Genetic Resources and Crop Evolution **43:** 303–308, 1996.

JA # 1807

Diversity in pearl millet germplasm from Central African Republic *

K. N. Reddy, S. Appa Rao & M. H. Mengesha
Genetic Resources Division, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh 502 324, India

Received 22 February 1995, accepted in revised form 14 July 1995

ISSN 0925-9864

OFFPRIN

Genetic Resources and Crop Evolution
An International Journal

1144

JA 1807

Honorable Minister for Rural Development, CAR during December 1988–January 1989 and 129 pearl millet samples were collected. This paper describes the diversity observed in these collections when evaluated under uniform conditions at IAC Patancheru, India.

Materials and methods

The areas covered, route followed and sampling procedure adapted were described elsewhere (Appa Rao *et al.*, 1990). All the 129 accessions collected by ICRISAT and 17 collected by ORSTOM were evaluated at ICRISAT Asia Center (IAC), Patancheru (17° 25′ N latitude and 78° E longitude) in alfisols, for several morpho-agronomic characters during rainy and postrainy seasons. Rainy season crop was grown during June to October and the postrainy season crop was raised during November to March. Accessions were grown in an augmented block design. Each accession was planted in 2 rows of 4 m length with 75 cm spacing between rows and 10 cm between plants within a row. Life saving irrigations was given during rainy season, while in postrainy season, the crop was irrigated at regular intervals. Fertilizers were applied at the rate of 100 kg nitrogen and 40 kg phosphorus ha^{-1} during both seasons. Observations were recorded as per the descriptors for pearl millet (IBPGR & ICRISAT, 1993) on time to flowering, plant height, spike length and spike thickness during rainy and postrainy season. On the other hand, observations on grain characters were recorded during postrainy season only. Data were analyzed using GENSTAT software. A hierarchical cluster analysis of Ward's minimum variance method (Ward, 1963) was applied over nine selected characters using the cluster procedure of SAS (1985), which produced a dendrogram showing successive fusion of individuals, which ultimately culminates into a single cluster.

Results and discussion

Evaluation of germplasm accessions at IAC, Patancheru revealed considerable diversity among different accessions for almost all the characters studied. The time to flower ranged from 57 to 140 days with a mean flowering time of 128 ± 1.1 days in rainy season. While during the postrainy season, it ranged from 57 to 132 days with a mean of 73 ± 0.8 days (Table 1). Pearl millet from CAR varies widely for plant height and it ranged from 140 to 410 cm with a mean of 311 ± 6.1 cm in rainy season and from 75 to 310 cm with a mean of 155 ± 2.6 cm during postrainy season, indicating the sensitivity of the material to daylength and temperature. All the accessions from CAR except IP 7959, flowered late in rainy season when compared to postrainy season. IP 7959 flowered late by 6 days during postrainy season. IP 17396 and IP 17401 flowered early in rainy season by as many as 70 days indicating their high photoperiod sensitiveness. IP 17401 is also highly temperature and photoperiod sensitive for plant height and grew 250 cm more in rainy season than in postrainy season. None of the accessions grew tall during postrainy season than during rainy season. The rainy season at IAC is characterized by long days and high temperature compared to postrainy season. During the rainy season, the mean maximum and minimum temperatures were 30.8 °C and 21.8 °C respectively and in postrainy season it was 30.4 °C and 14.2 °C respectively. The daylength decreases from 13.93 h in June to 12.47 h in October in rainy season and varies from 11.91 h in December to 12.7 h in March. The differences in flowering time and plant height in postrainy season compared to rainy season could be attributed to sensitivity differences in daylength and temperature. In general, plant height was reported to vary depending on the growing season (Carberry & Campbell, 1985). Pearl millet from CAR produces few basal tillers ranging from 1 to 6 with an average of 3 ± 0.1.

