https://doi.org/10.29321/MAJ.10.A02127

Madras Agric. J. 75 [9 & 10] ; 323-329 September & October, 1988

AN APPRAISAL OF GENETIC DIVERSITY IN PROSO MILLET (*Panicum miliaceum* L.)

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Mahalanobis' D^2 Statistic was used to estimate the genetic diversity among 50 types of proso millet (*Panicum miliaceum* L.). The types grouped themselves into as many as 15 clusters indicating wide genetic variability among them. Geographic distribution was not related to genetic diversity pointing to the availability of wide genetic variability in the types from the same geographic region. The clusters XII and XIV were highly divergent from the others. The type MS. 5201 in cluster XIV was superior in yield of grain and straw, panicle length and rachis number while MS. 1452/1 in cluster II was superior for panicle number. The type MS. 4955 in cluster VII recorded the lowest number of days to half bloom. When these types which are highly divergent are utilized in a crossing programme, a large spectrum of recombinants are likely to be unleashed. The rank total analysis disclosed that yield of grain and straw and panicle length contributed most to genetic divergence.

Crosses involving parents which are genetically diverse are expected to result in wide recombination and are likely to throw larger proportions of desirable segregants. In earlier days, geographical sources were regarded as primary criterion for inferring genetic diversity. Lysoy (1962) made a series of crosses involving closely related and geographically remote forms of proso millet and made selections within the F2 and later generations and concluded that best results were shown by selections derived from crosses involving geographically remote forms. Genetic materials from the same eco-geographic region also possess wide genetic make up and the condition *vice versa* is also not uncommon. Hence it becomes necessary to estimate the genetic diversity among the types as a prelude to selection of parents in a hybridization programme aimed at improving proso millet.

MATERIALS AND METHODS

Fifty genotypes of proso millet with diverse geographic origin (38 types from 11 states of India and six types each from USA and USSR) were chosen from the germplasm bank maintained at the Millets Breeding Station, Agricultural College and Research Institute, Coimbatore. The experiment was laid out in a randomized block with three replications. Each type was sown in a ridge of 2.7m long spaced 40cm apart. The plants

Part of M Sc. (Ag.) thesis submitted by the first author to the Tamil Nadu Agricultural University, Coimbatore.

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Table 1. Analysis of variance for nine characters in proso millet

Source	DF	Mean squares								
		Days to half bloom	Plant height	Panicle number	Panicle length	Panicle weight	Rachis number	Grain weight	Straw yield	Grain yield
Genotypes	49	56.77**	206.36**	273.56*	16.46**	3.23**	10.70**	8335.05**	134.33**	164.62**
Error	98	3.11	25.17	53.28	2.85	0.23	1.12	788.81	26.40	37.07

(**) Significant at 1% level.

were spaced at 15cm within a ridge. The experiment was conducted during the rainy season of 1977. Five plants were selected at random for each type ineach replication and observations were recorded on individual plants or nine characters namely, days to half bloom, plant height, number of panicle, length of primary panicle, weight of primary panicle, number of primary rachis in the primary panicle, 100-grain weight, straw yield and grain yield.

The data were subjected to multivariate analysis (Rao, 1952). For determining the group constellations or clusters, a relatively simple criterion suggested by Tocher (Rao, 1952) was followed. After establishing the group constellations or clusters, the average intra and inter-cluster divergence was worked out taking in to consideration all the component D^2 values possible among the members of the two clusters taken for consideration. The squre root of the D^2 values gave the distance between the clusters.

Ranking of individual D^2 values contributed by each character was worked out for nine characters by using the technique that the highest contribution of a character is indicated by its lowest rank total and *vice versa* (Murthy *et al.*, 1965).

RESULTS AND DISCUSSION

Analysis of variance showed significant differences among the types for all the characters studied (Table-1). The generalized D^2 values ranged from 1.78 to 238.73. By the application of clustering technique, the 50 types were grouped in to 15 clusters. The constitutents of the cluster with their source are presented in Table 2. Among them cluster III was the largest consisting of nine types followed by cluster I which had eight types. Cluster II and X had three types each. Clusters XIV and XV consisted of only one type each and the other clusters included two types each.

