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Growth, flowering and yield attributes of full-sib (Amrapali × Sensation) hybrids of mango

H. Rymbai*, Manish Srivastav, S.K. Singh, A.K. Singh and Vinod*****

Division of Fruit & Horticultural Technology, ICAR-Indian Agricultural Research Institute, New Delhi 110 012

ABSTRACT

The present investigation was carried out to study the growth, flowering and yield attributes of 50 full-sib mango hybrids belonging to 'Amrapali' × 'Sensation' cross along with their parents during 2010-2012. The hybrids and their parents showed significant variation for growth, leaf, flowering and yield characters. Results revealed the maximum number of leaves in H-12-8 (48.60), maximum leaf area in H-13-7 (136.82 cm^2) and longest petiole length in H-13-4 (5.22 cm). Hybrids such as H-1-10, H-13-1 and H-13-4 had the maximum inflorescence pigmentation (7.00 rating). Maximum number of hermaphrodite flowers per panicle was observed in H-1-1 (362.48), whereas male flowers were maximum in H-2-9 (1499.50). However, the maximum sex ratio was noted in H-3-5 (0.94). The longest flowering duration was obtained in H-1-14 (20.68 days). Maximum fruit weight was recorded in H-1-5 (315.43 g) and yield in H-1-1 (44.25 kg/tree). This study would be of great helpful in selection of potential parents for their further utilization in mango improvement programmes.

Key words: Growth, flowering, full-sib, hybrids, mango, yield.

INTRODUCTION

Mango (*Mangifera indica* L.) is the most popular fruit among the tropical fruits of the world. In India, there are hundreds of mango cultivars, however, only few are preferred in the international market (Chadha and Pal, 2; Rathore *et al*., 6). These few recognized high quality mango cultivars need considerable improvement to be more acceptable for export. Mango is considered to be a difficult plant species to handle in breeding programme owing to its high heterozygosity and long juvenile period. Therefore, combining all the desirable traits in a single genotype is an onerous task (Iyer and Schnell, 4). Hence, breeding objectives have to be defined for specific purposes. Presently, there is preference for red peel mango in the international markets. Therefore, emphasis has been shifted to the development of mango hybrids having red peel colour and suitable for export. At Indian Agricultural Research Institute, New Delhi mango hybridization work is in progress and several thousands of flowers were crossed in the last two decades and plants of hundreds of hybrids belonging to different full-sib families have been planted in the hybrid evaluation blocks. This hybrid population belonging to different full-sib families serves as core resource for studying genetics of agronomic traits in mango. The phenotypic characterization and quantification of variation among population of these hybrids is of utmost importance for identifying the potential progenies having desirable combinations of traits, which may further be utilized in hybridization programme. Keeping in view the above facts, the present investigation was carried out with an objective to study growth, flowering and yield attributes of newly evolved full-sib mango hybrids.

MATERIALS AND METHODS

Present investigation was carried out during 2010-12 on 50 full-sib mango hybrids and their parents 'Amrapali' and 'Sensation', developed and maintained by the Division of Fruits and Horticultural Technology, IARI, New Delhi under uniform cultural practices to ensure yield of quality fruits. The age of these hybrids varied and are grouped as 6-7 years (H-9-5, H-10-1, H-11-1, H-11-6), 9-10 years (H-12-1, H-12-5, H-12-6, H-12-8, H-12-10, H-12-11), 8-9 years (H-9-1), 14-15 years (H-1-9, H-1-10, H-1-11, H-1-12, H-1-13, H-1-14, H-3-5, H-3-6, H-3-7, H-3-8, H-3-11, H-3-12, H-3-14, H-4-4), 15-16 years (H-1-2, H-1-3, H-1-4, H-1-5, H-3-3, H-3-4, H-4-2, H-4-3), 16-17 years (H-1-6, H-4-1), 17-18 years (H-1-7), 18-19 years (H-3-1, H-3-2), 19-20 years (H-1-1), 26-27 years (H-7-3, H-7-4), 28-29 years (H-13-1, H-13-2, H-13-4, H-13-5, H-13-6, H-13-7, H-13-8), 29-30 years (H-2-9) and 31-32 years (H-7-1), while parents are 'Amrapali' (25-26 years) and 'Sensation' (30-31 years). For vegetative growth parameters, a single tree was taken as treatment. However, three trees were taken in case of parents, *i.e*., 'Amrapali' and 'Sensation'. Height of individual hybrid tree was

*Corresponding author's present address: Div. of Hort., ICAR-Research Complex of NEH Region, Umiam, Meghalaya; E-mail: rymbaihort@gmail.com