Table 1. Diversity in pearl millet germplasm from Central African Republic, evaluated at IAC, Patancheru[a]

Character	Range	Mean ± SE
Days to flower – R[b]	57–140	128 ± 1.1
Days to flower – PR	57–132	73 ± 0.8
Plant height (cm) – R	140–410	311 ± 6.1
Plant height (cm) – PR	75–310	155 ± 2.6
Total tillers (no.)	1–6	3 ± 0.1
Productive tillers (no.)	1–4	3 ± 0.1
Spike exsertion (cm)	−18–13	5 ± 0.3
Spike length (cm) – R	11–35	20 ± 0.3
Spike length (cm) – PR	8–34	21 ± 0.3
Spike thickness (mm) – R	14–33	19 ± 0.2
Spike thickness (mm) – PR	14–30	22 ± 0.3
1000 grain mass (g)	5–13	9 ± 0.2

[a] Based on 146 accessions.
[b] R = Rainy season, PR = Postrainy season.

Spike length is one of the most important yield contributing trait of pearl millet. Pearl millet spikes from CAR are small ranging in length from 11 to 35 cm in rainy season and 8 to 34 cm in postrainy season. However, the mean spike length did not vary much with the season. Spike thickness which is measured in millimeters at the maximum diameter of the spike depends mainly on the length of involucre, rachis thickness, and grain size, especially grain length. Like spike length, spike thickness was also stable as the range and mean were almost the same during both the seasons. However, IP 7958 which was not affected much due to planting season for flowering, produced long and thick spikes during postrainy season when compared to that in rainy season. Landraces from southern Africa produce shorter spikes compared to those from West Africa (Clement, 1985). Frequency distribution of different spike shapes shows the predominance of cylindrical spike shape (49%) followed by candle (34%) and conical (11%) shapes (Table 2). The other spike shapes found in low proportion were club, lanceolate and oblanceolate (Fig. 1). Grain size varied considerably from 5 to 13 g per 1000 grain, which is considerably high. About 52% of the pearl millet accessions from CAR produce grey colored grain followed by cream or white color. However, other grain colors such as ivory, yellow, grey brown, brown and purple also found. Grain shape is predominantly globular (58%), followed by oblanceolate, obovate, elliptical, and hexagonal (Table 2). Globular grain shape is a characteristic feature of the race globosum, which is widely distributed in western Africa (Brunken *et al.*, 1977; Bono, 1973; Kumar & Appa Rao, 1987).

Table 2. Frequency distribution for spike shape, grain shape and grain color of pearl millet germplasm from Central African Republic, evaluated at IAC, Patancheru

Character	Frequency (%)
Spike shape	
Cylindrical	49.3
Conical	10.6
Candle	33.8
Others	6.3
Grain shape	
Obovate	15.1
Oblanceolate	22.6
Globular	57.5
Others	4.8
Grain color	
Ivory	4.1
Cream	26.9
Yellow	11.0
Grey	51.7
Others	6.2

The cluster analysis indicated a clear 2 and 16 cluster partition (Fig. 2). For the 2 cluster partition, the two groups were designated as A and B containing 60 and 82 accessions respectively (Fig. 2). Because of incomplete data, 4 accessions did not fall into any group. Accessions of group B are late maturing, tall and produce larger spikes with large grains compared to the accessions of group A. When 16 cluster partition was considered, these subgroups or clusters were designated as 1 to 16 continuously and group A and B were subdivided into 8 subgroups each. Group A contained 1, 2, 3, 4, 5, 6, 7, 8 clusters and group B contained 9, 10, 11, 12, 13, 14, 15, 16 clusters. Eight clusters of group A consisted 17, 1, 15, 11, 2, 1, 9 and 4 accessions respectively (Table 3). The accessions of all clusters of group A, except the cluster number 5, and 6 flowered late during both rainy and postrainy season (Table 4). The lone accession IP 6051 which formed cluster number 2 behaved uniquely and flowered late in both rainy (137 ± 0.0 days) and postrainy (90 ± 0.0 days) season, and produced long spikes (32 ± 0.0 cm) when compared to the spikes of genotypes in other clusters indicating the true nature of the genotype for flowering. On the other hand, cluster 6 which consists only one accession (IP 7959) also performed differently and flowered early in both rainy (98 ± 0.0 days) and postrainy (60 ± 0.0 days) season. Cluster 6 was very close to cluster 5 which consists only two accessions (IP 6068 and IP 7957), possibly due to the close resemblance for flowering time. Accessions of these two clusters are early among all the clusters of group A. Cluster 4 consisting 11 accessions produced large grains (8.1 ± 0.2 g) when compared to other clusters of group A, indicating its superiority for this trait.

