFGHI
7	Hastings x Gerawi	12	39.2	FGHIJ
9	Blue Ribbon x S.70	13	38.8	FGHIJK
36	S.70 (male parent)	14	38.6	FGHIJKL
18	Dale x S. 186	15	38.6	FGHIJKL
20	Dale x Ankolib	16	37.9	GHIJKL
13	N 109 x S.70	17	37.7	GHIJKL
25	Sugar Drip x S.70	18	37.6	GHIJKL
37	S.186 (male parent)	19	37.0	GHIJKL
26	Sugar Drip x S.186	20	36.0	HIJKLM
24	N 100 x Ankolib	21	35.8	HIJKLM
8	Hastings x Ankolib	22	35.6	HIJKLM
10	Blue Ribbon x S.186	23	35.4	HIJKLM
14	N 109 x S.186	24	34.6	IJKLMN
6	Hastings x S.186	25	34.3	IJKLMN
11	Blue Ribbon x Gerawi	26	34.1	JKLMN
19	Dale x Gerawi	27	33.6	KLMN
15	N 109 x Gerawi	28	33.4	KLMN
23	N 100 x Gerawi	29	33.2	LMNO
22	N 100 x S.186	30	31.0	MNO
29	E-35-1 (female parent)	31	30.9	MNO
27	Sugar Drip x Gerawi	32	29.8	NO
38	Gerawi (male parent)	33	28.3	O
39	Ankolib (male parent)	34	23.5	P
30	Hastings (female parent)	35	22.4	P
34	N 100 (female parent)	36	22.1	P
31	Blue Ribbon (female parent)	37	21.7	P
35	Sugar Drip (female parent)	38	20.5	PQ
33	Dale (female parent)	39	20.1	PQ
32	N 109 (female parent)	40	16.5	Q
	Mean		35.2	
	Range: Hybrids		29.8-50.1	
	Range: Parents		16.5-38.6	
	LSD(0.05)		4.44	
	LSD(0.01)		5.79	
	CV (%)		15.7	

#: Means with letter in common are not significantly different at 0.05 probability level according to Duncan's multiple range test.

Table 5. Dry matter yield (DMY) of hybrids (entry no: 1-28), their parents, and the hybrid check (Pannar 888) averaged over years (2002-2003) and locations (Shambat, Islang).

Entry no	Name	Rank	DMY (t/ha) #	
1	E-35-1 x S.70	1	6.68	A
3	E-35-1 x Gerawi	2	6.54	AB
17	Dale x S.70	3	6.28	AB
2	E-35-1 x S.186	4	6.17	ABC
4	E-35-1 x Ankolib	5	5.88	BCD
21	N 100 x S.70	6	5.57	CDE
5	Hastings x s.70	7	5.44	DEF
16	N 109 x Ankolib	8	5.33	DEFG
28	Sugar Drip x Ankolib	9	5.26	DEFGH
40	Pannar 888 (Check)	10	5.20	DEFGH
13	N 109 x S.70	11	5.12	EFGHI
12	Blue Ribbon x Ankolib	12	5.09	EFGHIJ
18	Dale x S. 186	13	4.96	EFGHIJK
36	S.70	14	4.91	EFGHIJKL
9	Blue Ribbon x S.70	15	4.78	FGHIJKLM
25	Sugar Drip x S.70	16	4.75	FGHIJKLM
26	Sugar Drip x S.186	17	4.63	GHIJKLMN
14	N 109 x S.186	18	4.58	GHIJKLMN
8	Hastings x Ankolib	19	4.57	GHIJKLMN
20	Dale x Ankolib	20	4.49	HIJKLMN
37	S.186	21	4.48	HIJKLMN
24	N 100 x Ankolib	22	4.39	IJKLMN
19	Dale x Gerawi	23	4.33	JKLMN
29	E-35-1	24	4.28	KLMNO
7	Hastings x Gerawi	25	4.23	KLMNO
11	Blue Ribbon x Gerawi	26	4.20	KLMNO
10	Blue Ribbon x S.186	27	4.16	LMNO
23	N 100 x Gerawi	28	4.15	LMNO
15	N 109 x Gerawi	29	4.01	MNO
6	Hastings x S.186	30	3.99	MNO
22	N 100 x S.186	31	3.88	NO
27	Sugar Drip x Gerawi	32	3.86	NO
38	Gerawi	33	3.53	OP
34	N 100	34	3.00	PQ
39	Ankolib	35	2.88	PQ
33	Dale	36	2.78	QR
30	Hastings	37	2.74	QR
35	Sugar Drip	38	2.61	QR
31	Blue Ribbon	39	2.49	QR
32	N 109	40	2.08	R
	Mean		4.46	
	Range: Hybrids		3.86-6.68	
	Range: Parents		2.08-4.91	
	LSD(0.05)		0.648	
	LSD(0.01)		0.844	
	CV (%)		18.1	

: Means with letter in common are not significantly different at 0.05 probability level according to Duncan's multiple range test.