Table 2. Composition of D^2 Clusters

Cluster No.	Number of types	Designation	Source
	8	MS.4914	Madhyapradesh
		MS.4847	Karnataka
		MS.4977	Karnataka
		MS.4863	West Bengal
		MS.4978	Orissa
		MS.4961	Gujarat
		MS.4865	West Bengal
		MS.2424	Tamil Nadu
II	5	MS.1620	Tamil Nadu
		MS.1595	Tamil Nadu
		MS.1452/1	Tamil Nadu
		MS.1597	Tamil Nadu
		MS.5002	USA
III	9	MS.1583	Tamil Nadu
		MS.5222	USSR
		MS.4872	Bihar
		MS.4882	Bihar
		MS.5017	USA
		MS.4824	Tamil Nadu
		MS.4906	Jammu and Kashmir
		MS.5046	USA
		MS.5006	USA
	2	MS.4937	Utter Pradesh
		MS.4920	Utter Pradesh
V	2	MS.1658	Tamil Nadu
		MS.5233	USSR
VI	2	MS.4982	USA
		MS.4979	Orissa
VII	3	MS.4955	Gujarat
		MS.4958	Gujarat
		MS.5220	USSR
VIII	2	MS.1328	Tamil Nadu
		MS.5202	USSR
IX	3	MS.4802	Kerala
		MS.1402	Tamil Nadu
		MS.1713	Tamil Nadu
X	5	MS.4973	Tamil Nadu
		MS.4848	Karnataka
		MS.4839	Karnataka
		MS.5235	USSR
		MS.1309	Tamil Nadu
XI		MS.4894	Bihar
		MS.4393	Bihar
XII		MS.4931	Uttar Pradesh
		MS.4934	Uttar Pradesh
XIII	3	MS.4985	USA
		MS.4813	Tamil Nadu
		MS.4867	West Bengal
XIV	1	MS.5201	USSR
XV	1	MS.1707	Tamil Nadu

The clusters I, IV, IX, XI and XII comprised of types from more or less similar eco-geographic regions indicating identical genetic architecture among them. Each one of the other eight clusters had types from different geographic regions. This leads to the inference that factors other than geographic diversity may be responsible for such grouping and that the nature

Table 3. Intra and inter-cluster average D^2 and D (within parenthesis) values

Clus-	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I	3.94 (1.98)	10.24 (3.20)	19.60 (4.43)	15.70 (3.96)	24.57 (4.98)	77.11 (8.78)	59.02 (7.68)	38.93 (6.24)	42.90 (6.55)	11.74 (3.43)	32.00 (5.67)	88.67 (9.42)	23.78 (4.88)	76.99 (8.77)	61.66 (7.85)
II		2.96 (1.72)	22.45 (4.74)	22.08 (4.70)	12.87 (3.58)	65.03 (8.06)	53.10 (7.29)	26.25 (5.12)	37.16 (6.10)	11.30 (3.36)	30.58 (5.53)	103.24 (10.16)	36.23 (6.02)	76.17 (8.73)	48.86 ((6.99)
III			8.98 (2.99)	25.34 (5.03)	50.56 (7.11)	112.37 (10.60)	52.39 (7.24)	58.58 (7.65)	16.61 (4.10)	38.95 (6.24)	70.00 (8.37)	43.61 (6.60)	19.62 (4.43)	29.95 (5.47)	68.5 (8.28)
IV				1.78 (1.33)	25.44 (5.04)	44.08 (6.64)	20.28 (4.50)	25.76 (5.08)	30.35 (5.51)	26.71 (5.17)	22.40 (4.73)	57.23 (9.34)	48.21 (6.94)	70.78 (8.41)	26.17 (5.12)
V					1.83 (1.35)	30.92 (5.56)	49.39 (7.03)	8.03 (2.83)	61.04 (7.81)	12.98 (3.60)	12.75 (3.57)	157.47 (12.55)	76.01 (8.72)	122.69 (11.08)	34.67 (5.89)
VI						1.96 (1.40)	39.97 (6.32)	20.97 (4.58)	106.86 (10.34)	62.97 (7.94)	16.44 (4.05)	238.73 (15.45)	161.76 (12.72)	193.11 (13.90)	18.22 (4.27)
VII							4.65 (2.16)	33.92 (5.82)	32.67 (5.72)	70.46 (8.39)	46.57 (6.82)	111.83 (10.57)	101.04 (10.05)	77.45 (8.80)	11.11 (3.33)
VIII								5.05 (2.25)	61.01 (7.81)	27.76 (5.27)	15.67 (3.96)	166.93 (12.92)	98.41 (9.92)	126.10 (11.23)	19.02 (4.36)
IX									6.91 (2.63)	64.16 (8.01)	84.02 (9.17)	39.98 (6.32)	45.17 (6.72)	16.31 (4.04)	52.07 (7.22)
X										9.52 (.09)	23.79 (4.88)	133.16 (11.54)	47.31 (6.88)	112.85 (10.62)	61.88 (7.87)
XI											6.37 (2.52)	185.14 (13.61)	96.37 (9.82)	155.38 (12.47)	29.97 (5.47)
XII												6.84 (2.62)	46.06 (6.79)	12.13 (3.48)	160.02 (12:65)
XIII													12.84 (3.58)	48.29 (6.95)	122.20 (11.05)
XIV														—	114.05 (10.68)
XV															—

