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CHARACTERIZATION OF MANGO GERMPLASM IN NORTH KARNATAKA, INDIA: 1. TREE MORPHO-PHENOLOGY, PRODUCTIVITY AND FRUIT CHARACTERS

G.S. KARIBASAPPA[1], U.G. NALAWADI AND G.S. SULIKERI, University of Agricultural Sciences, Dharwad, India; [1]Present address : National Research Centre for Grapes, Manjri Farm, Solapur Road, Pune 412 307 (Maharashtra State)

A study was conducted on characterization of mango germplasm with 67 genotypes, on trees of 17-19 years old, maintained at the College of Agriculture, Dharwad, India. The genetic variability was observed for 40 characters, comprising tree morpho-phenology and fruit physico-chemical and quality characters. High phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were obtained for hermaphrodite flowers, panicle number, fruit number, tree volume, bearing panicles at harvest stage, pulp content per fruit, sugar, titratable acidity and ascorbic acid contents. High heritability along with high expected genetic gain was noticed for tree volume, panicle number, bearing panicle number, total and hermaphrodite flowers per panicle, fruit number, fruit volume and pulp content, which suggested that improvement in these could be brought by direct selection. High positive correlations were recorded for fruit volume with fruit weight(0.997), pulp weight with minor width (0.875), physiological loss of fruit weight with major width (0.804), leaf area with leaf breadth (0.911), fruit number with bearing panicles (0.892), but a high negative correlation recorded between earliness of panicle emergence and duration of flowering (–0.647). Significant negative correlations were also noticed between fruit number and fruit size (–0.38) and fruit number and sugar content (–0.33). Grouping of accessions based on tree size, bearing capacity, irregularity level, fruit size and shape have been presented in tabular forms, that enable to locate genotypes for desirable traits.

Key words: *Mangifera indica*, flowering, shoot and panicle characters, fruit characters, tree size, yield, irregularity index, genetic variability

Mango is a predominant fruit crop of the transitional belt of Karnataka and also in India. Properly described, characterized and evaluated germplasm is a necessity for its improvement. One of the main objectives of the mango improvement in India and also elsewhere is to develop dwarf tree types with good fruiting potential (Iyer, 1991). Fruit characters, however relied most extensively for the descriptions and classification of mango varieties by many fruit taxonomists (Woodhouse, 1909; Rolphs, 1915; Wester, 1920; Singh and Singh, 1956 and Gangolly *et al.*, 1957). In most cases the prolific bearers are known to be lacking in quality and those with good fruit quality are either irregular or shy bearers (Singh, 1990). Success in mango improvement primarily depends on the nature and magnitude of variation present in the germplasm. An assesment of heritable and non-heritable components in the total variability will be of immense value in the choice of selection procedures through breeding. Characterization

based on certain qualitative characters is useful in the identification of genotypes, as these attributes are more reliable over environments. Hence the present study aims to estimate the amount of genetic variability, heritability and expected genetic advance for tree morpho-phenology, fruit physico-chemical characters and also in certain qualitative characters.

MATERIAL AND METHODS

Sixty seven mango accessions (see Table 1) were planted during July 1975 at the Silver Jubilee Orchards of the College of Agriculture, Dharwad, Karnataka, in a randomized block with 4 trees each per replication and experiment consisted of two replications. Among these, 63 accessions were obtained from the Regional Fruit Research Station, Vengurla, Maharashtra and 4 accessions of local origin collected from the orchards around Dharwad and North Kannada districts. Brief descriptions of most of these accessions may be found in the International Checklist of Mango Cultivars (Pandey, 1984). All the cultivars were grafted on an unknown polyembryonic rootstock. The present study is based in the data obtained from trees for 2 successive seasons in 1992-93 and 1993-94 during their 17-19 years of orchard life. Two trees were selected for each replication for recording of observations and the mean data for the 2 years is presented for 40 characters, as shown in the Table 2(a and b).

The data were subjected to the standard statistical procedures of analysis of variance (ANOVA). The phenotypic and genotypic coefficients of variation (PCV, GCV) were computed as suggested by Burton and Dewane (1953). Heritability in broad sense was based on the formula of Lush (1940) and the expected genetic advance (GA) derived as per cent mean following Johnson *et al.* (1955).

