VARIABILITY IN NAMIBIAN SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH SUBSP. *BICOLOR*)

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INTRODUCTION

During April 1991 and April 1992 the International Crop Research Institute for the semi-arid Tropics (ICRISAT) collected crop germplasm in Namibia (Appa Rao *et al.*, 1991, 1992a, 1992b). The main aim of these missions was to collect germplasm of "traditional cultivars" of pearl millet (*Pennisetum glaucum* (L.) R. Br.) and sorghum (*Sorghum bicolor* (L.) Moench subsp. *bicolor*) in the crop growing regions of northern Namibia. Pearl millet is the most important subsistence crop in Namibia and Namibian germplasm had never been used in plant breeding programmes. Namibian landraces of crops were at that stage not conserved in any way, and development following independence, was seen as a threat to the existence of these traditional cultivars (SIDA, 1989). Namibia was also about to launch both its national plant genetic resources programme and cereal crop improvement programme, and these collections were to become an important basis for both.

The resulting collection, which included 123 accessions of sorghum (Table 1), is probably not fully representative of the diversity found in Namibia, but unless material is adequately described, gaps cannot be identified. In order to identify future collecting priorities and make the material more valuable to users, it was decided to characterise all accessions of sorghum in the collection of the National Plant Genetic Resources Centre (NPGRC). The NPGRC also received only small amounts of seed per accession, and seed multiplication therefore was necessary. For the sake of cost-effectiveness, it was decided to combine seed multiplication with characterisation.

MATERIALS AND METHODS

Seeds of all sorghum samples (124) in the collection of the NPGRC were sown in an experimental field at Mahenene Research Station. Since successful seed multiplication was critical, Mahenene was chosen because the infrastructure needed for irrigation was present at this station.

Seeds were planted in a randomized block, in two replications. Each plot consisted of 4 rows of 4 m length. Spacing of about 25 cm within and 75 cm between rows was used. Alleys of 1m width were left open between plots. Planting was done by a machine adapted for the planting of small experimental plots. The field was irrigated prior to sowing on 15 December 1995. Shortly after germination, irrigation was applied once, resulting in 20mm water additional to the rainfall. In November 1995 a basal dose of fertilizer (3:2:1 (25%) N:P:K) at 150kg/ha was applied before sowing. On 19 January and mid-February 1996, 30kg/ha N in form of urea, were applied. No plant protection measures were applied throughout the season, since pest and disease incidence appeared to be low.

Isolation of the different accessions was achieved by means of pollination bags which were used to cover the heads just prior to full development of spikelets. The bags were kept in place until harvest, thus ensuring selfing of the heads. Harvesting was done by hand from 29 to 31 May 1996. Further processing of germplasm was also done by hand.

Data collection according to the International Plant Genetic Resource Institute (IPGRI) also known as the International Board for Plant Genetic Resources (IBPGR/ICRISAT, 1993) descriptor list was done both in the field and after harvesting at the NPGRC. Data was taken from 5 randomly chosen individuals in each plot and each replicate. For quantitative data, averages, standard deviations (s) and coefficients of variation (cv) were calculated, for other characters, frequencies of each character state per accession were recorded. For easier analysis, only the most frequent state was used in this summary. Associations between characters were determined using the Chi-Square-Test in r x c contingency tables.

RESULTS

The climate and other conditions under which this characterisation was carried out, are summarized in Fig.1 and 2, and Table 2.

Table 2: Conditions at Mahenene Research Station

Latitude	17°26'30" S
Longitude	14°47'20" E
Altitude	1100m
Soil texture	sand
Soil pH	5.4 to 5.9, average 5.7
Field spacing:	
within row	25cm
between rows	75cm
Watering	rainfed (348.3 mm) and irrigated (20mm)
Fertilizer:	
basal	150kg/ha 3:2:1 (25%) N:P:K
side	2 x 30kg/ha N (urea)
Pollination method:	selfing through bagging

TABLE 1: SORGHUM ACCESSIONS COLLECTED IN NAMIBIA BYICRISAT.

Region	Kunene	North Central	Okavango	Caprivi	TOTAL
size (km^2)	136 549	54 526	42 771	18 530	252 376
# accessions	5	66	22	30	123
total area under sorghum: 15 000 ha (Leuschner *et al.*, 1993)					