Table 6. Performance of hybrids, their parents and the check hybrid for three characters in forage sorghum averaged over years (2002-2003) and locations (Shambat, Islang).

Hybrids		Days to flower	Plant height (cm)	Leaf: stem ratio (%)
E-35-1 X S.70		74.3	243	35.7
E-35-1 X S.186		70.0	253	36.4
E-35-1 X Gerawi		70.4	247	38.0
E-35-1 X Ankolib		77.6	228	41.3
Hastings X S.70		59.9	245	35.3
Hastings X S.186		55.6	241	36.1
Hastings X Gerawi		56.3	233	38.5
Hastings X Ankolib		79.8	218	38.2
B.Ribbon X S.70		56.2	237	36.7
B.Ribbon X S.186		53.3	237	35.3
B.Ribbon X Gerawi		55.3	236	39.8
B.Ribbon X Ankolib		63.0	239	35.9
N 109 X S.70		57.3	238	36.4
N 109 X S.186		54.1	227	36.8
N 109 X Gerawi		54.7	232	41.1
N 109 X Ankolib		64.8	231	39.3
Dale X S.70		64.1	245	37.8
Dale X S.186		56.9	244	34.4
Dale X Gerawi		58.9	234	42.0
Dale X Ankolib		66.2	232	41.0
N 100 X S.70		58.4	241	37.0
N 100 X S.186		54.7	216	37.3
N 100 X Gerawi		55.7	232	39.9
N 100 X Ankolib		71.4	226	43.8
Sugar Drip X S.70		60.0	229	38.4
Sugar Drip X S.186		55.3	229	38.3
Sugar Drip X Gerawi		55.8	226	40.2
Sugar Drip X Ankolib		66.5	242	37.5
Parents				
E-35-1	♀	82.5	171	46.1
Hastings	‘’	61.1	191	43.4
Blue Ribbon	‘’	55.2	197	43.5
N 109	‘’	57.3	116	53.7
Dale	‘’	71.0	188	40.3
N 100	‘’	61.7	179	41.0
Sugar Drip	‘’	65.9	189	44.9
S.70	♂	67.2	233	34.4
S.186	‘’	54.4	227	32.6
Gerawi	‘’	56.2	231	40.1
Ankolib	‘’	66.4	180	42.4
Check				
Pannar 888		67.6	217	42.8
Mean		62.3	223	39.3
Hybrids: Range		53.3-79.8	216-253	34.4-43.8
Parents: Range		54.4-82.5	116-233	32.6-53.7
LSD (0.05)		2.02	12.8	2.78
LSD (0.01)		2.64	16.7	3.62
C.V %		4.0	7.2	8.8

Table 7. Performance of hybrids, their parents and the check hybrid for three characters in forage sorghum averaged over two locations (Shambat, Islang)

Hybrids	2002			2003		
	Stem diameter (cm)	No. of tillers/plant	Regrowth (g/m row)	Stem diameter (cm)	No. of tillers/plan	Regrowth (g/m row)
E-35-1 X S.70	2.03	2.73	253	1.77	1.34	296
E-35-1 X S.186	1.93	1.89	217	1.67	1.77	161
E-35-1 X Garawi	1.76	2.90	207	1.52	1.86	236
E-35-1 X Ankolib	1.83	2.62	297	1.57	1.50	210
Hastings X S.70	1.65	1.75	337	1.64	1.44	289
Hastings X S.186	1.51	1.97	291	1.56	1.50	208
Hastings X Garawi	1.45	2.99	506	1.56	1.90	324
Hastings X Ankolib	1.87	2.34	228	1.60	1.27	209
B.Ribbon X S.70	1.55	1.87	199	1.46	1.37	223
B.Ribbon X S.186	1.58	2.22	378	1.25	1.47	187
B.Ribbon X Garawi	1.48	2.21	295	1.33	1.93	284
B.Ribbon X Ankolib	1.87	2.57	330	1.51	1.75	145
N 109 X S.70	1.61	2.19	303	1.35	1.80	247
N 109 X S.186	1.40	1.95	360	1.38	1.30	250
N 109 X Garawi	1.44	3.25	505	1.34	1.90	310
N 109 X Ankolib	1.63	2.91	306	1.54	1.57	146
Dale X S.70	1.49	2.24	255	1.42	1.87	269
Dale X S.186	1.49	1.49	297	1.48	1.90	365
Dale X Garawi	1.53	3.11	574	1.37	2.44	325
Dale X Ankolib	1.65	2.71	223	1.50	2.13	322
N 100 X S.70	1.69	2.17	307	1.46	1.47	361
N 100 X S.186	1.33	2.30	388	1.39	1.77	233
N 100 X Garawi	1.46	2.63	339	1.24	1.54	238
N 100 X Ankolib	1.42	2.59	235	1.51	1.70	130
Sugar drip X S.70	1.64	2.28	262	1.47	1.63	242
Sugar drip X S.186	1.51	1.89	416	1.47	1.93	382
Sugar drip X Garawi	1.28	2.56	369	1.40	1.70	234
Sugar drip X Ankolib	1.88	2.40	252	1.83	1.24	176
Parents						
E-35-1 ♀	1.54	1.50	118	1.68	1.43	126
Hastings ♀	1.28	1.29	68	1.27	1.03	103
Blue Ribbon ♀	1.21	1.00	45	1.18	1.00	63
N 109 ♀	1.08	1.02	20	1.23	0.90	36
Dale ♀	1.27	1.21	57	1.17	1.23	123
N 100 ♀	1.29	1.42	94	1.35	1.56	88
Sugar Drip ♀	1.18	1.60	65	1.26	0.96	99
S.70 ♂	1.71	1.71	137	1.82	1.57	167
S.186 ♂	1.57	1.86	132	1.56	1.38	247
Garawi ♂	1.31	2.89	449	1.17	2.16	408
Ankolib ♂	1.46	2.31	237	1.41	1.55	291
Pannar 888 (Check)	1.08	3.23	462	1.13	3.30	383
Mean	1.52	2.19	270	1.44	1.63	228
S.E.±	0.06	0.21	41.2	0.05	0.15	26.8
Hybrid : Range	1.33 - 2.03	1.49 - 3.25	199 - 574	1.24 - 1.83	1.24 - 2.44	130- 382
Parents : Range	1.08 - 1.71	1.00 - 2.89	20 - 449	1.17 - 1.82	0.90 - 2.16	36 - 408
LSD (0.05)	0.155	0.587	115.0	0.138	0.417	74.96
LSD (0.01)	0.205	0.775	151.8	0.182	0.550	99.0
C.V %	8.93	23.5	37.3	8.36	22.5	28.8