of selection forces opreating under respective domestic conditions might have been similar across the geographic barriers. Many earlier studies on D^2 statistic in crops like wheat (Somayajulu *et al.*, 1970), rice (Vairavan *et al.*, 1973) and sorghum (Govil and Murthy, 1973) have also exposed the lack of relationship between geographic diversity and genetic diversity. This may perhaps be due to the free exchange of materials from one place to other (Verma and Mehta, 1976) and varieties evolved under similar selection pressure will cluster together irrespective of their geographic origin (Singh and Bains, 1968).

Each of the six types from USA and USSR were distributed over four and six clusters respectively. Even the 15 types from TamilNadu were found scatetred in nine clusters. The existence of wide genetic variability even among the materials chosen from the same geographic region is thus

Table 4. Cluster means for the nine characters in proso millet

Cluster	Days to half bloom	Plant height (cm)	Panicle number	Panicle length (cm)	Panicle weight (g)	Rachis number	Grain weight (mg)	Straw yield (g)	Grain yield (g)
I	33.19	71.60	23.88	24.63	1.84	16 02	450.6	10.42	13.78
II	38.76	86.18	44.65	27.83	2.20	17.84	524.6	21.51	26.47
III	36 22	82.72	25 71	28.34	2.62	17.71	472.8	13.98	18.54
IV	29.03	68.53	9 97	23.38	2.45	14.60	456.2	4.30	6.72
V	41.17	78.85	36 17	26 69	2 09	15.80	543 3	19.90	19.24
VI	30.37	68.29	24.60	23.65	1.83	13.87	557 5	7.25	9 52
VII	28.58	74.46	17.44	28.50	2.78	15.29	530.4	7.44	12.80
VIII	42.07	76.20	24.30	26.35	1.60	15.64	565.0	12.15	8 55
IX	36 38	89.43	26.78	29 68	4.06	19 04	523 2	20.34	26.64
X	38.74	73.12	30.02	25.08	1.69	15.75	468.8	11.00	12 88
XI	30.97	65.74	22.50	22.60	1.20	13 63	494.4	6.22	8 97
XII	31.17	84.36	11.10	29.15	5.38	18.76	412.0	15.57	17.00
XIII	32.75	77.96	28.44	27.47	2.64	17.53	425.1	16.46	18.51
XIV	36.27	96.23	27.07	31.53	4.87	20.27	507.0	26 67	34.00
XV	32.83	78.67	17.93	22.97	2.50	17.67	595.7	12.50	22.03
Range	23.58 to 42 07	65.74 to 96.23	9.97 to 44.65	22.60 to 31.53	1.20 to 5.38	13 63 to 20 27	412.0 to 595.7	4.30 to 26.67	6.72 to 34.00
General mean	35 02	77.96	26.32	26.63	2.45	16.67	488 8	13.49	16.88

apparant. Singh *et. al.* (1971) felt that the temperature and ranifall pattern respectively could influence crop characters of the same race. Another reason attributed for such variation is the differential adaptation of various types belonging to the same eco-geographic region. Murthy and Arunachalam (1966) explained that such a wide adaptability could be possible due to reasons such as heterogeneity, genetic architecture of the populations, past history of selection, developmental factors and degree of general combining ability. For pedigree breeding, intercrossing these groups of parents from the same geographic region which are divergent among themselves is more desirable than choosing parents from other regions (Gupta and Singh, 1970).