Table 1. Accessions of mango germplasm at the College of Agriculture, Dharwad (Karnataka, India)

ACCESSIONS		
Alampur Baneshan (alb)	Alphonso (alp)	AuRumani (aur),
Beneshan (ben)	Bombay Green (bg)	Baramasi (bms)
Bappekai (bpk)	Batlimavu (btl)	Chandramavu (chm)
Chausa (chs)	Cowasji Patel (cjp)	Cherukurasam (ckr)
ckr × Khader-18/16 (ckr.kdr)	Creeping (crp)	Suvarnarekha (csr)
csr × nl (csr.nl)	Dashehari (dhr)	Dilpasand (dlp)
Dophasla (dps)	Fernandin (fnd)	Fazli (fzl)
Himayuddin (him)	Jehangir (jeh)	kari Ishad (kid)
Kurukkan (kkn)	KO-11 (ko-11)	KO-27 (ko-27)
Kalepad (kpd)	Langra (lgr)	Local-15L (loc-1)
Local-36L (loc-2)	Local-98L (loc-3)	Local-4 (loc-4)
Lal Pairi (lpr)	Lucknow Suffaida (ls)	Mulgoa (mlg)
Mallika (mlk)	Nekkare-1 (nek-1)	Nekkare-2 (nek-2)
Neelum (nl)	Neeluddin (nld)	Neelgoa (nlg)
Neeleshan (nls)	nl × alb-92 (nl.alb-92)	nl × alb-94 (nl.alb-94)
nl × alb-137 (nl.alb-137)	nl × him-32 (nl.him-32)	nl × him-33 (nl.him-33)
nl × him-46 (nl.him-46)	nl × him-63 (nl.him-63)	nl × him 3/7 (nl.him-3/7)
nl × Panchadarakalasa-4 (nl.pk-4)	nl × pk-77 (nl.pk-77)	nl × pk-78 (nl.pk-78)
Nazuk Pasand (nzp)	Olour (olr)	Peddarasam (pdr)
Pahutan (pht)	Pulihora (plh)	pairi (pr)
Rumani (rmn)	Rataul (rtl)	Ratna (rtn)
Sardar (sdr)	Swarna Jehangir (sj)	Totapuri (tp)
Vellaikolamban (vlk)		

Table 2(a). Description of 21 tree morpho-phenological and productivity characters

S. No.	Character	Unit	Method of estimation
1.	Tree volume (Tv): (Castle,1983)	m^3	$Tv = 1/6\ \pi \times h \times 2r^2$, where, h-height of the tree(m) and r-canopy radius(m) i.e., r = canopy spread (East-West + North-South)
2.	Bearing Shoot Length (Lsh):	cm	Ten tagged shoots with active terminal buds were measured for each tree during mid-October of 1992 and 1993
3.	Proximal shoot length (Lpsh):	cm	Proximal shoots in all the above cases,measured
4.	Number of leaves (Lvs):	number	Active leaves present on the above shoots
5.	Leaf length (Lln):	cm	Average of leaves from 3rd and 4th positions from tip of the above shoots
6.	Maximum leaf width (Lbr):	cm	As above
7.	Leaf area (Lar):	cm^2	Derived by using a planimeter
8.	Panicle emergence (Pem):	rating	Based on time of emergence on the above shoots as: very early (before 15 D3cember)-1, early (15-30 December)-2, normal (1-15 January)-3, late (16-31 january)-4 and very late (beyond 31 January)-5
9.	Panicle length (Lpa):	cm	Length of primary rachis/rachii at peak flowering
10.	Thickness of primary rachis (Tpa):	mm	Measured at the base of primary rachis/rachii by Vernier caliperse
11.	Colour of the primary rachis (Pcol):	rating	With reference to Exotica colour chart as: green-1, sea-foam colour/creamish white-2, pink/red tinge on green background-3, light pink/red/maroon-4 and deep red/purple-5
12.	Secondary rachii per panicle (Rac):	number	Recorded from the base of the primary rachis to its tip
13.	Hermaphrodite flowers (Hfl):	number	Counted at peak flowering and just after
14.	Total flowers (Tfl):	number	Male flowers and Hfl, together
15.	Flowring duration (Dfl):	days	From the date of first flower opening to the date of last flower opening per panicle
16.	Panicles per tree (Pan):	number	Counted by marking in each of the 4 directions in a tree at the time of peak flowering
17.	initial fruitset (Ifs):	number	Fruitlets per panicle set at marble stage
18.	Bearing panicles (Bpn):	number	Panicles per tree that carried atleast one fruit till harvest maturity
19.	Fruit retention (Frt):	number	Fruits per panicle at harvest
20.	Fruit yield (Frn):	number	Fruits per tree at harvest
21.	Irregularity index (Ir):	per cent	As suggested by Pearce and Dobersek-Urbane (1967)