6, most of the hybrids that significantly out-yielded Abu Sab'in selections were later in flowering especially when compared to S. 186 (Rubatab type). Nevertheless, one of these hybrids, namely, Dale x S.70 was earlier in flowering than S.70 (Alyab type). This hybrid seems to depict a good compromise between forage yield and earliness. The hybrid Hastings x S.70 may be the second choice in this regard although it was not sig-nificantly better in yield than Pannar 888. Combining all desirable traits in one hybrid is not an easy task due to unfavorable association encountered between characters. Early flowering in many instances is adversely associated with forage yield. The data presented by Ross, et al. (1983) for correlation among forage traits indicate that late flowering favors greater stem and leaf yields. However, in this context, the results obtained could be more valued considering that the hybrids were tested against improved versions of the traditional cultivar Abu Sab'in and the hybrid Pannar 888, which was characterized by earliness and high yield levels (Mohammed, 2001).

CONCLUSION

The data presented for forage yield clearly demonstrate the possibility of developing local hybrids exceeding the introduced ones and the traditional cultivar Abu Sab'in in forage yield. Still, a potential exists for developing hybrids combining increased forage yield with improved regrowth, tillering and leaf: stem ratio especially when referring to the local cultivar Abu Sab'in. However, improvement in earliness was not clearly manifested by this study. More research efforts are therefore needed, if we decided to include earliness as a desirable trait under the local production system.

ACKNOWLEDGEMENTS

Thanks are due to J F Pedersen, Research geneticist-University of Nebraska, USDA-ARS and the Agricultural Research Division, Institute of Agriculture and Natural Resources, University of Nebraska, for providing the female lines in A3 cytoplasm.

REFERENCES

Bacon GH (1948). Crops of the Sudan. In J.D. Tothill Ed., "Agriculture in the Sudan". Oxford University Press. London. pp. 304-316.

Dharampal Singh, Singh U (1973). Genetic association in Sorghum *vulgare* Pers. Madras Agric. J. 60: 1222-1224.

Ejeta G (1983). Current status of sorghum improvement research and development in the Sudan. In : G. Ejeta Ed., "Hybrid Sorghum Seed in the Sudan". Proceedings. Purdue University. pp. 11 - 18.

Ibrahim Abu El Hassan Salih, Orfi Ayman Mohamed Rashid (1996). Variability and character association of forage yield components in some sorghum cultivars. U. K. J. Agric. Sci. 4: 1-17.

Ross WM, Groz H J, Haskins F A, Hookstra G H, Rutto J K, Ritter R (1983). Combining ability effects for forage residue traits in grain sorghum hybrids. Crop Sci. 23 : 97-101.

Steel RGD, Torrie JH (1960). Principles and Procedures of Statistics. 2nd ed. McGraw-Hill Book Co., New York. pp. 347-349.

Mohammed Maarouf I (2001). Annual Report 2000/2001. Shambat Research Station. In: Fodder and Pasture Research Program (2000-2005). ARC. Wad Medani. Sudan. pp. 5-9.