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Morphological Characterization and Correlation Assessment of Quantitative and Qualitative Traits of Proso Millet (*Panicum miliaceum* L.) Germplasm

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Abstract

Studies of quantitative and qualitative morphological variability are necessary for the improvement of crops. Therefore, ten proso millet lines collected from different regions of India were screened during Kharif 2020-2021 at the Biotechnology Centre, JNKVV Jabalpur, to evaluate different morphological parameters. The characters included under study were days to 50 % flowering, plant height (cm), number of tillers per plant, panicle length (cm), Flag leaf width (FLW) (cm), Flag leaf blade length (FLBL) (cm), Days to maturity, grain yield per plant (gm), and 1000-grain weight (gm) while qualitative traits were plant growth habit, plant pigmentation, leaf sheath: pubescence, inflorescence shape, compactness of inflorescence, grain colour and the grain shape. All data were taken at the different growth stages of the plants and calculated the mean performance of all parameters to assess the variability that could be facilitated desired trait selection for yield enhancement. Pearson Correlation analysis and other indices proved to be a helpful approach for rapid and cost-efficient screening of large numbers of genotypes for characterization.

Key words : Proso millet, morphological variability, correlation analysis, Panicum miliaceum.

Introduction

Proso millet (*Panicum miliaceum* L.) is a common millet or broomcorn millet. It is cultivated in the Kharif season and genus Panicum diploid cereal crop with a number of chromosomes 2n =36. Millets can be grown in infertile soil under intense heat and scanty rainfall (1). It is consumed as a staple cereal food in the region of arid and semiarid tropics of the world, such as Asia, Africa, and parts of Europe (2). In India, proso millet is grown in Madhya Pradesh, Uttar Pradesh, Bihar, Tamil Nadu, Maharashtra, Andhra Pradesh, and Karnataka.

Millets are rich sources of proteins, phytochemicals, micronutrients, and antioxidants, like phenolic acids and glycated flavonoids (3). In addition to their nutritive value, several potential health benefits like preventing cancer and cardiovascular diseases are reported for millet (4,5). Furthermore, proso millet-based food products have a lower glycemic index (GI) than other cereals, such as corn, which seems to be a good component for low-GI food products (6).

Correlation coefficient studies can provide the association of traits that directly or indirectly affected the yield traits. Correlation studies and principal component analysis would help identify the desired traits to enhance crop productivity. Multivariate hierarchical cluster analysis was used to group all accession which could help identify accessions with diverse traits (7,8). Qualitative characterization of the accessions can provide pivotal information for managing genetic resources and help discriminate each line with distinct characters. Mass selection has been used to improve grain yield in several crops through indirect selection for highly heritable traits associated with yield.

Materials and Methods

The research trial was conducted at Biotechnology Centre, Jawaharlal Nehru Krishi Vishwa Vishwa Vidyalaya, Jabalpur, India, during the Kharif season (2020-2021). The accessions were collected from various geographic and climatic regions in India (Table-1). Suitable agronomical practices were done to maintain a healthy crop. Observations were recorded on five plants for plant height (cm), number of tillers per plant, panicle length (cm), Flag leaf width (FLW) (cm), Flag leaf blade length (FLBL) (cm), days to 50 % flowering, Days to maturity, Yield Per plant(gm), 1000 - grain weight (gm) and qualitative traits were analyzed for plant growth habit, plant pigmentation, leaf sheath: pubescence, inflorescence shape, compactness of inflorescence, grain colour and the grain shape. The statistical analysis of the results was through using SPSS 16.0 software. The results were presented as the mean and range of various proso millets (Table-2). The Pearson's correlation coefficient and similarity matrices were accustomed to constructing a dendrogram for all the genotypes using Past software supported UPGMA. Mean values of ten genotypes for nine quantitative traits were subjected to multivariate hierarchical cluster analysis. All qualitative observations and frequency of variants were scored

Table-1 : List of accessions used in the morphological characterization studies.

S. No.	Accession code	Lat-Lon	Collection site	Scientific name
1.	PM-1	12.97° N 77.59° E	Banglore	*Panicum miliaceum*
2.	PM-2	12.97° N 77.59° E	Banglore	*Panicum miliaceum*
3.	PM-3	12.97° N 77.59° E	Banglore	*Panicum miliaceum*
4.	PM-4	24.53° N 81.30° E	Rewa	*Panicum miliaceum*
5.	PM-5	24.53° N 81.30° E	Rewa	*Panicum miliaceum*
6.	PM-6	24.53° N 81.30° E	Rewa	*Panicum miliaceum*
7.	PM-7	24.53° N 81.30° E	Rewa	*Panicum miliaceum*
8.	PM-8	17.38° N 78.48° E	Hyderabad	*Panicum miliaceum*
9.	PM-9	24.53° N 81.30° E	Rewa	*Panicum miliaceum*
10.	PM-10	17.38° N 78.48° E	Hyderabad	*Panicum miliaceum*

Table-2 : Complete mean performance of all morphological data of proso millets genotypes.

