Indian J. Pl. Genet. Resources 9(1): 43-51, 1996

DIVERSITY IN PEARL MILLET GERMPLSM FROM SUDAN

K.N. Reddy, S. Appa Rao and M.H. Mangesha

Genetic Resources Division, ICRISAT Asia Center,
Patancheru 502 324 (Andhra Pradesh)

Out of 589 pearl millet (*Pennisetum glaucum* (L.) R. Br.) germplasm accessions from Sudan assembled at ICRISAT Asia Center, Patancheru, 581 were evaluated for morphological and agronomical characters during the rainy and postrainy seasons. The infloresences were small, thin with small corneous grain. Almost all defined spike shapes and grain shapes were found indicating considerable diversity in the germplasm from Sudan. The unique feature of 40 per cent yellow grain germplasm which is a rich source for carotene serves as a genetic base to develop improved cultivars with yellow grain. As most of the accessions produce several thin stems with high biomass, they are useful to breed forage types.

Key words : Diversity, pearl millet, germplasm, Sudan

Sudan lies between 22^0 and 39^0 E longitudes and 4° and 22° N latitudes (Anonymous, 1969). Climate of Sudan ranges widely from tropical type in the northern desert to wet southern part with more than 1000" rainfall in some areas. Most of the northern Sudan is dry sandy, while south of Khartoum between the White Nile and the Blue Nile rivers is wide clay plains. In Sudan, pearl millet is the most important crop next only to sorghum. It is grown on an estimated area of 1150 thousand hectares producing 221 thousand metric tones grain (FAO, 1994). The genebank at ICRISAT Asia Centre (IAC) had assembled 589 pearl millet germplasm accessions from Sudan. Since characterization of germplasm is a prerequisite to asses the diversity and to identify promising genetic stocks for crop improvement, all accessions were evaluated for morphological and agronomical characters during two contrasting seasons at IAC, which is described in this paper.

MATERIALS AND METHODS

Pearl millet germplasm assembled at IAC from Sudan include 6 accessions from the Rockefeller Foundation assembled in India, 140 collected by IBPGR

Approved for publication as ICRISAT Journal Article No. 1797.

and the rest collected by ICRISAT. They were evaluated at ICRISAT Asia Centre (IAC), Patancheru (18°N latitude and 78°E longitude) in alfisols during two contrasting seasons - the rainy and postrainy. Germplasm accessions were grown in an augmented block design with repeated checks for every 20 test accessions. For evaluation, each accession was planted in 2 rows of 4 m length spaced at 75 cm apart with 10 cm space between plants within the row. Life saving irrigations were provided in rainy season, but during the postrainy season irrigations were provided at regular intervals. Fertilizers were applied at the rate of 100 kg nitrogen and 40 kg phosphorus ha^{-1} during both rainy and postrainy seasons. Observations were recorded on selected morphoagronomic characters as per the descriptors for pearl millet (IBPGR and ICRISAT, 1993). Observations on time to 50% flowering, plant height, spike length and spike thickness were recorded both in rainy and postrainy seasons. Observations on other characters such as spike density, bristle length, endosperm texture, green fodder yield potential, grain yield potential, and the overall plant aspect, were scored visually on a 1-9 scale during rainy season, where 1 is the lowest or least desirable, while 9 is the highest or most desirable (IBPGR and ICRISAT, 1993). Grain characters were recorded in postrainy season only. The data were analyzed using GENSTAT statistical program.

RESULTS AND DISCUSSION

Considerable diversity was observed for several characters, such as time to 50% flowering, plant height, tiller number, spike exsertion, spike length and spike thickness (Table 1), and grain characters. In general, germplasm from Sudan flowered late with a mean flowering time of 86 days during rainy and 71 days in postrainy season. Time to flower ranged from 47 to 128 days during rainy and 38 to 120 days in postrainy season. The accessions which flower in less than 50 days such as IP 9866, IP 9894, IP 13326 in rainy season and IP 10831 in postrainy season are good sources for early maturity. The rainy season at IAC is characterized by long days and high temperature compared to the postrainy season. During the rainy season, the day length decreases from 13.93 hours in June to 12.47 hours in October. In the postrainy season it varies from 12.1 hours in November to 12.7 hours in March. Mean monthly temperature varies from 34.1°C in June to 20.2°C in October in rainy season and 10.6°C in November to 36.3°C in March. The reduction in flowering time during the postrainy season compared to the rainy season could be attributed to differences in day length and/or temperature sensitivity. On the other hand, IP 8631, IP 8658, IP 8661 and IP 13331 did not show any difference in flowering time due to season indicating their insensitivity to photoperiod and temperature.

