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Assessment of Genetic Divergence and Selection Indices for Fruit Characters in Mango (*Mangifera indica* L.)

A.K. Barholia* and SangeetaYadav
Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya,
R. A. K. College of Agriculture, Sehore 466 001 M.P.

Genetic diversity and selection indices among 48 genotypes were estimated based on physical fruit characters in mango in subsequent on and off years. Based on D^2 values, 48 genotypes were grouped in 5 clusters in two subsequent years. Number of genotypes varied from cluster to cluster due to existence of genotype – environment interactions. Popular mango varieties namely, Langra, Amrapali, Dashehari, Chousa, Neelum, Fazli, Alphonso, Totapari, Mallika and land races of Bhopal division of Madhya Pradesh like SBM 01-10, SBM 01-13, SBM 01- 14, SBM 01-38 and SBM 01-19 appeared most divergent and showed real genetic diversity. Fruits per tree, fruit yield per tree, weight per fruit, length and width of fruit and percentage weight of pulp contributed more towards genetic divergence hence, selection of parents based on these physical fruit traits in form of selection indices be advantageous in genetic improvement of physical fruit quality with high yield in mango (*Mangifera indica* L.). Genotypes SBM 01-10, SBM 01-36, SBM 01-09, SBM 01-30 and SBM 01-6 showed comparatively high estimates of selection indices during on year while, SBM 01-36 followed by SBM 01-12, Totapari, SBM 01-17 and SBM 01-29 exhibited the maximum estimates for fruit yield/ tree during off year. Alphonso followed by SBM 01-5, SBM 01-13, Langra and SBM 01-14 during on year and Dashehari, Safeda, SBM 01-3 and SBM 01-39 in off year exhibited the minimum estimates of varietal indices for this trait. The ranking pattern of the genotypes based on selection indices was different in two years. Genotypes SBM 01-9, SBM 01-10, SBM 01-30, SBM 01-6 and SBM 01-36 which showed maximum varietal indices and phenotypic performance in both the years thus, appeared promising for use in breeding programme.

Key words: Genetic diversity, Inter and intra cluster distances, Genotypes, Fruit characters, Selection indices

The success of any crop improvement programme depends on genetic diversity in the existing available germplasm. The nature and degree of genetic divergence among the gene pool facilitate the breeder in selection of genetically diverse parents which are expected to through spectrum of variability after hybridization. Mahalanobis D^2 analysis has been found a powerful tool to quantify the degree of divergence among the genotypes but, practical utility of this technique has not been adequately tested for genetic improvement in mango (Karihaloo *et al*., 2003). Being a vegetatively propagated fruit crop, mango has a good scope for development of hybrid varieties by the use of genetically diverse parents. The selection of genotypes based on phenotypic performance or yield *per se* is not much effective due to presence of genotype - environment interaction in phenotypic expression of the genes. On the other hand, selection based on genetic merits of several characters in the form of selection indices using discriminant function analysis of Fisher (1936) has been found a powerful tool in selection breeding programme. This analysis discriminates the economic genotypes from a population based on their genetic merits. However, the practical utility of these techniques has not been tested in mango. The present study was undertaken with this objective and view.

*Corresponding author email :dr.arunbarholia@gmail.com

Materials and Methods

The materials of the present study comprises forty eight genotypes comprising 31 landraces from Bhopal division of Madhya Pradesh, 15 improved varieties and 02 hybrids, which were selected based on popular fruit characters like fruit size, suitability for pickles and table purposes, peel colour, firmness of pulp, flavour and storability. These genotypes were evaluated for physical characters of fruit in randomized complete block design with three replications in two subsequent on and off years. Two trees per genotype were randomly selected in each replication after fruit set. The fruits of selected trees were collected from each genotypes in each replications at full maturity stage and subjected to ripening for recording observations on fruits per tree, fruit yield per tree (kg), weight per fruit (g), length and width of fruit (cm), peel thickness (cm), length and width of stone (cm), percentage weight of peel, pulp and stone and ratio indices of length-width,

peel-pulp and pulp-stone. Genetic divergence among genotypes was computed using Mahalanobis D^2 analysis (Mahalanobis, 1928) by computer software SPAR 1 for physical and chemical fruit characteristics separately. The procedure given by Smith (1936) and outlined by Singh and Choudhary (1985) was used for calculation of discriminate function coefficients for various characters. The mean values of each character of individual genotype were multiplied by respective discriminate coefficients and the sum was taken as selection index for genotype. Finally, the genotypes were arranged in order of their merit to select the best variety for further improvement through breeding techniques.