Table 2(b). Description of 19 fruit characters* studied in mango

Sl. No	Character	Unit	Method of estimation
22.	Fruit volume (Frv)	cm^3	Volume of fleshly harvested fruits estimated by water displacement
23.	Fruit weight (Frw)	g	Mean weight of the above fruits
24.	Fruit length (Frl)	cm	Length from base to apex,measured by Vernier caliperse
25.	Major fruit-width (Fb1)	cm	Maximum width along dorsal- ventral direction
26.	Minor fruit-width (Fb2)	cm	Maximum width between left and right shoulders
27.	Ripe fruit weight (Rfw)	g	Fresh fruit individually wrapped under newsprint paper and kept for ripening in ventilated cartons. Just ripened fruits were weighed as marked by colour break and slight softening of the fruit mass.
28.	Physiological loss of weight (Plw)	g	Plw - Frw - Rfw
29.	Pulp weight (Ppw)	g	Pulp/juice extracted from ripened fruits
30.	Stone weight (Stw)	g	Weight taken direct soon after pulp/juice extraction
31.	Total soluble solids (Tss)	per cent	Pooled pulp/juice samples taken in duplicate were recorded by Erma hand refractometer
32.	Reducing sugars (Rs):	g/fruit	Estimated as per A.O.A.C. (1970)
33.	Total sugars (Ts)	g/fruit	Cumulative of non-reducing and reducing sugars
34.	Titratable acidity (Tac)	g/fruit	By titrimetry,using phenolphthalien and standard sodium hydroxide
35.	Ascorbic acid content (Asc)	mg/fruit	Following the procedure of A.V.C.,(1966)
36.	Pulp fubreness (Fbr)	rating	Average of 5 judges rated as: negligible-1,slight-2,moderate-3,rich-4 and heavy-5
37.	Ripe fruit firmness (Fir):	rating	As above and rated as: infirm-1,moderate firm-2 and very firm-3
38.	Juiciness of the pulp (Jui):	rating	As above and rated as: less juicy-1,medium-2 and very juicy-3
39.	Ripe fruit skin colour (skc)	rating	As above and rated as:greenish/unchanged ground colour-1,light greenish yellow/slight change-2,medium yellow/cadmium-3,deep chrome/yellow/orange-4,slight red blish on any background colour- 5 and deep red blush on any background colour-6.
40.	Pulp colour (Ppc)	rating	As above and rated as:light yellow/whitish-1,medium yellow/light orange-2 and deep orange-3.

*mean of 8 fruits/replication

RESULTS AND DISCUSSION

Variability estimates such as range, phenotypic and genotypic coefficients of variability, heritability and expected genetic advance are presented in Table 3 for both tree morpho-phenology and fruit characters. The F test of ANOVA indicated that all the studied characters were highly significant.

High PCV and GCV were noticed for the morphological characters; hermophrodite flowers (70.3-62.7), panicles per tree (56.0-51.0), fruit yield (62.8-55.9), tree volume (58.0-57.2) followedby initial fruit set and bearing panicles and among the fruit characters titratable acidity (93.0-89.1), ascorbic acid content (79.0-75.7) followed by reducing sugars, pulp weight, total sugars and physiological loss of weight. These attributes indicate that a greater variability already existed among the entries, suggesting ample scope for improvement in such characters. Moderate PCV and GCV were recorded for fruit retention, total flowers, proximal shoot length, colour of the primary rachis, bearing shoot length and leaf area maong the morphological characters and for ripe fruit weigfht, fruit weight, pulp fibre content, stone weight and ripe fruit skin colour among the fruit characters. Whereas low variability was noticed for leaf length, secondary rachii per panicle, number of leaves, maximum leaf width, thickness of primary rachis, flowering duration, panicle emergence, panicle length, fruit length, major fruit-width, minor fruit-width, total soluble solids, ripe fruit firmness, juiciness of the pulp and pulp colour. This emphasizes the need for generating more variability for these characters.

