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DIVERGENCE AND CLASSIFICATION OF DWARF AND NON-DWARF PEARL MILLET ACCESSIONS

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ABSTRACT

To identify parents for crossing, the diversity in a sample of dwarf and non-dwarf inbred lines, using 11 morphological traits was studied in summer season 1994 (E1) and rainy season 1994 (E2) at ICRISAT Asia Center, Patancheru, India. Significant diversity was observed in this set of 10 inbred lines and five control entries. Inter-cluster and intra-cluster distances were calculated using Mahalanobis D^2 statistic. These 15 accessions were grouped into 4 clusters in E1 and E2, as well as across (pooled over) environments. The grouping was fairly consistent and largely independent of environmental influence. The traits that mainly contributed to groupings were time to 50% stigma emergence, panicle length, effective tillers, leaf blade width and 1,000 grain mass. The set of inbreds ICMP 85410, ICMP 91205, ICMP 83503 and ICMP 89024 were selected for intercrossing since those fell into different groups.

Key words: *Pennisetum glaucum*, pearl millet, divergence, genetic distance, cluster analysis.

A large number of dwarf and non-dwarf pearl millet [*Pennisetum glaucum* (L.) R. Br.] inbreds are maintained at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Pearl Millet Parental Line Collection (IPMPLC). Several of these parental lines have been widely utilized in the Indian national program as well as at ICRISAT to produce high yielding single-cross hybrids that are downy mildew [*Sclerospora graminicola* (Sacc.) J. Schrot] resistant in India [1-3]. WC-C75 [4] is used as one of the control entries.

The importance of diversity in choosing parents for hybridization has been emphasized by several workers. The more diverse the parents, the greater are the chances of achieving larger amount of heterotic expression in F_1s and broad spectrum of variability in segregating generations [5, 6]. To create new variability for deriving improved parental lines, appropriate crosses among existing diverse inbreds appears essential [6, 7]. The objective of the present study was to evaluate diversity among a sample of elite dwarf and non-dwarf inbreds from the IPMPLC using cluster analysis based on morphological traits.

MATERIALS AND METHODS

Ten elite inbred lines (5 dwarf and 5 non-dwarf) broad at ICRISAT and five control entries (Table 1) four of which were also bread at ICRISAT [1-3, 8 and 9] were grown in two different environments, summer season 1994 (E1) and rainy season 1994 (E2) at ICRISAT Asia Center, Patancheru, India.

Table 1. Pedigrees of 15 pearl millet accessions studied

Entry name	Pedigree	Plant type	PMIPC number
ICMP 85410	(ICP 165 × ICP 220)-64	Dwarf	IPC 0735
ICMP 501	(B 282 × 3/4 EB-100-11)-9-2-1	Dwarf	IPC 0392
ICP 220	SD 2 × EB 2(D 1088-1)	Dwarf	-
ICP 105	B 282	Dwarf	IPC 1447
81B	Induced DM resistance selection from Tift 23D2B	Dwarf	--
ICMP 91205	(ICRC II × IP 8022)-51-1-3	Tall	IPC 1654
ICMP 83503	(J 1248 × 700112-1)-2-18-1-2-4	Short	IPC 1356
ICMP 89024	(J 104 × MBP 110)-35-7-3	Short	IPC 1614
ICMP 423	EC-S3-211-1-2	Tall	IPC 0094
ICMP 451	LCSN 72-1-2-1-1	Tall	IPC 0107
Controls			
7042	7042 (ICML 22)	Short, early	
EC-C75	Bred from 7 full-sib progenies of WC selected at Coimbatore in 1975.	Tall	
P7	P7	Tall	
J 104	J 104	Short	
700651	700651 (ICML 16)	Tall, late	