Pearl millet germplasm from Sudan grew very tall with a mean height of 259 cm during the rainy and 131 cm during the postrainy season. The

range of variation for plant height is considerable and varied from 90 to 420 cm during the rainy and 60 to 285 cm in postrainy season (Fig. 1). All the

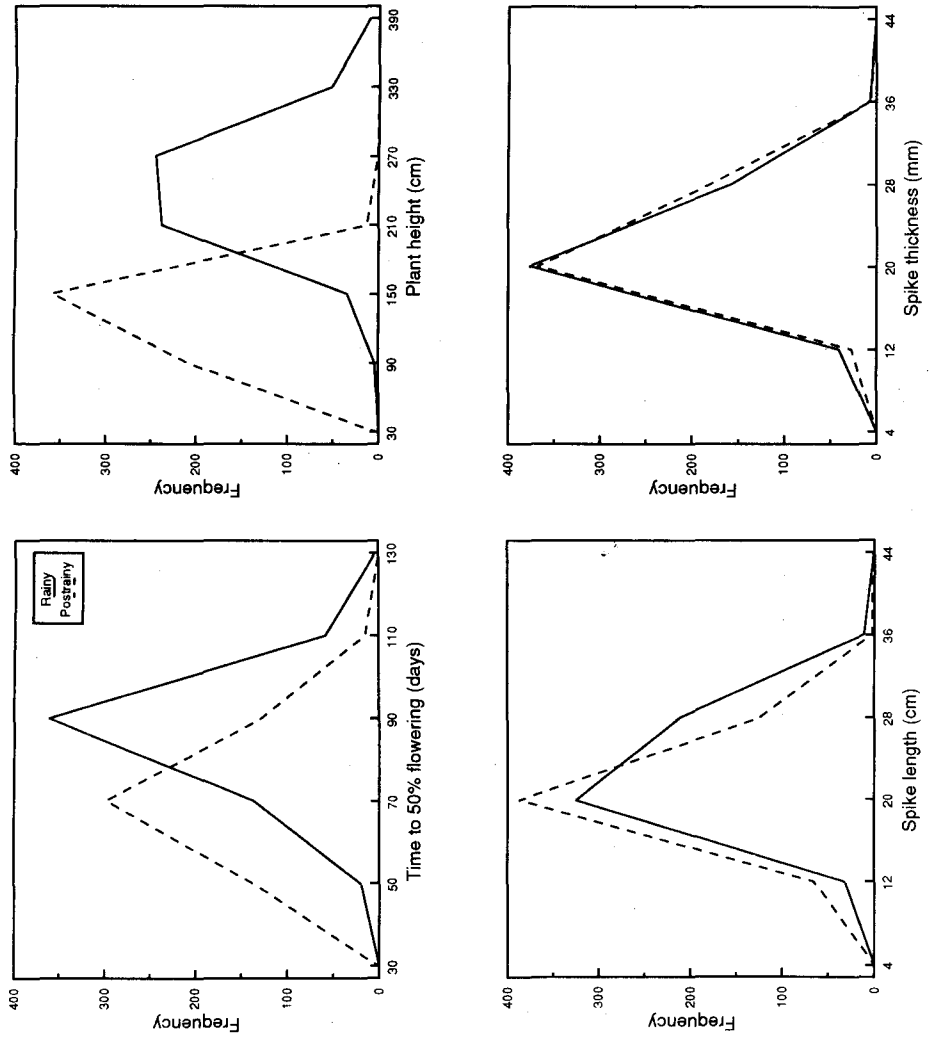

Fig. 1. Expression of pearl millet germplsm from Sudan when evaluated at IAC during rainy and postrainy seasons.