High heritability and high expected genetic gain was noticed among the morphological characters, such as total flowers (0.704-949.2), panicles per tree (0.831-417.2), fruit yield (0.79-220.4), bearing panicles (0.812-147.1), hermophrodite flowers (0.794-113.8) and tree volume (0.973-60.8) and among the fruit characters for fruit voloume (0.985-309.5), fruit weight (0.982-304.0), ripe fruit weight (0.981-278.3) and pulp weight (0.972-207.1). This indicates a definite scope for improvement in these characters, though selection is to be made in a mixed population but can also be extended for a correlated progress in the monoculture (Spitters, 1984) and may support the competitive ability to progress by concentrating on to a fewer individuals (Cannell, 1984). High heritability with low expected genetic gain was recorded for shoot length, proximal shoot length, number of leaves per shoot, leaf length, maximum leaf width, panicle length, thickness of primary rachis, secondary rachii per panicle, colour of primary rachis, panicle emergence, initial fruit set, fruit retention, fruit length, major fruit width, minor fruit-width, total soluble solids, reducing sugars, titratable acidity, ascorbic acid content, pulp fibre content, ripe fruit firmness, juiciness of the pulp, ripe fruit skin colour and pulp colour. These results suggest that though they were environmentally stable, due to non-additive gene effects, the direct selection based on these characters would be less effective, hence should be resorted to indirect selections.

Correlation study among these characters indicated very high positive correlations for leaf area with maximum leaf width (0.911), leaf area with leaf length (0.839), the morphological characters fruit yield with bearing panicles (0.892) and shoot length with proximal shoot length (0.658), whereas high negative correlation was recorded for duration of flowering with panicle emergence (–0.647). Similarly among the fruit characters, very high positive correlations were recorded for fruit weight with fruit volume (0.997), ripe fruit width with fruit volume (0.996), physiological loss of weight with major fruit-width (0.804), pulp weight with minor fruit width (0.722) and total sugars with reducing sugars (0.712). Hence any manipulation in these characters would also involve their counterpart.

Table 3. Estimates of genotypic variability, heritability and genetic advance in mango

Sl. No.	Character	Range	Mean	PCV %	GCV %	Heritability (H^2)	Expected GA % of Mean	F value
a. Tree morpho-phenology								
1.	Tv	7.6 (kkn)-115.5 (tp)	52.2	58.0	57.2	0.973	60.7	74.02**
2.	Lsh	5.1(rmn) - 20.5 (nl.him-32)	10.7	31.2	26.5	0.715	4.9	6.03**
3.	Lpsh	5.0 (mlg)-16.8 (nl.him-32)	8.6	38.5	30.5	0.629	4.3	4.39**
4.	Lvs	8.0 (nl.pk-4) - 17.2 (nl.pk-77)	12.6	18.2	15.2	0.700	3.3	5.67**
5.	L1n	13.4(mlg) - 24.5(alp)	17.8	15.2	12.4	0.668	3.7	5.01**
6.	Lbr	2.9(nzp)-7.6 (vlk)	4.7	20.7	18.4	0.791	1.6	8.57**
7.	Lar	29.2(nzp)-109.5 (vlk)	61.8	32.4	26.7	0.680	28.0	5.26**
8.	Pan	72(nek-1)-1445 (kpd)	435.3	56.0	51.0	0.831	417.2	10.84**
9.	Bpn	30.5(ko-11)-403.5 (kpd)	165.2	53.2	48.0	0.812	147.1	9.63**
10.	Lpa	9.0(kkn)-39.4 (vlk)	26.7	21.3	18.5	0.753	8.8	7.09**
11.	Tpa	3.8(nlg)-8.9 (vlk)	5.7	18.9	17.6	0.863	1.9	13.62**
12.	Rac	1226.0(nzp)-53.5 (ckr)	38.7	17.2	14.0	0.660	9.1	4.89**
13.	Pcol	1.0(dhr,1s,rt1,uls,vlk) - 5.0	3.4	34.0	33.8	0.989	2.4	182.31**
14.	Tfl	423(nl.pk-4)-2925 (bpk)	1531.0	42.8	35.9	0.704	949.2	5.75*
15.	Htl	3.5(jeh) - 267.5(mlk)	98.9	70.3	62.7	0.794	113.8	8.70**
16.	Pem	1.5(vlk)-5.0 (nlg,nls,sj)	3.6	26.6	24.4	0.838	1.7	11.37**
17.	Dfl	23.5 (mlg)-66.5 (nl.him-46)	35.6	23.4	22.6	0.934	16.0	29.25**
18.	Ifs	1.0 (jeh)-12.9 (fzl)	5.2	56.2	47.9	0.724	4.4	6.26**
19.	Frt	0.062(jeh)-1.5 (nl,nl.pk-77)	0.5	48.9	43.7	0.798	0.4	8.92**
20.	Frn	27.0(jeh)-580.0(kpd)	215.4	62.9	55.9	0.790	220.4	8.53**
b. Fruit character								
21.	Frw	116.0(nek-1)-815.6(cjp)	307.7	48.9	48.4	0.982	304.0	109.62**
22.	Frv	120.3 (pht)-836.8 (btl)	304.0	50.2	49.8	0.985	309.5	131.80**
23.	Frl	6.8 (pht)-16.0(btl)	10.5	19.9	19.7	0.984	4.2	121.27**
24.	Fb1	5.6(dhr) - 11.3 (cjp)	7.7	17.3	17.2	0.987	2.7	88.45**
25.	Fb2	5.1(csr.nl)-10.2 (cjp)	6.9	17.2	17.0	0.976	2.4	82.09**
26.	P1w	5.9(loc-1)-70.6 (btl)	29.7	52.1	50.8	0.951	30.3	40.05**
27.	Rfw	104.7(nek-1)-747.5 (cjp)	278.0	49.5	49.1	0.981	278.3	103.52**
28.	Ppw	53.4(loc-1)-553.8(cjp)	187.7	55.1	54.3	0.972	207.0	70.81**
29.	Stw	16.9 (crp)-69.1 (jeh)	36.1	32.6	30.2	0.861	20.8	13.39**
30.	Tss	11.0(bg)-27.2 (ko-27)	17.2	21.6	19.7	0.832	6.3	10.92**
31.	Rs	1.6(loc-1)-26.8 (cjp)	7.8	68.0	64.2	0.893	9.8	17.64**
32.	Ts	6.2(nek-1)-64.9(jeh)	24.8	54.4	52.4	0.928	25.8	26.66**
33.	Tac	0.1(nek-2)-2.8 (btl)	0.4	93.0	89.1	0.918	0.7	23.47**
34.	Asc	2.3(loc-2)-42.7 (kpd)	9.9	79.0	75.7	0.918	0.7	23.47**
35.	Fbr	1.0(ckr.kdr)-4.9 (bpk)	2.8	34.5	34.2	0.984	2.0	126.04**
36.	Fir	1.0(kkn)-2.9(rtn)	2.2	17.9	16.6	0.866	0.7	13.88**
37.	Jui	1.1(jeh)-3.0(kkn)	2.0	19.5	18.4	0.896	0.7	18.26**
38.	Skc	1.1(nl.him-32)-6(csr,chm,nlg)	4.2	29.1	29.0	0.993	2.5	282.54**
39.	Ppc	1.3(fzl)-3.0(bg)	2.3	19.7	19.1	0.934	0.9	28.59**