**Managing Director, N.H.B., GoI, Gurugram

***Div. of Genetics, ICAR-IARI, New Delhi

measured with the help of a standard wooden scale from the base of the tree near the soil surface to the highest point of the crown and expressed in meter. The tree spread was calculated by measuring the canopy spread in East-West (E-W) and North-South (N-S) directions with the help of measuring tape (meter). Number of leaves was counted on 10 tagged bearing shoots from each of the mango hybrids. Leaf characters were studied for 20 leaves taken from 3rd and 4th positions of 10 bearing shoots. Leaf length was measured excluding petiole from base to tip of the leaf and leaf width was measured in the middle of the leaf and expressed in cm. Leaf area was measured with the help of leaf area meter (LI-COR Model 3100) in cm^2. Petiole length was measured using measuring scale (cm).

Anthocyanin pigmentation of newly emerged vegetative flush and inflorescence axis of full-sib mango hybrids and parents were rated as high pigment intensity (7), medium pigment intensity (5) and no pigment (3). Flowering duration was recorded in days, from the date of first flower opening to the date of last flower opening in a tagged panicle. The number of male, hermaphrodite and total flower were counted by tagging ten panicles in four directions on each tree. In order to avoid error, the counted flowers on panicles were removed and fresh opened flowers were counted on daily basis. The sum of male and hermaphrodite flowers counted on the tagged panicles was expressed as total number of flowers. Sex ratio was calculated by dividing number of hermaphrodite flowers with number of male flowers. The inflorescence length was measured from the base to the tip of fully developed inflorescence with the help of a measuring scale and expressed in centimetre. The inflorescence breadth was recorded in the middle portion of fully developed inflorescence with the help of a measuring scale and expressed in centimetres.

Fruit number per tree was recorded by counting the number of fruits at the time of harvest. Fruits weight in gram was recorded using electric balance (Adiar Dutt-1620C). Yield per tree was obtained by weighing all the fruits at harvesting and expressed in kg. The vegetative growth parameters, like plant height, canopy spread, canopy volume, fruit number per tree and yield (kg/tree) were analysed using Augmented Design. The data on different parameters were analysed using analysis of variance (ANOVA) based on randomised block design (RBD) using SPSS. Valid conclusions were drawn only on significant differences between the treatment mean at 0.05 level of probability.

RESULTS AND DISCUSSION

Plant growth characters of full-sib mango hybrid family and their parents showed significant variation ($p \leq 0.05$, LSD = 0.40, Table 1). Among age group (6-7 years), H-10-1 recorded maximum plant height (6.03 m), canopy spread in E-W (3.45 m) and N-S (3.22 m) and leaf area (99.44 cm^2). While, maximum leaf number (39.30) and petiole length (4.97 cm) was noted in H-11-1 and H-11-6, respectively. Among age group (9-10 years), maximum plant height (6.64 m), canopy spread in E-W (3.93 m) and N-S (3.86 m), canopy volume (36.50 m^3), leaf area (114.73 cm^2) and petiole length (5.01 cm) was recorded in Hybrid H-12-10. While H-12-8 recorded maximum leaf number (48.60). Among age group 14-15 years,

Table 1. Growth and leaf characteristics of full-sib mango hybrids of Amrapali × Sensation (data pooled over 2010-11 and 2011-12).

Hybrid	Age group (yr)	Plant height (m)	Canopy spread (m)		Canopy vol. (m^3)	Leaf No.	Leaf area (cm^2)	Petiole length (cm)
			E-W	N-S				
H-9-5	6-7	2.55	2.78	2.83	2.39	13.00	94.11	3.06
H-10-1	6-7	6.03	3.45	3.22	46.82	20.60	99.44	4.42
H-11-1	6-7	4.34	3.83	3.93	15.29	39.30	61.63	3.00
H-11-6	6-7	5.04	3.05	3.18	18.28	17.50	80.71	4.97
H-12-1	9-10	3.50	2.99	2.97	9.10	19.60	75.30	3.80
H-12-5	9-10	2.67	2.48	2.42	4.15	38.60	74.70	3.06
H-12-6	9-10	5.05	2.86	2.58	15.42	26.60	90.47	3.78
H-12-8	9-10	4.16	3.51	3.35	19.82	48.60	71.45	4.27
H-12-10	9-10	6.64	3.93	3.86	36.50	20.70	114.73	5.01
H-12-11	9-10	6.31	3.34	3.30	14.91	20.00	80.76	4.74
H-9-1	8-9	6.30	3.52	3.87	36.13	8.80	79.49	3.24

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Table 1 Contd...