The experimental material were grown in a randomized complete block design with three replications in an Alfisoil. Gross plot size was 4 rows of 4 m length and 0.75 m distance between rows. Plant-to-plant distance within row was 0.1 m. Fertilizer dose was 40 kg ha^{-1} N and 40 kg $ha^{-}1$ P_2O_5 as basal dose one week prior to sowing and 40 kg ha^{-1} N as top dressing 28 days after seedling emergence. The field was irrigated at an interval of 15 days in E1. No irrigation was applied in E2. Two central rows of each plot were harvested for grain yield after trimming 0.5 m from each end (harvested area = 4.5 m^2). Data on 18 characters were recorded. Time to 50% stigma emergence (days), time to anthesis (days), panicle yield (kg ha^{-1}), number of panicles, number of plants, downy mildew incidence (%), grain yield (kg ha^{-1}) and 1,000 grain mass (g) were recorded on a plot basis. Plant height (cm), panicle length (cm), panicle girth (cm), main stem node number, internode length (cm) between 3rd and 4th nodes from top, basal tillers (number/plant), effective ear bearing tillers (number/plant), leaf sheath length (cm), leaf blade length (cm) and leaf blade width (cm) at fourth node from top, were recorded from five random plants. Out of these, 11 traits with significant phenotypic differences and high broad sense heritability (> 0.80) on plot basis were considered for analysis of genetic diversity and clustering.

The diversity among the 15 accessions was evaluated using Mahalanobis's D^2 statistic [10]. Cluster analysis for grouping the accessions was done using Ward's minimum variance method [11].

RESULTS AND DISCUSSION

Eleven important highly heritable traits (time to 50% stigma emergence, plant height, panicle length, panicle girth, internode length, basal tiller number, effective tiller number, leaf sheath length, leaf blade length, leaf blade width and 1,000 grain mass) were used for the divergence study and cluster analysis. The cluster composition and inter and intra cluster divergence values are given in table 2 and table 3

Table 2. Clustering of 15 pearl millet accessions in summer session 1994 (E1) and rainy season 1994 (E2) and pooled over environments (E1 and E2)

Inbred group	Clusters E1	Clusters E2	Clusters Across	Summer season (E1)	Rainy season (E2)	Pooled over environments (E1 and E2)
1	I	I	I	*ICMP 85410, ICMP 501, ICP 220, ICP 105, 81B*	*ICMP 85410, ICMP 501, ICP 220, ICP 105, 81B* ICMP 91205	<u>*ICMP 85410, ICMP 501, ICP 220, ICP 105, 81B*</u>
2	II	II	II	*700651*, ICMP 91205	*700651*	<u>*700651*</u>, ICMP 91205
3	III	IV	IV	*ICMP 83503, 7042, J 104*	ICMP 83503,ICMP 423,7042,J 104	<u>*ICMP 83503*</u>, ICMP 423,<u>*7042, J 104*</u>
4	IV	III	III	*ICMP 89024*, ICMP 423, *ICMP 451, WC- C75, P7*	*ICMP 89024, ICMP 451, WC-C75, P7*	<u>ICMP 89024, ICMP 451, WC-C75, P7</u>

Underlined accessions are clustered in the same group in both E1 and E2, and also pooled.

Table 3. Intra- and inter-cluster distances pooled over environments (E1 and E2)

Clusters	I	II	III	IV
I	3.62	4.62	4.91	5.58
II		2.32	4.56	6.53
III			3.11	5.06
IV				3.85

E1 = Rainy season 1994; E2 = Summer season 1994

respectively. In the D^2 analysis in E1, time to 50% stigma emergence made maximum contribution to divergence (41.9%) followed by 1,000 grain mass (22.9%), panicle girth (15.2%), panicle length (5.7%) and plant height (4.8%). These five traits accounted for 90.5% of the divergence observed in these 15 accessions. The contribution to divergence of the remaining six traits was either very low or zero. In E2, panicle length (33.3%), leaf blade width (17.1%), effective tiller number (16.2%), plant height (5.7%), panicle girth (5.7%) and 1,000 grain mass (5.7%) contributed 83.7% of the observed divergence in these 15 accessions. In pooled analysis over both the environments, 1,000 grain mass (28.6%), panicle length (22.9%), effective tiller number (11.4%), time to 50% sigma emergence (10.5%) and leaf blade width (7.6%) contributed substantially to divergence among these accessions (Table 4). These results are almost