Significant negative correlations were also recorded for fruit yield with fruit volume (–0.36), fruit yield with total sugars (–0.38) and fruit weight with total sugars (–0.27). These results are in confirmation with an earlier report which indicated that the bearing capacity in mango was linked to the inferior fruit quality, especially the low sugar contents (Sharma and Majumder, 1989).

Grouping of mango genotypes based on certain attributes od tree volume (tree size) as small (< 40 m^3), medium (40-80 m^3) and large (> 80 m^3) in combination with the attribute of fruit yield (bearing capacity) as, shy bearer (< 150), average (150-300) and good bearer (> 300) is presented in Table 4. Twenty nine genotypes had small trees, with a mean tree volume of 22.9 m^3, followed by 23 genotypes with medium size trees, with a mean of 61.6 m^3 and 15 genotypes with large trees with a mean of 94.2 m^3. Statistical analysis by the F test indicated that the groupings did not vary within a tree size attribute, but highly significantly varied between the attributes. The Chi-square test for homogeneity of variance in tree volume indicated that the variance was homogeneous for groups both within and between the attributes of tree size across the groups belonging to the bearing capacity. Similarly, groupings based on the bearing capacity have resulted in 28 shy bearers with a mean of 99.3 fruits, followed by 24 average bearers with a mean of 216.1 fruits and 15 good bearer genotypes with a mean of 396.7 fruits. The F test indicated that groupings did not vary within an attribute but highly significantly varied between the

Table 4. A two-way classification of mango genotypes based on tree volume and fruit bearing