Hybrid	Age group (yr)	Plant height (m)	Canopy spread (m)		Canopy vol. (m^3)	Leaf No.	Leaf area (cm^2)	Petiole length (cm)
			E-W	N-S				
H-1-9	14-15	5.45	4.23	4.20	36.17	27.20	79.12	2.52
H-1-10	14-15	4.55	2.49	2.35	8.54	10.60	94.60	2.55
H-1-11	14-15	5.92	5.03	4.32	35.39	30.00	81.56	3.60
H-1-12	14-15	7.13	3.75	3.72	34.34	17.70	104.20	3.87
H-1-13	14-15	6.90	3.97	3.69	31.55	22.30	79.71	3.06
H-1-14	14-15	5.82	5.00	4.50	37.97	20.20	94.19	2.98
H-3-5	14-15	5.20	5.64	5.61	56.67	13.20	72.35	2.94
H-3-6	14-15	2.94	2.09	2.11	4.83	12.50	91.73	3.13
H-3-7	14-15	2.57	5.30	5.27	27.62	17.40	71.65	2.96
H-3-8	14-15	3.13	6.52	6.49	45.81	14.20	73.56	3.22
H-3-11	14-15	5.26	4.03	4.00	29.18	15.60	70.98	3.02
H-3-12	14-15	7.98	6.01	5.93	93.64	7.80	82.27	4.24
H-3-14	14-15	6.14	5.45	5.21	43.04	14.20	55.89	2.97
H-4-4	14-15	3.18	2.95	2.99	9.83	13.00	105.28	3.04
H-1-2	15-16	6.45	3.61	3.59	27.10	13.20	68.65	3.66
H-1-3	15-16	8.15	4.50	4.13	46.22	16.50	77.30	3.16
H-1-4	15-16	6.55	5.06	5.03	57.52	14.20	69.99	3.44
H-1-5	15-16	4.27	3.40	3.34	19.57	21.00	79.55	3.89
H-3-3	15-16	7.02	5.73	5.89	86.16	12.80	72.94	2.98
H-3-4	15-16	7.36	4.28	4.44	51.46	15.40	80.47	2.98
H-4-2	15-16	6.29	3.75	3.79	15.90	12.30	66.99	4.60
H-4-3	15-16	7.24	2.92	2.96	25.46	16.20	80.72	3.13
H-1-6	16-17	6.12	4.44	4.36	40.18	18.60	71.73	2.77
H-4-1	16-17	10.11	4.66	4.72	87.44	12.90	79.92	4.88
H-1-7	17-18	6.87	3.91	3.89	35.93	15.00	78.97	2.94
H-3-1	18-19	6.55	3.91	3.90	34.69	26.60	63.20	3.14
H-3-2	18-19	6.25	4.53	4.39	41.34	19.20	81.77	2.86
H-1-1	19-20	7.67	6.62	6.50	109.65	14.80	71.25	3.76
H-7-3	26-27	6.23	2.82	2.81	18.35	13.20	68.82	2.48
H-7-4	26-27	7.32	3.42	3.41	29.55	16.40	81.52	2.86
H-13-1	28-29	8.20	6.37	6.14	255.99	13.40	87.05	3.72
H-13-2	28-29	8.14	7.91	7.83	104.26	13.20	58.72	2.76
H-13-4	28-29	7.87	7.39	7.74	164.95	13.20	70.26	5.22
H-13-5	28-29	8.39	6.97	7.34	142.73	27.00	107.10	3.04
H-13-6	28-29	8.68	5.90	6.07	79.82	16.20	101.88	4.24
H-13-7	28-29	8.12	5.73	5.53	97.88	23.80	136.82	4.54
H-13-8	28-29	7.79	6.94	6.28	108.28	13.00	85.72	3.16
H-2-9	29-30	8.22	8.45	8.14	182.96	13.60	99.47	2.44
H-7-1	31-32	5.32	4.23	4.20	32.58	14.40	111.92	2.52
Sensation	30-31	7.30	9.20	9.02	203.30	15.80	55.90	3.85
Amrapali	25-26	4.19	4.68	4.63	30.64	23.40	107.40	2.85
$CD_{0.05}$	-	0.46	0.33	0.42	1.77	1.83	7.87	0.37