Parameter/ Genotypes	PHT	PL	NPL	FLW	FLL	DTF	DTM	GYDP	TSW
PM-1	78.34	13.20	2.30	1.30	14.00	35.00	55.20	8.36	1.81
PM-2	76.47	12.80	3.20	1.20	13.00	37.33	58.90	8.45	1.74
PM-3	79.60	9.94	3.21	1.60	24.00	41.50	65.30	8.86	1.69
PM-4	79.90	20.83	4.47	1.20	18.00	45.00	74.90	9.81	1.58
PM-5	78.32	12.44	3.69	1.25	14.00	42.33	69.50	11.25	1.47
PM-6	84.32	12.25	2.69	1.30	12.000	43.33	71.90	10.37	1.45
PM-7	87.69	14.02	5.00	1.40	14.00	45.00	75.50	7.13	1.43
PM-8	78.35	14.00	3.03	1.50	15.00	38.00	62.30	9.34	1.81
PM-9	85.86	20.10	3.00	1.30	24.00	46.60	75.10	16.36	1.74
PM-10	85.60	20.31	2.93	1.20	26.00	48.92	78.00	18.45	1.69
Mean	81.44	14.98	3.35	1.32	17.40	42.30	68.66	10.83	1.64
Min	76.47	9.94	2.30	1.20	12.00	35.00	55.20	7.13	1.43
Max	87.69	20.83	5.00	1.60	26.00	48.92	78.00	18.45	1.81
SD	3.99	3.91	0.82	0.135	5.27	4.41	7.84	3.67	0.14
SEM	1.26	1.23	0.259	0.042	1.66	1.39	2.48	1.16	0.04

based on IBPGR (9) descriptors for Panicum miliaceum and P. sumatrense (Table-3 and Table-4).

Results and Discussion

Values with descriptive statistics of all the parameters such as mean, range, and standard deviation (Table-2) helped eliminate undesirable accessions. Plant heights varied between 76.47 cm and 87.69 cm, with a mean value of 81.44 cm. The mean value for days to 50 % flowering was 42.30 days and ranged from 35.20 to 48.92. Total numbers of tillers are one of the important yields contributing characters, ranging from 2.3 to 5.0 with a mean of 3.35. The mean values for panicle length ranged from 9.94cm to 20.83cm, with a mean of 14.98 cm. Flag leaf width ranged from 1.20 to 1.60 cm, with a grand mean of 1.32cm. Flag leaf blade length varied from 12.0 - 26.0 cm, with a mean of 17.40 cm. The days to the maturity value of minor millet genotypes varied from 55.20 to 78.00 days, with a mean of 68.66 days.1000-grains weight ranged from 1.43 to 1.81g with a mean of 1.64 g. Grain yield per plant showed a wide range of 7.13 to 18.45 g with a mean of 10.83g. Analysis of variance showed significant variation among the accession of proso millet for all the traits (Table-2). These findings were also approved in earlier studies (10,11).

Analysis of correlations between morphological quantitative traits : Plant height was positively and significantly correlated with days to 50% flowering (r=0.784) and days to maturity (r=0.792) at a 5% significance level. While panicle length positively correlated with days to 50% flowering (r=0.641) and grain yield per plant (r=0.677) at 1% significance. Days to 50% flowering were highly and positively correlated with days to maturity(r=0.980) at 5% significance and grain yield per plant (r=0.677) at 1% significance (Table 3). These correlation studies were also found for days to 50% flowering, days to maturity, plant height, and the number of tillers per plant (12,13,14,15).

Cluster analysis of morphological quantitative and qualitative traits : Cluster analysis of quantitative traits was done based on the Euclidian similarity index using

Table-3 : Correlation coefficient among morphological traits of proso millet germplasm.