Tree size (m3)	Bearing capacity (fruits/tree)			Tree size Mean F value	Bearing capacity mean F value
	Shy bearers (<150)	Average bearers (150-300)	Good bearers (>300)		
Small (<40)	dlp, fzl, him, jeh, ko-11, rmm, csr, nl.him-33, nld, rtn, nek-1, olr, vlk	ckr, crp, dps, loc-1, nzp, plh, sdr, nl.him-46, aur, pk, loc- 4, kkn	nl, csr.nl, sj, nek-2	22.9 2.79^{NS}	177.1 46.3^{**}
Medium (40-80)	alb, btl, bg, dr, fnd, ko-27, lgr, nl.him-32	ben, loc- 2, nl. pk-4, nl. pk-78, nl.alb-92, nl.alb-94, mlk, ckr.kdr.pht	bms, kpd, mlg, pr, nl.him-63, nlg	61.6 1.74^{NS}	234.7 40.1^{**}
Large (> 80)	chm, chs, cjp, kd, 1pr, pdr, n1.him-3/7	1s, tp, nl.alb-137	alp, loc-3, rt1, n1.pk-77, n1s	94.2 3.0^{NS} $\chi^2 = 1.34^{NS}$	218.8 93.4^{**} $\chi^2 = 22.23^{**}$
Tree size; Mean F value $\chi^2 = 2.70^{NS}$	49.2 159.3^{**}	46.1 67.4**	67.3 82.7**	52.2 76.3**	—
Bearing capacity; mean; F value $\chi^2 = 6.152^{*}$	99.3 1.0NS	216.1	396.7 1.1NS	-	206.3 0.48NS

Significant at *P = 0.05 and **P = 0.01; NS-non significant

attributes. However,m the Chi-square test indicated the heterogeneous variance of fruit yield for groups of both within and between the attributes of bearing capacity accross the groupings belonging to tree size. The medium tree size group had 6 genotypes (Baramasi, Kalepad, Mulgoa, Pairi, Neelum × Himayuddin-63 and Neelgoa), that were more productive (fruit yield mean 234.7) than the genotypes that exhibited large tree size (fruit, yield mean 318.8) and the genotypes of small trees (fruit yield mean 177.1). The F test also indicated very high significant differences among the groups. The most desirable attribute viz, the small tree size with good bearing capacity was noticed in Neelum, Suvarnarekha × Neelum, Swarna Jehangir and Nekkare-2.

Similarly, the classification of genotypes based on the bearing capacity and the irregularity index (Table 5) indicated that a maximum of 28 genotypes belonged to low irregularity with a mean of 12.7 per cent, followed by 25 genotypes in the moderate irregularity index group, with a mean of 31.4 percent, 9 genotypes in the high Ir group with a mean of 55.9 per cent and only 5 genotypes in very high irregularity index group alternate bearers) with a mean of 96.3 per cent. The Chi-square test indicated the presence of homogeneous variance of irregularity index in the entries. In general, significant differences were noticed in irregularity index levels due to the bearing capacity, where the average bearers recorded a maximum mean of 33.9 per cent irregularity index, followed by shy bearers with a mean of 31.6 per cent irregularity index and good bearers with a mean of 28.7 per cent irregularity index. Another most desirable attribute of the good bearing with low irregularity was noticed in Local-3, Pairi, Neeleshan and Nekkare-2. In

Table 5. A two-way classification of mango accessions based on bearing capacity and irregularity index

Bearing capacity (fruits/tree)	Ir index				Bearing capacity mean F value	Ir Index Mean F value
	Low (< 20%)	Moderate (20-50%)	High (50-80%)	Very high (81- 100%)		
Shy bearers	alb, bt1, chm, cjp, d1p, fnd, kid, ko-11, ko-27, rmn, nl.him-32, n1.him-33, rtn, nek-1, v1k	dhr, him, 1gr, pdr, csr, nld, nl.him- 3/7, olr	chs, 1pr	bg, fzl, jeh	99.3 1.55^{NS}	31.6 199.2**
Average bearers	ben, crp, loc-1, plh, sdr, tp, nl-alb-137, aur, loc-4	çkr, loc-2, nzp, nl.him-46, nl.pk-4, mlk, pht	dps, nl.pk-78, nl.alb-92, nl.alb-94, ckr.kdr, bpk, kkn	ls	216.1 0.05^{NS}	33.9 90.6**
Good bearers	loc-3, pr, nls, nek-2	alp, bms, kpd, mlg, nl, nl.him- 63, nl.pk-77, csr.nl, nlg, sj	-	rtl	396.7 0.68^{NS} $\chi^2 = 5.74^{NS}$	28.7 122.1** $\chi^2 = 4.97^{NS}$
Bearing capacity	Mean 176.4 F value 70.5** $\chi^2 = 22.23$**	261.1 50.0**	185.0 20.7*	156.7 13.52**	206.3 32.12**	—
Ir index	Mean 12.7 F value 0.26^{NS} $\chi^2 = 0.34$NS	31.4 3.06NS	55.9 0.006NS	96.3 0.12NS	—	31.7 111.3**