The clusters 9, 10, 11, 12, 13, 14, 15, 16 which were included in group B contained 2, 1, 10, 5, 10, 16, 4 and 34 accessions respectively (Table 3). Cluster 9 and 10 which consist 2 (IP 7958, IP 12918) and 1 accession (IP 7960) respectively are characterized by early flowering (78 ± 0.0 and 80 ± 0.0 days) and large spikes (34 ± 1.5 and 25 ± 0.0 cm) with large grain (10 ± 0.9 and 11 ± 0.0 g). Accessions of all the other clusters were late in flowering and produced long spikes with large grain but, did not differ much for all these traits. Based on these results, it can be concluded that all the clusters of group B except cluster

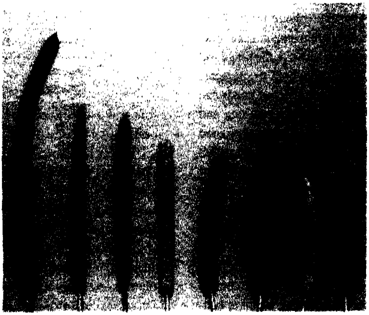

Fig. 1. Diversity for spike characters in pearl millet germplasm from Central African Republic.

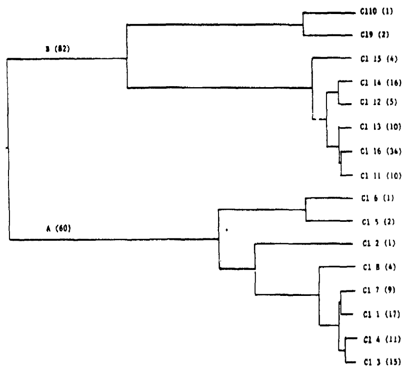

Fig. 2. Dendrogram showing different clusters of pearl millet germplasm accessions. Numbers in parentheses are the number of accessions in the cluster.

9 and 10 are the best sources of genotypes promising for fodder as well as grain. Accessions grouped into cluster 9 and 10 appear to be a good source for grain as they are early with reasonably good spike and grain size. In general, pearl millet germplasm from CAR is a good source for medium sized semi-compact heads with grey and cream or white colored globular grain. Several accessions with white lustrous, corneous grain from CAR are being used (Rai & Kumar, 1994) to

Table 3. Clusters formed and the accessions included in each cluster

Cluster no.	No. of entries included	Accession numbers (IP) of entries included in each cluster
1	17	6037, 6043, 6046, 6047, 6048, 6050, 6052, 6053, 6054, 6067, 6073, 6074, 6076, 6077, 6090, 6091, 6092
2	1	6051
3	15	6036, 6038, 6039, 6040, 6044, 6045, 6062, 6063, 6078, 6079, 6080, 6082, 6083, 6084, 6085
4	11	6042, 6049, 6055, 6070, 6071, 6072, 6081, 6086, 6087, 6088, 6089
5	2	6068, 7957
6	1	7959
7	9	6041, 6056, 6058, 6059, 6061, 6064, 6065, 6066, 6075
8	4	6057, 6060, 6069, 6093
9	2	7958, 12918
10	1	7960
11	10	17385, 17386, 17387, 17391, 17421, 17426, 17427, 17428, 17434, 17457
12	5	17389, 17400, 17409, 17413, 17433
13	10	17393, 17437, 17442, 17449, 17450, 17452, 17453, 17455, 17456, 17458
14	16	17384, 17425, 17438, 17439, 17440, 17441, 17443, 17444, 17445, 17447, 17451, 17454, 17459, 17460, 17461, 17462
15	4	17429, 17430, 17431, 17432
16	34	17388, 17390, 17392, 17394, 17395, 17396, 17397, 17398, 17399, 17401, 17402, 17403, 17404, 17405, 17406, 17407, 17408, 17410, 17411, 17412, 17414, 17415, 17416, 17417, 17418, 17419, 17420, 17422, 17423, 17424, 17435, 17436, 17446, 17448

Table 4. Cluster means for different characters of pearl millet germplasm from Central African Republic