581 accessions, except 6 grew taller during rainy season when compared to those in postrainy season indicating the sensitivity of pearl millet for plant height. Out of six, only two accessions IP 8282 and IP 10932 were not affected by the planting time for plant height, and four accessions IP 8014, IP 11706, IP 11711 and 11714 grew taller in postrainy season. Plant height was reported to vary considerably depending on the growing season (Carberry and Campbell, 1985; Maiti and Sato, 1990). The reduction in plant height during the postrainy season was also associated with reduction in flowering time. Based on flowering time and plant height it could be considered that pearl millet from Sudan is both day length and photoperiod sensitive. IP 8645 which flowers in about 100 to 115 days grows upto 3m height in both rainy and postrainy seasons and IP 8652 which flowers in 100 days grows over 4 m are found to be good sources for forage.

In general, pearl millet germplasm from Sudan produces several basal tillers ranging from 1 to 16 with a mean of 3, but some of these tillers do not produce spike, so, the mean productive tillers was only 2 per plant (Table 1). Pearl millet from Sudan is more diverse and relatively a good source especially for productive tillers, when compared to the millet from other countries of Sahel region such as Central African Republic, Nigeria, Niger, Mali, Senegal etc. IP 8291 which produces more than 10 productive tillers per plant may be suitable for both grain as well as forage purpose.

Table 1. Diversity for agronomic characters of pearl millet germplasm from Sudan

Character	Range	Mean ± SE
Time to flower (days)-R*	47-128	86.0 ± 0.53
Time to flower (days)-PR*	38-120	71.0± 0.56
Plant height (cm-R	90-420	250.3 ± 1.94
Plant height (cm)-PR	60-285	131.6 ± 1.09
Total tillers (no.)	1-16	3.2 ± 0.08
Productive tillers (no.)	1-10	2.1 ± 0.04
Spike exsertion (cm)	-15-17	3.4 ± 0.23
Spike length (cm)-R	13-42	23.1 ± 0.19
Spike length (cm)-PR	9-46	21.4 ± 0.19
Spike thickness (mm)-R	13-37	22.0 ± 0.17
Spike thickness (mm)-PR	12-38	22.6 ± 0.17
Grain weight (g)	3-15	8.8 ± 0.06

*R = Rainy; PR = Postrainy season.

Spike length varies considerably (Fig. 2) and range from 13 to 42 cm in rainy and from 9 to 46 cm in postrainy season. Spike length is relatively stable over seasons as the mean spike length was 23 cm during the rainy and 21 cm during the postrainy season.