Table 4. Accessions mean, range and culster means for the 11 traits assessed for divergence studies and the groups by cluster analysis pooled over two environments (E1 and E2)

	Accession		Cluster (means)			
Trait	Mean	Range	I	II	III	IV
Time to 50% flowering(d)	53	43-64	58	61	49	46
Plant height (cm)	137	68-200	103	176	163	138
Panicle length (cm)	21.3	10.0-29.0	23.0	26.5	23.3	14.0
Panicle girth (cm)	8.3	6.3-10.9	7.9	7.1	9.3	14.0
Internode length (cm)	15.4	9.0-20.0	10.8	17.5	18.0	17.5
Basal tillers (no.)	5.5	3.5-8.5	5.6	5.8	4.7	6.0
Effective tillers (no.)	2.5	1.1-5.8	2.2	1.7	2.0	4.0
Leaf sheath length (cm)	12.0	9.0-15.5	11.8	14.0	12.0	11.0
Leaf blade length (cm)	54.0	36-68	52.0	63.0	58.0	47.0
Leaf blade width (cm)	3.4	1.7-4.4	3.6	3.9	3.7	2.7
1000-grain mass (g)	8.4	6.6-11.2	7.9	7.9	9.4	8.1

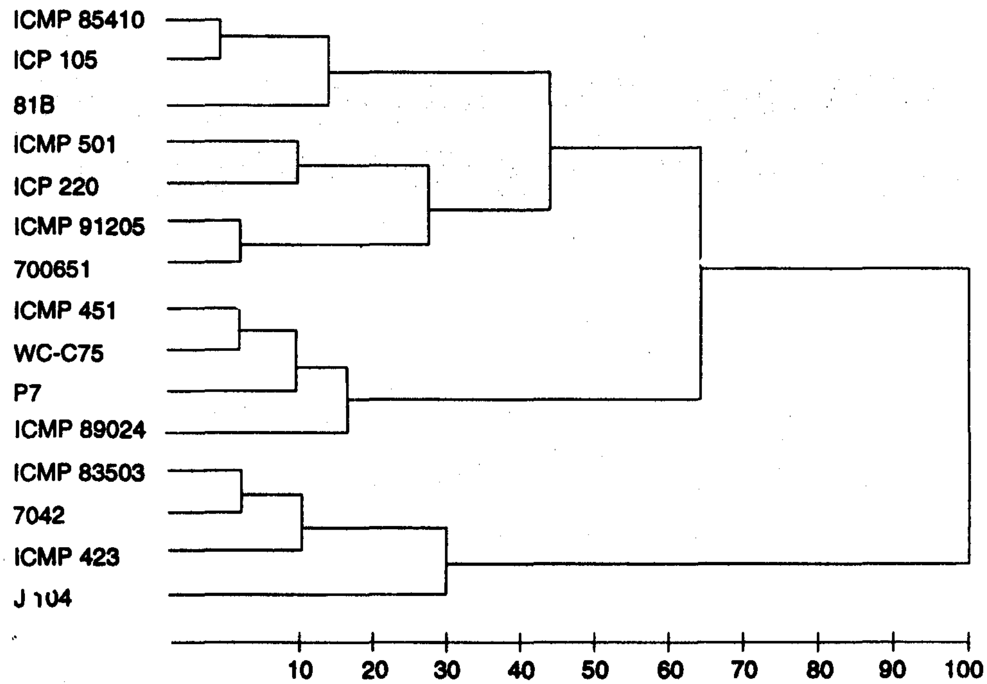

Fig. 1. Dendrogram of fifteen pearl millet inbreds pooled over summer season 1994 and rainy season 1994 environments at ICRISAT Asia Center