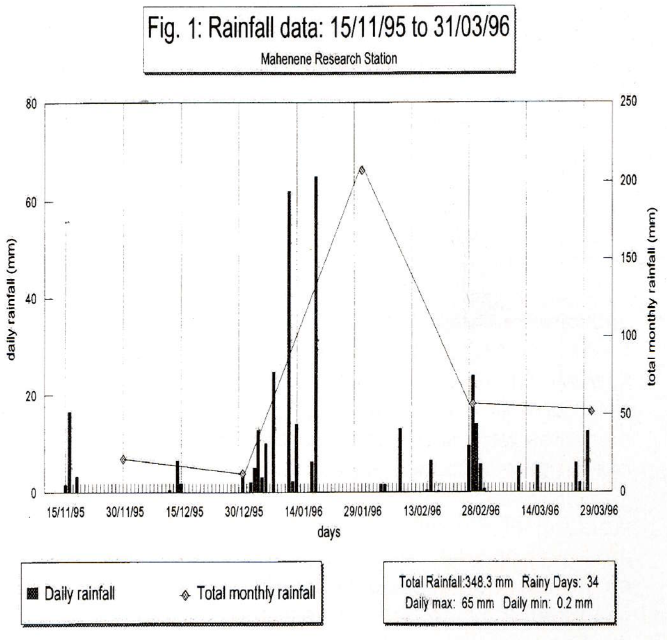

FIGURE 1: RAINFALL DATA FOR MAHENENE RESEARCH STATION DURING THE GROWING SEASON.

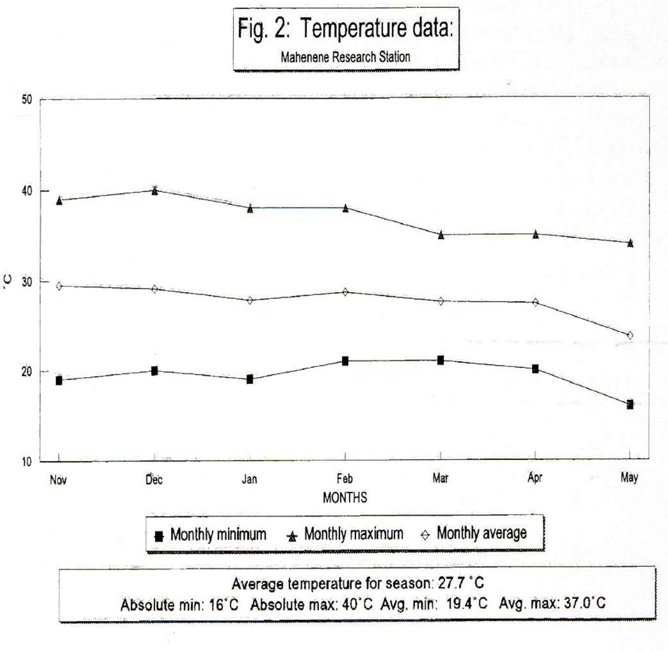

FIGURE 2: TEMPERATURE DATA FOR MAHENENE RESEARCH STATION DURING THE SEASON.

A summary of the data which was recorded, is shown in Table 3. Since long smut (*Tolyposporium ehrenbergii* (Kühn)Pat.) was observed on the accessions, it was decided to score unbagged heads on a scale of 1-10 for susceptibility to long smut (0 = not susceptible, 10 = highly susceptible). This score was awarded according to number of heads infested (out of 5 randomly chosen heads per plot) and degree of infestation per head.

DISCUSSION

Variability between accessions was found to be considerable for most characters observed. All three of the quantitative characters recorded, had coefficients of variation of above 20% (Table 3).

Endosperm colour was found to be white in all accessions and grain lustre was always absent. Only one accession (NAM 1198) was found to have twin seeds, as already reported by Appa Rao *et al.* (1992a). This accession originated from a farmer's field in the Ohangwena Region at Enyana, near Okongo (17°28' S, 17°35' E).

The majority of accessions (89.52%) were awn-less, a character probably selected for by farmers, since awned sorghum heads are more difficult to process manually. Association between presence of awns and the region of origin was a statistically significant (c^2_3 = 8.66, significant at P= 0,05). The presence of awns was positively associated with the Okavango Region, where more awned accessions were collected than expected. The majority of accessions also had white midribs (82.11%) and white glumes (55.65%) and dry plants were mostly tan-coloured (59.68%). It is not known, whether the latter characters are preferred by farmers or are co-incidental.

Seedling vigour was low in 58.62% of accessions. This could be a result of the less than optimum storage conditions under which these seeds were kept from the time of collecting in 1991/92 to incorporation into the NPGRC collection in 1993/94. Seeds were also threshed by machine, which is known to have a negative effect on germination (Ellis *et al.*, 1985; Hong & Ellis, 1996).

Most of the accessions had white coloured grains (40.32%), which is unexpected, since sorghum is grown in Namibia mainly for beer brewing, and red grains are preferred for this purpose (Lechner, pers. com.; Lucas, pers. com.). In the eastern regions of Caprivi and Okavango, white sorghum is also used for porridge to a limited extend. There is however no significant association (c^2_{10} = 8.65) between grain colour and the three main regions (Caprivi, Okavango and North Central, consisting of Oshikoto, Oshana, Ohangwena & Omusati Regions). This result may however also be due to the original collection not been done strictly at random.