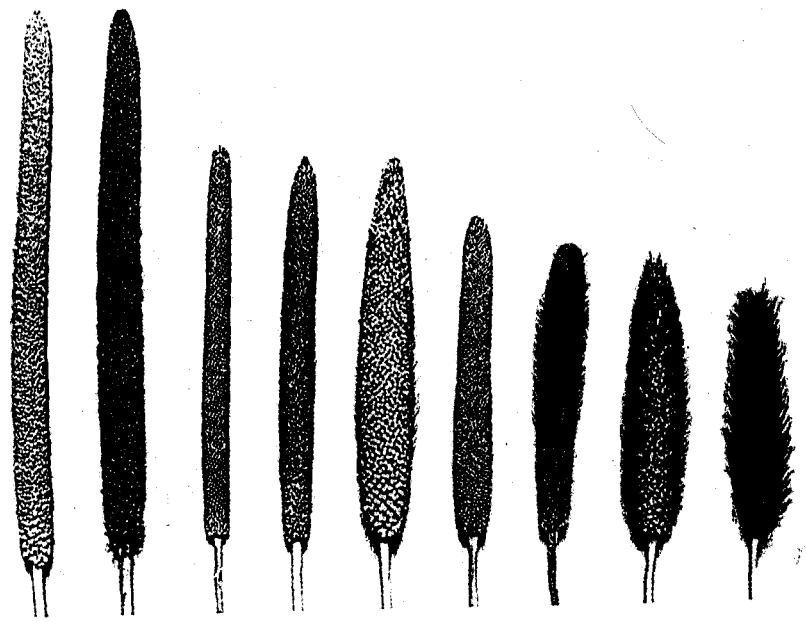

Fig. 2. Diversity for spike characters in pearl millet germplasm from Sudan

Variation for spike length among different plants within an accession is less compared to variation among accessions. Six accessions; IP 8736, IP 9867, IP 10772, IP 10775, IP 10893 and IP 13328 produced spikes more than 35 cm long in rainy season and IP 8655, IP 11716 and IP 11718 during postrainy season. Spike thickness, which is the diameter of the spike at maximum thickness, mainly depends on the length of the involurce, rachis thickness and grain size was most stable as the range and mean were almost the same during both the seasons and varied from 12 to 38 mm with a mean of 22 mm (Fig. 1, 2). Only two accessions; IP 9884 and IP 13337 in rainy and two accessions; IP 8010 and IP 13345 in postrainy season produced thick spikes (more than 35 mm). Variation for grain size was considerable as the grain weight ranged from 3 to 15 g per 1000 grains (Table 1). However, the mean grain weight is 8.8 g per 1000 grain, which is higher when compared to the mean of world collection (Mengesha and Appa Rao, 1986). As many as eight accessions namely IP 0847, IP 11678, IP 11679, IP 11682, IP 11683, IP 11684,

IP 11685 and IP 11689 produce large grains with grain weight more than 12 g per 1000 grains.

The relative length of the peduncle is one of the important characters for the production of quality grain. In accessions showing poor or negative exsertion, a part of the spike is held within the boot leaf leading to improper seed set, harboring of insects and diseases. Pearl millet germplasm from Sudan is highly diverse for spike exsertion ranging from -15 to 17 cm with a mean of 3.4 cm (Table 1). Accessions like IP 9840 and IP 10741 which showed considerable positive exsertion (more than 15 cm) are very useful in pearl millet improvement.

Table 2. Diversity for spike shape, grain shape and grain size in pearl millet germplasm accessions from Sudan

Character	Number of accessions	Frequency (%)
Spike shape		
Cylindrical	280	48.2
Conical	19	3.3
Club	1	0.2
Candle	187	32.2
Dumb-bell	2	0.3
Lanceolate	90	15.5
	5	0.8
Grain shape		
Oblong	110	18.9
Lanceolate	35	6.0
Elliptical	26	4.5
Hexagonal	117	20.1
Globular	293	50.4
Grain color		
Cream	33	5.7
Yellow	231	39.8
Gray	76	13.1
Gray brown	158	27.2
Brown	27	4.6
Purple	41	7.1
Other colors	15	2.6

No. of accessions studied = 581

Among the characters studied, spike shape was the most stable trait during both the seasons. Pearl millet germplasm from Sudan is highly diverse for spike shapes (Fig 2). The most common spike shape is cylindrical which accounts for 48 per cent of the accessions followed by 32.2 per cent of candle and 15.5 per cent of lanceolate spike shape (Table 2). Spikes of conical, club, dumbells and oblanceolate shapes are also found, but, they occur at very low frequency.

All the described grain shapes (IBPGR and ICRISAT, 1993) were found in Sudanese pearl millet germplasm, which vary from oblong to globular (Table 2). The most common grain shape is globular that account for 50 per cent of the total accessions. Globular grain shape is a character of the race globosum which is widely distributed in Western Africa (Brunken et al. , 1977). The occurrence of majority accessions with globular grain in Sudan suggests its similarity to the millet in Western Africa (Bono, 1973; Kumar and Appa Rao, 1986). The other major grain shapes to the world collection are 4.0 per cent for hexagonal, 3.4 per cent for oblong, 1.3 per cent for elliptical and one per cent for lanceolate shape.

The unique feature of pearl millet from Sudan is the occurrence of yellow grain,a rich source of carotene, the precursor of vitamin A, which is necessary for health of the eye. Hence, yellow grain is preferred by farmers over gray, brown, or purple. About 40 per cent of the pearl millet germplasm from Sudan produced yellow grains followed by gray-brown (27.2 per cent) and gray (13.1 per cent). However, other grain colors such as purple (7.1 per cent), purpish black (0.7 per cent) and ivory (0.2 per cent) were also found. Similarly, Pearl millet from Sudan is a rich source for purple and purplish black grain accounting for 26 and 15 per cent respectively in the world collection. Based on grain color, farmers in Sudan classify pearl millet in to three forms; *Dukhun Akhder* produces gray colored pericarp *Dukhun Abeit* has white and *Dukhun Ahmer* has red pericarp (Prasada Rao and Mengesha, 1980).