Results and Discussion

Analysis of variance revealed significant differences among the genotypes for fruit yield per tree and all the physical characters of fruits including ratio indices. It indicates the existence of considerable variability for all the studied characters

Table 1. Pattern and constituents of clusters in 48 genotypes based on genetic distance of physical fruit characters in mango

Clusters	On-year		Off-year	
	No.	Genotypes	No.	Genotypes
I	14	SBM 01-11, Dashehari, SBM 01-5, SBM 01-33, SBM 01-4, SBM 01-36, SBM 01-27, Sehroli, Suvaranarekha, SBM 01-6, Alphonso, Gajaria, SBM 01-26 and SBM 01-30	21	SBM 01-36, Gajaria, SBM 01-12, SBM 01-13, SBM 01-2, SBM 01-14, Amrapali, SBM 01-28, Chousa, SBM 01-30, Langra, SBM 01-35, Gulabkhas, SBM 01-6, Bombay Green, SBM 01-10, Fazli, SBM 01-1, SBM 01-9, Mallika and Totapari
II	13	SBM 01-12, SBM 01-2, Langra, Amrapali, Gulabkhas, SBM 01-9, Bombay Green, SBM 01-28, SBM 01-35, Fazli, SBM 01-1, Totapari and Mallika	10	SBM 01-22, SBM 01-24, SBM 01-20, SBM 01-17, SBM 01-37, SBM 01-23, SBM 01-29, SBM 01-3, Sinduria and SBM 01-15
III	12	SBM 01-22, SBM 01-24, SBM 01-37, SBM 01-20, SBM 01-17, SBM 01-15, SBM 01-29, SBM 01-3, SBM 01-39, SBM 01-23, SBM 01-19 and Dahiyar	8	SBM 01-25, SBM 01-27, SBM 01-4, Dashehari, Sehroli, SBM 01-26, Suvaranarekha and Alphonso
IV	05	Sinduria, Safeda, SBM 01-38, Neelum and SBM 01-25S	7	SBM 01-11, Dahiyar, Neelum, Safeda, SBM 01-39, SBM 01-5 and SBM 01-33
V	04	SBM 01-10, SBM 01-13, SBM 01-14 and Chousa	2	SBM 01-38 and SBM 01-19

thus, offering good scope for the selection of desirable genotypes. The mean squares due to years was also significant for fruit yield per tree, peel thickness, percentage weight of peel and pulp, pulp to peel ratio and pulp to stone ratio. It revealed that these traits were influenced by the ambient climatic conditions that prevailed in two years. The genotype x environment interaction was also significant for some of the fruit quality traits. Shrivastava *et al*. (1987), Kashyap and Jyotishi (1969), Samad and Faruque (1976), Kapse *et al.* (1989). Yadav *et al.* (1995), Singh (2002) and Dwivedi and Mitra (2003) have also reported significant variability for physical fruit appearance in fruit crops.

Table 2. Inter and intra cluster distances based on physical fruit characters in mango

Cluster	Years	I	II	III	IV	V
I	On-year	1013.09	1312.45	792.95	797.65	1274.86
		(31.83)	(36.23)	(28.16)	(28.24)	(35.70)
	Off-year	1655.04	1487.33	1150.15	1411.59	2178.98
		(40.68)	(30.56)	(33.91)	(57.57)	(46.68)
II		On-year	962.85	1521.97	1091.58	1281.69
			(31.03)	(39.01)	(33.04)	(35.80)
		Off-year	313.18	691.95	524.85	861.79
			(17.70)	(26.30)	(22.91)	(29.36)
III			On-year	346.09	570.23	1195.87
				(18.60)	(23.88)	(34.58)
			Off-year	415.73	663.12	1780.17
				(20.39)	(25.75)	(42.19)
IV				On-year	564.56	988.02
					(23.76)	(31.30)
				Off-year	608.38	1119.73
					(24.66)	(33.46)
V					On-year	1510.07
						(38.86)
					Off-year	659.57
						(25.68)