Endosperm texture was mainly on the intermediate to starchy side, a character which was probably selected for by farmers who prefer starchy seeds for ease of processing and taste. The waxy bloom for most accessions is slight to medium. The latter observations however may have been taken too late during the growing season, thus affecting the true score. Inflorescence shapes with erect branches dominate (79.03%). This may be farmer selected, but reasons for this selection are unknown. There is a significant association between region and inflorescence shape (c^2_{15} = 30.32, significant at P = 0.05). Inflorescence shape of category 4 of the descriptor list, is positively associated with the Caprivi Region, where more than double the number of accessions were collected than would be expected. Grain covering is mainly in the middle ranges from one third to three-quarters covered (76.62%). Shattering was on the low side, which is to be expected in a cultivated crop. There is no statistically significant association between grain covering and shattering (c^2_{35} = 50.4). Grain plumpness is mainly from intermediate to plump (88.71%), which is most likely the result of farmer selection for large, well-rounded seeds.

The scoring for smut susceptibility should be treated with caution. Upon opening pollination bags it was discovered that infestation was far more severe than on unbagged heads. This must be a result of the increased humidity and protection from the elements inside the pollination bags. A properly designed experiment is needed to evaluate smut susceptibility.

TABLE 3: SUMMARY OF MORPHOLOGICAL CHARACTERS OF NAMIBIAN SORGHUM ACCESSIONS (FIGURES FOR QUALITATIVE CHARACTERS ARE PERCENTAGES OF N ACCESSIONS).

	n	min	max	mean	s	cv
plant height (cm)	117	72	291	193.56	45.91	23.72
No. grains/panicle	122	380	2936	1459.37	538.30	36.89
1000-seed-weight (g)	124	15.20	57.20	34.48	8.48	24.60

	n							
seedling vigour	116	low	intermediate	high				
		58.62	39.66	1.72				
midrib colour	123	white	dull green	other				
		82.11	17.07	0.81				
waxy bloom	123	slightly	medium	75%	mostly			
		37.40	39.02	0.81	22.76			
inflorescence shape	124	very loose erect primary branches	loose erect primary branches	loose drooping primary branches	semi-loose erect primary branches	semi-compact elliptic	compact oval	
		0.81	32.26	4.84	46.77	9.68	5.65	
plant colour	124	pigmented	tan					
		40.32258	59.67742					
glume colour	124	white	mahogany	red	purple	black	other	
		55.65	10.48	0.81	7.26	24.19	1.61	
grain covering	124	25% covered	33% covered	50% covered	60% covered	75% covered	90% covered	100% covered
		7.26	28.2	30.6	4.84	12.90	8.06	1.61
awns	124	absent	present					
		89.52	10.48					
shattering	122	very low	2	low	4	intermediate	6	
		6.56	13.93	39.34	15.57	20.49	4.10	
grain colour	124	white	yellow	red	brown	buff	other	
		40.32	0.81	8.87	21.77	15.32	12.90	
grain lustre	124	absent	present					
		100	0					
grain plumpness	124	dimple	4	intermediate	6	plump		
		3.23	8.06	29.03	34.68	25.00		
grain form	124	single	twin					
		99.19	0.81					
endosperm texture	124	mostly corneous	4	inter-mediate	6	mostly starchy	8	completely starchy
		7.26	8.06	27.42	20.16	20.97	8.87	7.26
endosperm colour	124	white	yellow					
		100	0					
smut susceptibility 0 = least, 6 = most	121	0	1	2	3	4	5	6
		4.96	36.36	25.62	14.88	11.57	5.79	0.83

CONCLUSION

From the characterisation of the sorghum accessions at the NPGRC, some conclusions can be drawn. There is still considerable morphological variability amongst the sorghum landraces of Namibia. This variability needs to be conserved. A large proportion of the variability is conserved *ex situ* in the collection of the NPGRC, but further efforts need to be made to add to this collection. The national programme also needs to consider *in situ* or on-farm conservation of these landraces.

With the information known so far, some priorities for the future can be identified. In the regions of Oshana, Oshikoto and Kunene, more collecting needs to be done. During collecting missions, attention should be paid to character states that are not well represented in the present sorghum collection, eg. twin grains, lustrous grain, yellow endosperm, yellow grain. Some attention is also needed in identifying types resistant to long smut, since this disease seems to be a problem in Namibia. A proper experiment evaluating this character needs to be done. The accessions need to be characterised for days to germination and days to flowering, two important characters in the arid conditions of Namibia, but which could not be scored during this exercise because of staff shortage.

ACKNOWLEDGEMENTS

The support of the Ministry of Agriculture, Water & Rural Development, both financially and logistically, is acknowledged. The assistance in maintenance of and data capture on trial plots by staff at Mahenene Research Station, especially J. Iikela and K. Fleissner, is much appreciated. Financial support from the Southern African Development Community (SADC) Plant Genetic Resources Centre Project and the advice received through the project, is gratefully acknowledged. NPGRC staff member, E. Lucas is thanked for processing of germplasm and further data capture.

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