Significant at * P = 0.05 and **P = 0.01; NS - non significant

Table 6. A three-way classification of mango genotypes based on ruit size, major and minor# fruit shape indices

Fruit size (cm^3)	Major shape indices (frl : fb1 ratio)						Mean F value		
	Round (< 1.26)		Oval (1.36-1.40)		Oblong (> 1.40)				
	Cylindrical	Flat	Cylindrical	Flat	Cylindrical	Flat	Fruit size	Major shape	Minor shape
Small (< 200)	crp, kpd, nl, nl.him-32, pht	nl.pk-77, nek-1 nek-2	dps, kkn	-	dhr, ko-11, ls, loc-1, rtl, nl.him-33, csr.nl	-	151.5	1.35	1.09
							0.92^{NS}	19.8^{**}	15.3^{**}
Medium (200-350)	kid, lpr, pr, rmn, nl.pk-78	ko-27, plh, nl.him-63, nlg	alp, fnd, lgr, csr, nl.him-46, nld, rtn, sj, loc-4	nls, bpk	bms, chm, chs, nzp, nl.alb-92, nl.alb-94, nl.alb-137, vlk	nlk, olr	272.5	1.34	1.12
							1.08^{NS}	22.8^{**}	8.3^{**}
Large (> 350)	bg, cjp, jeh, mlg, nl.pk-4, aur	sdr	dlp, loc-2, loc-3, nl.him-3/7	-	btl, ckr, him, tp	alb, ben, fzl, pdr, ckr, kdr	480.9	1.39	1.11
							0.48^{NS}	7.3^{**}	36.2^{**}
							$\chi^2 = 54.8^{**}$	$\chi^2 = 7.9^{*}$	$\chi^2 = 15.9^{**}$
Fruit size									
Mean	-	302.2	-	-	286.3	-	-	317.2	-
F value		9.62^{**}			15.94^{**}			12.98^{**}	
major shape									
Mean	-0	1.15	-	-	1.34	-	-	1.56	-
F value		0.4^{NS}			0.3^{NS}			0.04^{NS}	
Minor shape									
Mean	1.08	1.11	1.18	1.09	1.11	1.21	1.09	1.11	1.17
F value	2.7^{NS}	101.2^{**}	2.1^{NS}	0.5^{NS}	24.1^{**}	-	42.0^{**}	70.5^{**}	4.0^{**}
F value	2.7^{NS}	101.2^{**}	2.1^{NS}	0.5^{NS}	24.1^{**}	-	42.0^{**}	70.5^{**}	4.0^{**}

#Minor shape index = Fb1:Fb2 ratio, where cylindrical = < 1.15 and flat = 1.15 and above)
Significant at *P = 0.05 and **) = 0.01; NS = non significant

addition to that, Nekkare-2 also exhibited a small tree size.

A classification of mango genotypes based on attributes such as fruit volume, fruit length:

major fruit-width ratio (as major shape index) and major fruit-width : minor fruit-width ratio (as minor shape index) has resulted in 15 out of a possible 18 groups of genotypes (Table 6). A maximum of 30 genotypes had medium sized fruits with a mean of 272.5 cm^3, followed by 20 genotypes in the large fruit group, with a mean of 480.9 cm3 and 17 genotypes with small fruits, with a mean of 151.5 cm^3. A maximum of 26 genotypes belonged to the oblong shape, 24 genotypes in the round shape and 17 in the intermediate oval shape. In minor shape attributes, as many as 50 genotypes belonged to cylindrical, whereas the remaining 17 were of flat shape. The F test indicated non-significant difference between the groups within fruit size and also for major shape index, but significantly differred for the groups within an attribute of minor shape index, suggesting the ineffectiveness of the minor shape index for classification of mango genotypes though the Chi-square test indicated its homogeneity of variance.