The Wilk's criteria showed the existence of genetic differences for physical fruit characters in both the years. The D^2 values varied from 24.09 to 359.78 and 20.14 to 346.47 in two subsequent years. Forty-eight genotypes were grouped in five clusters in both years (Table 1). The genotypes were grouped in such a way that genotypes together in a cluster bear smallest D^2 values than those grouped in the other clusters. The maximum number of fourteen and twenty one genotypes was grouped in cluster I in on and off years, respectively. Cluster V had the minimum number of 4 and 2 genotypes in two subsequent years. The number of genotypes in cluster II, III and IV were different in two years. It may be due to differential gene expression and existence of genotype – environment interaction in the phenotypic expression of physical fruit traits in mango as also reported by Beniwal and Jetsara

Table 3. Cluster means of the physical characters of fruits in mango

Cluster	Year	Fruits/ tree	Fruit yield / tree (kg)	Weight per fruit(g)	Fruit length (cm)	Fruit width (cm)	Peel thickness (cm)	Stone length (cm)	Stone width (cm)	Percentage			Ratio of		
										Peel (%)	Pulp (%)	Stone (%)	Length - width	Pulp - peel	Pulp – stone
I	On year	1410.14	135.47	137.98	7.73	5.37	2.01	6.44	3.59	19.64	56.39	23.97	1.39	3.10	3.07
	Off year	240.52	41.77	213.28	9.44	6.41	1.73	6.96	3.62	20.61	58.58	20.81	1.48	3.26	3.78
II	On year	778.36	167.52	237.42	10.22	6.83	1.53	7.76	3.79	18.92	64.23	16.85	1.51	3.86	4.46
	Off year	407.70	35.13	92.23	6.30	4.72	1.40	5.07	3.00	18.22	57.17	24.61	1.34	3.25	2.42
III	On year	1905.11	146.86	80.29	6.20	4.64	1.59	4.81	2.91	18.40	55.40	24.95	1.40	3.20	2.32
	Off year	180.63	31.76	174.08	7.22	5.96	1.63	6.88	3.33	17.64	64.70	17.66	1.41	3.94	3.82
IV	On year	928.47	111.63	131.30	7.06	5.25	1.41	5.90	3.37	18.09	58.84	23.07	1.34	3.49	2.91
	Off year	272.47	25.64	97.76	6.56	4.84	2.05	5.24	3.26	20.40	56.73	22.87	1.35	2.98	2.80
V	On year	1142.00	150.65	200.16	8.73	5.97	1.54	7.01	3.14	19.82	59.07	21.11	1.46	3.25	3.99
	Off year	470.33	33.33	74.83	5.47	4.88	1.67	4.81	3.01	26.65	39.80	33.54	1.12	2.68	1.20

(1980), Yadava *et al*., (1993) and Jain (1997) in food crops. It is important to note that the landraces of Bhopal division were grouped in almost all the clusters in two sets of analysis. Similarly, the varieties of South India like Neelum, Suvaranarekha, Alphonso and Totapari were also grouped in different clusters. The same pattern of divergence was observed for the varieties of North India. Langra, Amrapali, Dashehari and Chousa were grouped in different clusters in two years. It indicates that genetic diversity did not relate to geographic origin as also reported by Karihaloo *et al*. (2003) in mango and Gul Zaffer *et al.* (2004) in apricot.

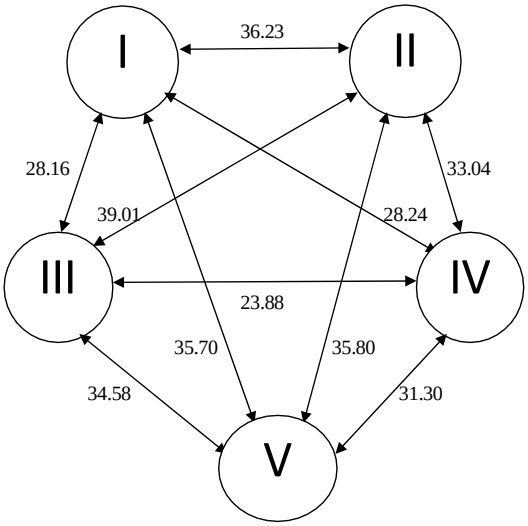

Fig 1a: Cluster diagram for physical fruit characters in mango based on "D^2 values during on-year.