	PHT	PL	NPL	FLW	FLL	DTF	DTM	GYDP	TSW
PHT	1	.416	.257	-.032	.346	.784**	.792**	.452	-.421
PL		1	.176	-.539	.509	.641*	.615	.677*	.123
NPL			1	-.013	-.112	.381	.489	-.303	-.603
FLW				1	.132	-.235	-.231	-.379	.151
FLL					1	.591	.442	.713	.325
DTF						1	.980**	.677*	-.458
DTM							1	.565	-.574
GYDP								1	.160
TSW									1

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)
Note : Plant height=PHT, panicle length=PL, No of Panicle=NPL, Flag leaf blade width=FLW, Flag leaf length=FLL, Days to 50% flowering=DTF, Days to Maturity=DM, Grain yield per plant=GYDP, 1000 Seed weight= TSW

Table-4 : Constituents of VI clusters in barnyard millet genotypes for 11 qualitative characters truncating the tree 65% similarity level.

Cluster	Number of genotypes	Constituent genotypes
I	5	PM-5, PM-6, PM-2, PM-3, PM-4
II	3	PM-8, PM-9, PM-10
III	2	PM-7, PM-1

Table-5 : Morphological qualitative characterization of Proso millet germplasm collected from different areas of Inda.

Accession code/ Characters	Growth habit	Plant pigmentation	Leaf-sheath: pubescence	Inflorescence : shape	Panicle : Compactness	Grain : Colour	Grain : Shape
PM-1	Decumbent	Present	Sparse	Arched	Semi compact	Dark Grey	Elliptical
PM-2	Erect	Present	Strong	Diffused	Open	Grey	Elliptical
PM-3	Erect	Present	Strong	Diffused	Open	Grey	Elliptical
PM-4	Decumbent	Present	Strong	Arched	Semi compact	Golden yellow	Oval
PM-5	Erect	Present	Sparse	Diffused	Open	Golden yellow	Oval
PM-6	Erect	Present	Sparse	Diffused	Open	Golden yellow	Oval
PM-7	Erect	Present	Glabrous	Diffused	Open	Dark Grey	Elliptical
PM-8	Erect	Absent	Strong	Arched	Semi compact	Straw white/ cream	Oval
PM-9	Erect	Absent	Glabrous	Arched	Semi compact	Dark Grey	Elliptical
PM-10	Erect	Absent	Strong	Arched	Open	Grey	Elliptical

Table-6 : Characterization and preliminary evaluation of proso millet germplasm.

| Character	Score	Phenotype	Number of variants	Percentage of variants
Growth habit	3	Erect	8	80.0
	5	Decumbent	2	20.0
	7	Prostrate	0	0.00
Plant pigmentation	9	Absent	3	30.0
	1	Present	7	70.0
Leaf sheath : pubescence	3	Glabrous	2	20.0
	5	Sparse	3	30.0
	7	Strong	5	50.0
Inflorescence shape	3	Arched	5	50.0
	5	Diffused	5	50.0
	7	Globose-elliptic	0	0.00
Compactness of inflorescence	3	Compact	0	0.00
	5	Intermediate	4	40.0
	7	Open	6	60.0
Grain : Colour	2	Straw white/cream	1	10.0
	3	Golden yellow	3	30.0
	5	Grey	3	30.0
	7	Dark Grey	3	30.0
Grain : Shape	2	Elliptical	6	60.0
	4	Oval	4	40.0
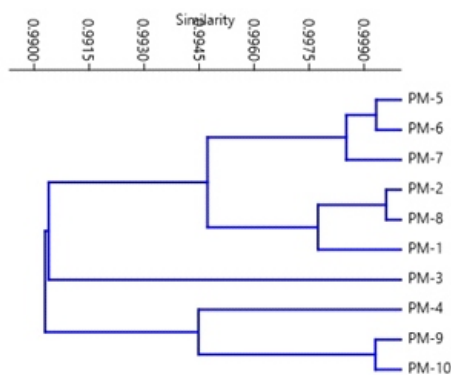
Figure-1 : Dendrogram representing the grouping of ten proso millet accessions formed through UPGMA based on different morphological quantitative markers.
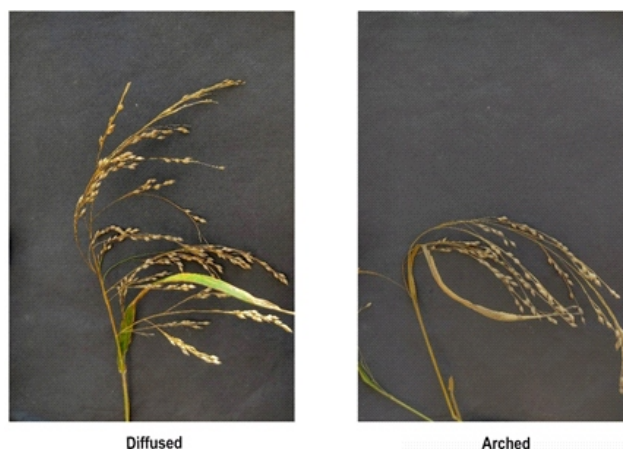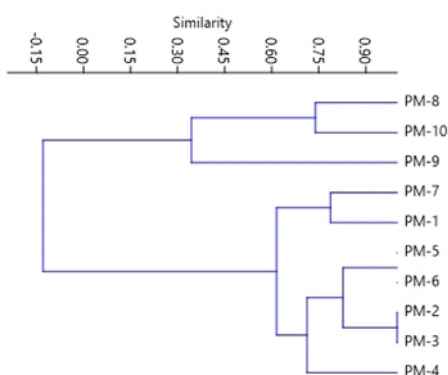