Accessions with oval fruit shape and medium size were found in 9 genotypes, i.e. Alphonso, Fernandin, Langra, Suvarnarekha, Neelum × Himayuddin-46, Neeluddin, Ratna, Swarna Jehangir and Local-4 and among these, rated for the attractive skin colour in the Alphonso (5.2), Suvarnarekha (6.0), Ratna (5.3) and Swarna Jehangir (5.5). Similarly, the rating for pulp fibreness had indicated a low and negligible presence in Alphonso, Langra, and Swarna Jehangir. These results have confirmed the earlier observations realized by Sulikeri *et al.* (1994). Among the large fruited genotypes,low fibreness was noticed in Bombay Green, Mulgoa, AuRumani, Neelum × Himayuddin-3/7, Alampur Baneshan, Cherukurasan × Khader 18/16, Batlimavu, Cherukurasam, Himayuddin and Totapuri. High pulp fibreness was noticed in Sardar, Cowasji Patel, Hehangir, Neelum × Panchadarakalasa-4, Dilpasand, Local-2, Local-3, Beneshan, Fazli and Peddarasam. However these large fruited genotypes need further testing for their suitability for canning or juice processing. In India most of the table varieties are said to have either slight or soft fibre, and those of sucking types are mostly juicy or soft fleshy with coarse fibres (Singh, 1990). The relative abundance of the fine fibre is a necessity to protect the interor of a fruit from bruising and internal collapse during handling and shipping but at the same time should be unobjectionable to the consumer (Knight, 1993; Iyer, 1991).

REFERENCES

A.O.A.C. 1970. Official Methods of Analysis, 11th ed., p.936.

A.V.C. 1966. Methods of Vitamin Assay,Inter Science Publishers, New York, 3rd ed., p.287

Burton, G.W. and E.M. Dewane. 1953. Estimating heritability in tall fesue (Festuca circulina) from replicated clonal material. Agron. J., **45** : 478-481.

Cannell, M.G.R. 1984. Competition and selection for yield ; a perspective from forestry. *In* : W.Langue., C.Zeven and N.G.Hongenboom (eds.), Efficiency in Plant Breeding. Centre for Agriculture Publishing and Documentation, Wageningen, Netherlands. p.33.

Castle, S.W. 1983. Growth, yield and cold hardiness of seven year oldBearss lemon trees on twenty seven rootstocks. Proc. Fla. State Hort. Soc., **96**: 23-2.

Gangolly, S.R., R. Singh, S. L. Katyal and D. Singh. 1957. Studies on morphological characters of mango fruits.The mango, ICAR, New Delhi, pp.30-35.

Iyer, C.P.A. 1991. Recent advances in varietal improvement in mango. Acta Horticulturae, **291**: 109-132.

Johnson, H.W., H. F. Robinson and R. E. Comstock. 1955. Estimates of genetic and environmental variability in soybeans. Agron. J., 47 : 314-318.

Knight, R.J. 1993. Evaluating important fruit characters in mango germplasm. Fruit Varietes Jl., 47: 25-31.

Lush, J.L. 1940. Inter-sire correlation and regression of off-spring, on dam as a method of estimating heritability of characters. Proc. Amer. Soc. Animal Prodn., **33**: 293-310.

Pandey, S.N.. 1984. International Checklist of Mango Cultivars. Division of Fruits and Horticultural Technology, IARI, New Delhi.

Pearce, S.C. and Dobersek-Urbanc S. 1967. The measurement of irregularity in growth and cropping. J. Hort. Sci. **42**: 295-305.

Rolphs, P.H. 1915. Mangoes in Florida. Bull. 127, Agric. Exp. Stn. Univ. Fla.

Sharma, D.K. and Majumder, P.K. 1989. Inheritance in mango. Acta Horticulturae **231**: 106-111.

Singh, R.N. 1990. Mango, ICAR, New Delhi, pp. 23-33 and 44-65.

Singh, L.B. and Singh, R.N. 1956. A monograph on the mangoes of Uttar Pradesh. Supdtt. of printing, Lucknow.

Spitters, C.J.T. 1984. Effects of intergenotypic competition on selection. In : Efficiency in Plant Breeding. Centre for Agriculture Publishing and Documentation, Wageningen, Netherlands. p.13-27. W. Langue, A.C. Zeven and N.G. Hongenboom (eds.),

Sulikeri, G.S., Patil, V.R., Madalageri, M.B. and Hulmani, N.C. 1994. Performance of some introduced mango varieties and hybrids under Dharwad (Karnataka) conditions. *Lalbaugh Journal* **36**: 29-32.

Wester, P.J. 1920. A descriptive list of mango varieties in India. *Philipp. Agric. Rev.*, **4**: 265

Woodhouse, E.J. 1909. The mangoes of Bhagalpur. *Q.J. Dep. Agric. Bengal*, **3**: 168.