The range of inter-cluster distance was 570.23 to 1521.97and 524.85 to 2178.98 in on and off years, respectively (Table 2). During on-year, Cluster II and III followed by cluster I and II, I and V and II and V were found most divergent while, cluster III and IV followed by I and III were least divergent. In off year, cluster I and V, I and IV, I and II and IV and V were most divergent. In this year, cluster II and IV followed by III and IV were least divergent clusters. Popular mango varieties namely, Langra, Amrapali, Dashehari, Chousa, Neelum, Fazli, Alphonso,

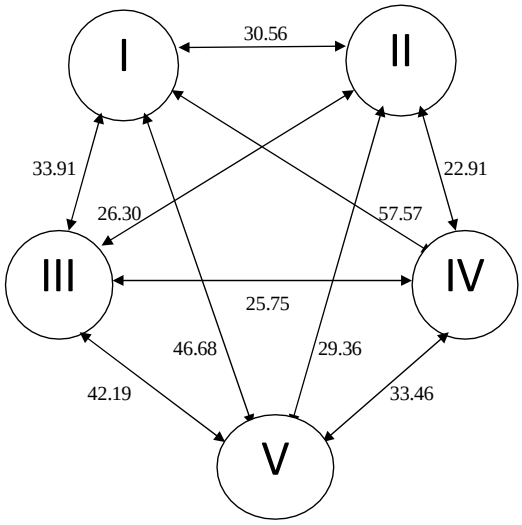

Fig 1b. Cluster diagram for physical fruit characters in mango based on ?D2 values during off-year.

Totapari and Mallika appeared to be consistent divergent and formed different clusters in two set of analyses. Similarly, the land races namely, SBM 01-10, SBM 01-13, SBM 01-14, SBM 01-38 and SBM 01-19 showed divergence for physical fruit traits in mango. The cluster means of various physical

Table 4. Varietal indices for fruit yield/ tree based on physical characters of fruits in mango

S.No.	Genotypes	Selection indices for fruit yield/ tree		*Per se*	
		On year	Off year	On year	Off year
1	Alphonso	*1015.84* I	11.59	*1015.84* I	11.59
2	Amrapali	1218.37	26.35	1218.37	26.35
3	B Green	1078.66	17.35	1078.66	17.35
4	Chousa	1257.37	24.16	1257.37	24.16
5	Dahiyar	1324.06	8.07	1324.06	8.07
6	Dashehari	1174.45	*-0.68* II	1174.45	*-0.68* II
7	Fazli	1201.52	25.68	1201.52	25.68
8	Gajaria	1106.66	10.43	1106.66	10.43
9	Gulabkhas	1078.94	13.62	1078.94	13.62
10	Langra	*1054.94 IV*	14.42	*1054.94* IV	14.42
11	Mallika	1141.21	38.75	1141.21	38.75
12	Neelum	1319.27	17.50	1319.27	17.50
13	Safeda	1396.58	*0.52* III	1396.58	*0.52* III
14	Sinduria	1419.00	*-5.01* I	1419.00	*-5.01* I
15	Totapari	1251.47	**49.50 III**	1251.47	**49.50 III**
16	Sehroli	1284.43	19.64	1284.43	19.64
17	Suvaranrekha	1279.03	28.05	1279.03	28.05
18	SBM 01-1	1172.09	40.91	1172.09	40.91
19	SBM 01-2	1208.28	17.53	1208.28	17.53
20	SBM 01-3	1514.04	*7.58* V	1514.04	*7.58* V
21	SBM 01-4	1517.83	13.27	1517.83	13.27
22	SBM 01-5	*1026.94* II	11.71	*1026.94* II	11.71
23	SBM 01-6	**2349.19 V**	32.91	**2349.19 V**	32.91
24	SBM 01-9	**2421.64 III**	38.82	**2421.64 III**	38.82
25	SBM 01-10	**2668.86 I**	34.91	**2668.86 I**	34.91
26	SBM 01-11	2146.73	20.90	2146.73	20.90
27	SBM 01-12	1939.36	**58.85 II**	1939.36	**58.85 II**
28	SBM 01-13	*1035.06* III	26.83	*1035.06* III	26.83
29	SBM 01-14	*1059.32* V	29.18	*1059.32* V	29.18
30	SBM 01-15	1902.71	24.66	1902.71	24.66
31	SBM 01-17	1478.81	**46.77 IV**	1478.81	**46.77 IV**
32	SBM 01-19	1905.24	33.36	1905.24	33.36
33	SBM 01-20	1603.17	35.38	1603.17	35.38
34	SBM 01-22	1657.42	34.36	1657.42	34.36
35	SBM 01-23	1614.64	37.19	1614.64	37.19
36	SBM 01-24	1614.45	32.61	1614.45	32.61
37	SBM 01-25	1178.83	22.15	1178.83	22.15
38	SBM 01-26	1408.59	41.97	1408.59	41.97
39	SBM 01-27	1451.48	21.11	1451.48	21.11
40	SBM 01-28	1273.50	40.39	1273.50	40.39
41	SBM 01-29	1525.14	**45.05 V**	1525.14	**45.05 V**
42	SBM 01-30	**2397.54 IV**	44.02	**2397.54 IV**	44.02
43	SBM 01-33	1653.99	43.35	1653.99	43.35
44	SBM 01-35	1253.67	**62.04 I**	1253.67	**62.04 I**
45	SBM 01-36	**2442.57 II**	42.89	**2442.57 II**	42.89
46	SBM 01-37	2011.83	15.37	2011.83	15.37
47	SBM 01-38	2311.94	29.82	2311.94	29.82
48	SBM 01-39	1802.80	*6.98 IV*	1802.80	*6.98 IV*