Figure-3 : Inflorescence shape.

Figure-2 : Dendrogram representing the grouping of ten proso millet accessions formed through UPGMA based on different morphological qualitative traits.

Figure-4 : Seed colour and shape.

past software. Dendrogram formed two clusters, one major and one minor (Fig.-1). Major cluster had seven genotypes, i.e. PM-5, PM-6, PM-7, PM-8, PM-2, PM-1, and PM-3 at 99.45 % similarity while minor cluster consisted three genotypes namely; PM-4, PM-9, and PM-10 (Fig.-1).

The cluster analysis of the ten accessions for seven qualitative traits using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) method resulted in grouping accessions into one major and one minor cluster while truncating the dendrogram tree similarity coefficient of 0.45 (Fig.-2). cluster I have accustomed the most prominent cluster with eight accessions, and cluster II consists of 3 accessions. Cluster I was further divided into two minor clusters in Table-4.

Diversity of quality traits : Seven qualitative traits were characterized for proso millet, which could be used to
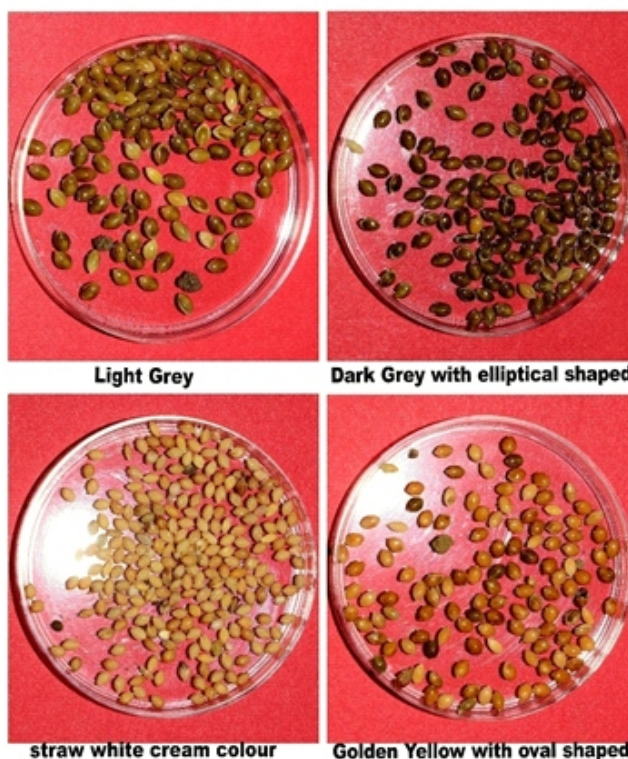
quickly identify the accession because qualitative traits are less affected by environmental conditions. All qualitative characters of proso millet were presented in Table-3. The highest frequency of variation of characters was founded in leaf sheath pubescence and grain colour (Fig.-4). Moderate frequency variants resulted in inflorescence shape and panicle compactness. Variability in flower shape is given in Fig.-3. Among all qualitative traits, fewer variants were found for traits like plant growth habit and plant pigmentation. Similar findings were also concluded in proso millet (16).

Conclusions

The collection of proso millet had ample variability based on quantitative and qualitative analysis. Therefore, it can be used for germplasm construction, discriminate among proso millet cultivars based on related traits and could be used for further studies on millet with correlation studies between all traits for selecting the best cultivar for the breeding programme. The Pearson's correlation study revealed that the characters viz., panicle length and days to 50 % flowering had a highly significant positive correlation with grain yield per plant. Significant positive correlation between days to 50% flowering and days to maturity at a 5% significance level. It can be concluded that an extensive range of variability was detected for different traits under this investigation which could be used for efficient manipulation in proso millet.

Acknowledgement

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