The intra-and inter-cluster D^2 and D values among the 15 clusters are presented in Table 3. The statistical distances among the clusters based on D values are also represented disgrammatically (Fig. I). The intra-cluster generalized distance ranged from 1.33 to 3.58. The lowest intra-cluster distance was recorded by the cluster IV while the cluster XIII registered the highest. The highest inter-cluster distance was recorded between the cluster VI and XII (15.45) while the clusters V and VIII were the closest (2.83). Based on the inter-cluster distances, XII and XIV were found to be highly divergent from all other clusters. The types involved in these clusters on one hand and the types of other clusters on the other may serve as potential parents in heterosis breeding. Adequater elationship between the extent of heterosis and genetic divergence was reported in tomato by Rajanna *et. al.* (1977).

Table 5. Rank totals for the nine characters in proso millet

Character	Rank total
Grain yield	4740
Panicle length	4908
Straw yield	4991
Rachis number	5582
Panicle weight	6214
Panicle number	6825
Grain weight	6993
Days to half bloom	7085
Plant height	7944

The cluster means for various characters are presented in Table 4. The Russian type MS. 5201 (cluster XIV) is highly divergent from ten other clusters. This type is also superior for grain yield, straw yield, panicle length and rachis number. The cluster II recorded the highest panicle number while the cluster VII registered the lowest number of days to half bloom. Hence intercrossing the types from these clusters may result in enlarged variability and selection for these could result in higher yield combined with earliness in proso millet. Thus the following types may be suggested as parents for hybridization based on their mean values and genetic divergence.

Cluster No.	Characters	Types
II	Panicle number	MS. 1452/1
VII	Days to half bloom	MS. 4955 and MS. 4958
XIV	Grain yield, straw yield, Panicle length and rachis number	MS. 5201

The rank totals for all the characters are furnished in Table 5. Grain yield contributed maximum to genetic divergence in proso millet. The major contribution of grain yield towards genetic divergance is well evident by its cluster mean where its range was very wide and this focuses attention on the importance of this character at inter-cluster level. The characters like plant height and days to half bloom contribut ed the least to genetic divergence. Based on their study in wheat, Somayajulu *et. al.* (1970) concluded that selection towards uniformity in the characters like flowering time and plant hight could cause an eroding effect on genetic diversity. Das and Borthakur (1973) showed that genetic variability was reduced in course of selaction. The possibility of operation of similar phenomenon towards plant height and days to half bloom cannot be overlooked here also.

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Madras Agric. J. 75 [9 & 10] : 330-333 September & October, 1988

VARIABILITY PARAMETERS IN CHICKPEA (*Cicer arietinum* L.)

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Twenty one diverse varieties of chickpea were evaluated for the estimation of different variability parameters in two environments. Genotypic coefficient of variation (GCV) ranged from 1.53 for days to maturity to 27.67 for grain yield per plant in E_1 and 2.14 for days to maturity to 37.40 for grain yield per plant in E_2. The estimates of heritability were high for all the characters studied. High genetic advance as per cent of mean coupled with high heritability were recorded for grain yield per plant, number of pods per plant and number of primary branches per plant.

The primary aim of any breeding programme is to evolve high yielding varieties with improved quality. Adequate genetic vari bility is a pre-requisite for any crop improvement programme to be asuccess. Quantitative characters are under heavy influence of environmental factors which necessitate the knowledge of variability owing to genetic factors, actual heritable variation in offsprings and the advance which can be made through selection. Therefore, the present study is undertaken in order to study the variability parameters in chickpea for different yield contributing characters.

MATERIALS AND METHODS

The experimental material comprising of 21 diverse varieties of

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