Considerable variation was also found for characters scored visually on a 1-9 scale (Table 3). More than 50 per cent of accessions showed synchrony for maturity with semicompact to compact spikes. As many as 23 accessions scored 8 for spike density which is an important yield contributing character. Almost all accessions produced spikes with very small bristles. However, few accessions IP 8009, IP 8708, IP 8713 and IP 9845 produced long bristles (Fig 2). More than 70 per cent germplasm produced partly starchy to corneous endosperm. Germplasm from Sudan is relatively a good source for grain yield potential with majority (77 per cent) accessions scoring 5 and 6 along with good score for green fodder yield potential (score 6 and 7), and overall plant aspect (score 5 and 6). However, IP 10833 with a score of 8 for grain yield and IP 9843 with a score of 9 for fodder yield were found as promising.

Table 3. Frequency distribution for different traits of pearl millet germplasm, visually scored on 1-9 scale

	Frequency (%)						
Visual Score	SSM	SPD	BL	ET	FYP	GYP	OPA
1	0.	0	61.3	0	0	0	0
2	0.7	0.7	27.4	0.7	0	0	0
3	3.1	1.4	6.5	2.9	0.9	1.2	1.0
4	5.9	6.5	1.6	5.7	4.1	14.6	25.0
5	19.3	32.2	1.4	17.0	11.7	48.4	50.0
6	30.6	36.5	0.7	22.6	36.0	29.4	21.2
7	34.1	18.8	0.5	25.8	44.9	6.2	2.9
8	6.4	4.0	0.5	22.7	2.6	0.2	0
9	0	0	0.2	2.6	0.2	0	0

**SM = Synchrony of Spike Maturity SPD = Spike Density
BL = Bristle Length
FYP = Folder Yield Potential
OPA = Overall Plant Aspect
ET = Endorsperm Texture
GYP = Grain Yield Potential

ACKNOWLEDGMENTS

Thanks are due to Dr. N. K. Rao, and Mr. D.V.S.S.R. Sastry for their suggestions in preparing the manuscript. We are also thankful to Mr. G. Dasaratha Rao, Mr. S. Nagachandra Rao and Mr. D. Bapa Rao, for their help in collecting the field data.

REFERENCES

Annymous. 1969. World Atlas of Agriculture vol. 4. Africa. Institute Geographico De Agostini - Novara (1969).

Bono. M. 1973. Contribution a la morpho-systematique des *Pennisetum* annuels cultives pour leur grain en afrique occidentale francophone. *Agronomie Tropicale* **28** : 229-355.

Brunken J., J.M.J. de Wet and J. R. Harlan. 1977. The morphology and domestication of pearl millet. *Econ. Bot.* **31** : 163-174.

Carberry P.S. and L.C. Campbell. 1985. The growth and development of pearl millet as affected by photoperiod. *Field Crops Res.* **11**: 207-217.

FAO (Food and Agricultural Organization). 1994. 1993 Production Yearbook 47 : 82-83. FAO, Rome.

IBPGR and ICRISAT. 1993. Descriptors for pearl millet [*Pennisetum glaucum* (L.) R. Br.]. International Board for Plant Genetic Resources, Rome Italy; International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India.

Kumar K.A. and S. Appa Rao. 1987. Diversity and utilization of pearl millet germplasm. *In*: Proceedings of the International Pearl millet Workshop, ICRISAT, Patancheru, India. p 69-82.

Maiti R.K. and G.G.L. Sato. 1990. Effect of sowing date, environment on growth, development and yield potentials of 15 pearl millet cultivars (*Pennisetum americanum* L. Leeke) during autumn-winter seasons in Martin, *M. L. Mexico J. Experl. Bot.* **41**: 1609-1618.

Prasada Rao K.E. and M.H. Mengesha. 1980. Sorghum and millets germplasm collection in eastern Sudan. Genetic Resources Progress Report 16, ICRISAT, Patancheru; A.P., India.