Cluster no.	Character[a]								
	DFLR	DFLPR	PHTR	PHTPR	SPLR	SPLPR	SPTR	SPTPR	GRWT
1	126 ± 1.2	74 ± 1.1	242 ± 5.6	117 ± 2.8	17 ± 0.5	18 ± 0.5	16 ± 0.3	17 ± 0.3	6.5 ± 0.1
2	137 ± 0.0	90 ± 0.0	238 ± 0.0	109 ± 0.0	32 ± 0.0	14 ± 0.0	19 ± 0.0	19 ± 0.0	4.8 ± 0.0
3	125 ± 1.8	70 ± 1.2	240 ± 12.7	128 ± 1.8	19 ± 0.7	21 ± 0.4	18 ± 0.5	19 ± 0.5	7.8 ± 0.2
4	125 ± 1.8	72 ± 1.7	270 ± 5.7	121 ± 2.8	18 ± 0.4	17 ± 0.4	19 ± 0.5	20 ± 0.6	8.1 ± 0.2
5	75 ± 17.5	60 ± 3.0	189 ± 49.0	98 ± 22.5	18 ± 0.4	18 ± 2.4	20 ± 0.1	17 ± 1.4	7.2 ± 0.3
6	98 ± 0.0	60 ± 0.0	260 ± 0.0	140 ± 0.0	28 ± 0.0	25 ± 0.0	25 ± 0.0	20 ± 0.0	5.1 ± 0.0
7	130 ± 1.7	74 ± 1.8	208 ± 11.3	128 ± 2.5	15 ± 0.5	15 ± 0.7	17 ± 0.5	20 ± 0.4	7.5 ± 0.3
8	125 ± 1.7	73 ± 3.7	199 ± 21.3	132 ± 5.5	14 ± 0.8	15 ± 2.3	20 ± 1.2	25 ± 0.1	7.0 ± 0.2
9	78 ± 0.0	73 ± 1.5	268 ± 2.5	175 ± 5.0	34 ± 1.5	25 ± 3.5	31 ± 1.0	24 ± 1.0	9.8 ± 0.9
10	80 ± 0.0	75 ± 0.0	260 ± 0.0	150 ± 0.0	25 ± 0.0	34 ± 0.0	33 ± 0.0	17 ± 0.0	11.0 ± 0.0
11	136 ± 0.8	72 ± 0.7	354 ± 9.9	169 ± 5.0	22 ± 1.2	21 ± 0.4	22 ± 0.7	22 ± 0.6	11.0 ± 0.2
12	134 ± 1.3	69 ± 1.2	374 ± 11.2	184 ± 7.3	25 ± 0.4	24 ± 0.7	20 ± 0.7	20 ± 0.2	11.0 ± 0.3
13	132 ± 1.4	70 ± 0.9	378 ± 6.1	170 ± 2.4	19 ± 0.4	21 ± 0.5	20 ± 0.2	24 ± 0.2	9.0 ± 0.1
14	131 ± 1.1	71 ± 0.8	371 ± 5.6	163 ± 3.4	20 ± 0.4	21 ± 0.4	18 ± 0.4	20 ± 0.3	9.0 ± 0.1
15	135 ± 1.1	70 ± 0.4	373 ± 4.8	185 ± 6.5	9 ± 0.5	23 ± 1.0	19 ± 0.5	26 ± 0.8	11.0 ± 0.2
16	135 ± 0.5	70 ± 0.4	370 ± 3.4	175 ± 1.9	23 ± 0.5	24 ± 0.3	21 ± 0.3	26 ± 0.3	11.0 ± 0.2

[a] DFLR = Time to flower in rainy season (days); DFLPR = Time to flower in postrainy season (days); PHTR = Plant height in rainy season (cm); PHTPR = Plant height in postrainy season (cm); SPLR = Spike length in rainy season (cm); SPLPR = Spike length in postrainy season (cm); SPTR = Spike thickness in rainy season (mm); SPTPR = Spike thickness in postrainy season (mm); GRWT = 1000 Grain weight (g).

develop improved cultivars with high yield potential for grain as well as fodder.

The above clustering provided a structure to select a limited number of pearl millet germplasm accessions from Central African Republic for use in crop improvement program for Central African Republic and/or any other region with similar agroclimatic conditions. The clustering indicates that the data reduction through computer can simplify sampling of large collections for research purposes and or otherwise in establishing a core collection (Brown, 1989). This data reduction also helps in resolving the problem of redundancy in many genebanks (Holden, 1984).