in conformity with earlier reports [7, 12-17]. The present investigation however did not reveal substantial or adequate contribution of plant height to diversity as reported by others [7, 12, 13]. Panicle length, 1,000 grain mass, effective tiller number and time to 50% stigmna emergence were the most important contributors to diversity in this group of accessions which support the findings of earlier workers [7, 12-15]. The importance of tiller number for divergence in the dwarf derivatives as in the present study was reported earlier [15]. Contribution of leaf blade width identified in the present study was not known earlier. Contribution of leaf blade length to divergence had been reported earlier [14]. It is obseved that some traits contributing to yield increase such as panicle length, panicle girth and 1,000 grain mass and affecting adaptation such as time to 50% stigma emergence, effective tiller number and lead blade width were the major sources of diversity among the group of inbred lines involved in this study (Table 4).

The 15 accessions were grouped into 4 diverse clusters in E1 and E2, as well as across (pooled over) environments (Table 2). Groupings were reasonably consistent across these two environments. Dwarf inbreds ICM 85410, ICMP 501, ICP 220, ICP 105 and 81B clustered together in each of E1 and E2, as well as across environments. This was in conformity with our earlier study and also by others [15]. Dendrograms were constructed based on pooled means (Figure 1). The clustering pattern was almost similar in the two environments except for ICMP 91205 and ICMP 423. Thus 13 of 15 accessions clustered in similar group in both environments. Inbred 700651 (ICML 16) was found very distinct, being extremely divergent compared to other inbreds, and formed a separate group in E2 and clustered with ICMP 91205 in E1 and across environments (Table 2). These inbreds are late in flowering and have morphological attributes very distinct from the most of other inbreds in this study. ICMP 83503, J 104 and 70-42 fell into the same cluster in both the environments and across environments analysis. Likewise ICMP 89024, ICMP 451, WC-C75 and P7 clustered together in each of E1 and E2, as well as across environments. These inbreds were phenotypically somewhat similar but have distinct origin. Thus divergence depended more on morphological attributes than geographic origin of the inbred lines. Other workers, who had similar conclusion in groups of wide range of accessions have shown that geographical distribution and genetic diversity need not be directly related [7, 13, 14, 16 and 17].

The analysis indicates that the grouping of the inbred lines with respect to the traits considered in this study are consistent and largely independent of the environments. This classification might have wide applicability in breeding new pollinators. ICMP 85410, ICMP 91205, ICMP 83503 and ICMP 89024 having clustered in different groups can make a set of elite inbreds for intercrossing [6, 12]. The progenies derived from such crosses are likely to produce superior pollinators.

The main criteria for selection of genotypes as parents for hybridization using D^2 analysis is the inter cluster distance. Genotypes included in clusters with maximum inter-cluster distance are obviously more divergent. In the present study inter cluster(D) values were observed to be the highest between clusters II and IV (6.53) and the lowest between clusters II and III (4.56). The values between other clusters fall within this range. Several workers suggested that selection of parents for hybridization should be done from two clusters having wider inter cluster distance to get more variability among the segregants. Maximum intra-cluster distance was in cluster IV (3.85) and minimum in cluster II (2.32). Several workers prefer intra-cluster crossing particularly if the distance is substantial.

The results on accession mean, range and cluster mean values (Table 4) for different characters showed a wide range of variation. The set of accessions in this study represent dwarf to medium height (68 to 200 cm), early to medium flowering

(43 to 64 days) and short to medium panicle length (10.0 to 29.0 cm) with distinct groups having similar values of trait within a group. Analysis of cluster means indicated that the entries 7042 (ICML 22) and J 104 in cluster VI are distinctly early flowering with small leaf blade length, and 700651 (cluster II) is dintinct in tall plant height (194 cm) and large panicle length (26.0 cm). Cluster II entries are distinct for their long maturity requirement.

This analysis has helped identify diverse parents for hybridizaton. This is expected to generate a wide spectrum of variability in segregating generations. With adequate care in selection during segregating generations, it is possible that the inbred lines with relatively large panicle length and girth and early maturity can be derived.

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