characters of fruits in two years revealed that fruits per tree, fruit yield per tree, weight per fruit, length and width of fruit and percentage weight of pulp contributed more towards genetic divergence (Table 3). Hence, selection of parents based on *per se* performance of these characters in form of selection indices would be advantageous in genetic improvement of fruit appearance and yield in mango.

The selection or varietal indices for fruit yield per tree based on linear combination of physical fruit characters was in between 1015.84 to 2668.86 and -0.01 to 62.04 during on and off years, respectively (Table 4). SBM 01-10 followed by SBM 01-36, SBM 01-9, SBM 01-30 and SBM 01-6 exhibited maximum estimates of selection indices during the on year. Alphonso followed by SBM 01-5, SBM 01-13, Langra

and SBM 01-14 showed minimum estimates of selection indices in this year. During off year, SBM 01-36 recorded the maximum estimates of selection indices, followed by SBM 01-12, Totapari, SBM 01-17 and SBM 01-29 while, Sinduria followed by Dashehari, Safeda, SBM 01-39 and SBM 01-3 showed the minimum estimates for fruit yield / tree. The ranking pattern of the genotypes based on selection indices was different in two years, which may be due to genetic capability of alternate bearing in mango. Genotypes SBM 01-9, SBM 01-10, SBM 01-30, SBM 01-6 and SBM 01-36 showed maximum varietal indices and phenotypic performance in both the years and thus, appeared promising for use in breeding programme aimed at genetic improvement in fruit yield in mango.

The present study indicates that Langra, Amrapali, Dashehari, Chousa, Neelum, Fazli, Alphonso, Totapari, Mallika, SBM 01-10, SBM 01-13, SBM 01-14, SBM 01-38 and SBM 01-19 were most divergent and showed real genetic diversity hence, these genotypes could be selected as parents in hybridization programme aimed at genetic improvement in physical fruit quality with high yield in mango. Landraces SBM 01-9, SBM 01-10, SBM 01-6 and SBM 01-13 appeared as higher yielder based on yield *per se* and genetic merits of fruit characters hence, these genotypes can be used in breeding programmes for genetic amelioration in fruit yield in mango. However, the study also suggests the vigorous testing and evaluation of large number of genotypes of diverse origin in different environments for identification, documentation and registration of diverse genotypes/ landraces/ cultivars in view of WTO regime. It further suggests that promising landraces of Bhopal division of Madhya Pradesh be maintained in a natural park or mango garden to conserve the biodiversity in order to check the genetic erosion in mango.

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