Acknowledgements

We gratefully acknowledge the help of Mr G Swaminathan, Statistics Unit, ICRISAT in analyzing the data. Our thanks are due to Mr G Dasaratha Rao, Mr S Nagachandra Rao, Mr D Bapa Rao, Mr B Manik Reddy and Mr A Bhaskar Rao of GRD, ICRISAT for their help in evaluating the germplasm.

References

Anonymous (1992) The Europa World Year Book, 1992. 33rd ed., Vol. 11: Afghanistan to Jordan

Appa Rao S, Mengesha MH & Kafara J (1989) Germplasm collection mission to Central African Republic. Genetic Resources Progress Report 55, Genetic Resources Unit, ICRISAT, Patancheru, India

Appa Rao S, Mengesha MH & Kafara J (1990) Plant germplasm collection mission to Central African Republic. FAO/IBPGR Plant Genet Res Newsl 83/84: 27–28

Bono M (1973) Contribution a la morpho-systematique des *Pennisetum* annuels cultives pour leur grain en afrique occidentale francophone. Agron Trop 28: 229–355

Brown AHD (1989) The case of core collection. *In*: The use of Plant Genetic Resources, pp 136–156. AHD Brown, OH Frankel, DR Marshall & JT Williams (eds) Cambridge University Press, Cambridge, UK

Brunken J, de Wet JMJ & Harlan JR (1977) The morphology and domestication of pearl millet. Econ Bot 31: 163–174

Carberry PS & Campbell LC (1985) The growth and development of pearl millet as affected by photoperiod. Field Crops Res 11: 207–217

Clement JC (1985) Les mils p'encillaires de l'Ouest: prospections et collecte Rome, Italy, International Board for Plant Genetic Resources. 231 pp

FAO (Food and Agricultural Organization of the United Nations) (1994) 1993 Production yearbook. FAO Basic Data Unit, Statistics Division, Rome, Italy

Holden JHW (1984) The second ten years. *In*: JHW Holden & Williams JT (eds) Crop Genetic Resources: Conservation and Evaluation, pp 276–285. Allen & Unwin, Inc., Winchester, MA, USA

IBPGR & ICRISAT (1993) Descriptors for pearl millet [*Pennisetum glaucum* (L.) R. Br.]. IBPGR, Rome, Italy & ICRISAT, Patancheru, India. 43 p

Kumar KA & Appa Rao S (1987) Diversity and utilization of pearl millet germplasm. In: Proc. Intern. Pearl Millet Workshop, ICRISAT. pp 69–82

Rai KN & Anand Kumar K (1994) Pearl millet improvement at ICRISAT an update. Int Sorghum Millets Newsl 35: 1–29

SAS Institute (1985) SAS User's Guide: Statistics. State Univ. Press, Cary, NC, USA

Ward JH (1963) Hierarchical grouping to optimize an objective function. J Am Stat Assoc 58: 236–244

For information about current subscription rates and prices for back volumes for
Genetic Resources and Crop Evolution ISSN 0925-9864
please contact one of the customer service departments of Kluwer Academic Publishers or return the form overleaf to

Kluwer Academic Publishers Customer Service P O Box 322 3300 AH Dordrecht the Netherlands Telephone (+31) 78 524 400 Fax (+31) 78 183 273 Email services@wkap nl

or

Kluwer Academic Publishers Customer Service P O Box 358 Accord Station Hingham MA 02018-0358 USA Telephone (1) 617 871 6600 Fax (1) 617 871 6528 Email kluwer@world std com

Call for papers

Authors wishing to submit papers related to any of the themes or topics covered by *Genetic Resources and Crop Evolution* are cordially invited to prepare their manuscript following the Instructions for Authors Please request these instructions using the card below

---

Author response card

Genetic Resources and Crop Evolution

I intend to submit an article on the following topic

Please send me detailed Instructions for Authors

NAME

INSTITUTE

DEPARTMENT

ADDRESS

Telephone

Telefax

Email

Library Recommendation Form

Route via Interdepartmental Mail

To the Serials Librarian at

From Dept /Faculty of

Dear Librarian

I would like to recommend our library to carry a subscription to
Genetic Resources and Crop Evolution, ISSN 0925 9864
published by Kluwer Academic Publishers

Signed Date