H-3-12 recorded maximum plant height (7.98 m) and canopy volume (93.64 m^3). However, maximum canopy spread in E-W (6.52 m) and N-S (6.49 m) was recorded in H-3-8, leaf number in H-1-11 (30.00), leaf area (105.28 cm^2) in H-4-4 and petiole length in H-1-12 (3.87). In the age group 15-16 years, H-1-3 recorded maximum plant height (8.15 m). While, hybrid H-3-3 recorded maximum canopy spread in E-W (5.73 m) and N-S (5.89 m) and canopy volume (86.16 m^3). Maximum leaf number was noted in H-1-5 (21.00), leaf area in H-4-3 (80.72 cm^2) and petiole length in H-4-2 (4.60 cm). Among age group (16-17 year), H-4-1 recorded maximum plant height (10.11 m), canopy spread in E-W (4.66 m) and N-S (4.72 m), canopy volume (87.44 m^3), leaf area (79.92 cm^2) and petiole length (4.88 cm). Hybrid H-1-6 showed maximum leaf number (18.60). Among age group 18-19 yr, H-3-1 recorded maximum plant height (6.55 m), leaf number (26.60) and petiole length (3.14 cm). While, H-3-2 showed maximum canopy spread in E-W (4.53 m) and N-S (4.39 m), canopy volume (41.34 m^3) and leaf area (81.77 cm^2). H-7-4 recorded maximum values for all the characters in the age group 26-27 years. Among age group 28-29 years, maximum plant height (8.68 m) was noted in H-13-6, while canopy spread in E-W (7.91 m) and N-S (7.83 m) was noted in H-13-2. Maximum canopy volume was recorded in H-13-1 (255.99 m^3) and leaf number in H-13-5 (27.00). While, H-13-7 showed the maximum leaf area (136.82 cm^2) and petiole length (4.54 cm). Among all the age groups, it was observed that maximum plant height was recorded in hybrid H-4-1 (10.11 m) and minimum in hybrid H-9-5 (2.55 m). It was interesting to note that 84% of the hybrids were taller than their seed parent 'Amrapali' (4.19 m). Whereas, only 24% of hybrids had more plant height than their male parent 'Sensation' (7.30 m). This might be due to more contribution of 'Sensation' on hybrids as parent for tree height. Because of the fact that under north Indian conditions 'Amrapali' has dwarf tree stature, while 'Sensation' is semi-vigorous. 'Sensation' showed maximum plant spread in both E-W (9.20 m) and N-S direction (9.02 m), while H-3-6 recorded the minimum in E-W (2.09 m) and N-S direction (2.11 m). Out of 50 hybrids, 36 and 34% had more plant spread than Amrpali in E-W and N-S direction, respectively. While none of the full-sib hybrids had greater plant spread than 'Sensation' in any of the direction. Hybrid H-13-1 recorded maximum canopy volume (255.99 m^3). It was observed that 60% hybrids had plant and canopy volume more than female parent 'Amrapali'. However, only hybrid H-13-1 had more volume than pollen donor parent 'Sensation'. For all the growth parameters, it showed that 60-84% of hybrids recorded more values than 'Amrapali' as against 12-18% over 'Sensation'. This indicated that most of the hybrids recorded intermediate values for growth characters between less vigourous 'Amrapali' and semi-vigourous 'Sensation'. This may be due to the fact that male parent 'Sensation', which itself is a large tree has genetically contributed for higher tree growth characters in the hybrids. The results obtained in the present investigation are in corroboration with the results observed by Selvan *et al.* (8) on mango hybrids. They found that variation in growth characters amongst mango hybrids could be due to variation in genetic makeup under the present set of environmental and edaphic conditions. Similar results have also been reported by Kanpure *et al.* (5) in mango.

Leaf characteristics showed significant variation ($p \leq 0.05$, LSD = 0.40) among the full-sib mango hybrids and their parents (Table 1). Maximum number of leaves on bearing shoots was found in hybrid H-12-8 (48.60) and minimum in hybrid H-3-12 (7.80). It was recorded 50% hybrids given more number of leaves than 'Sensation' (15.80), however, 18% hybrids recorded more leaves number than 'Amrapali' (23.40). Maximum leaf area was found in hybrid H-13-7 (136.82 cm^2) and minimum in hybrid H-3-14 (55.89 cm^2). Leaf area of 80% of the hybrids ranged between 'Sensation' (55.90 cm^2) and 'Amrapali' (107.40 cm^2), except H-3-14, which was lesser than male parent, and H-7-1, H-12-10 and H-13-7, which were larger than female parent. Petiole length was found to be maximum in hybrid H-13-4 (5.22 cm) and minimum in hybrid H-2-9 (2.44 cm). It is evident that maximum percentage of hybrids (50-98) had leaf characters greater than 'Sensation', while only 6-18% over 'Amrapali' indicated that most of the hybrids had values ranged for leaf characters between 'Amrapali' and 'Sensation'. The variation in leaf characters among hybrids and their parents was owing to their highly heterozygous nature (Sarkar *et al.*, 7).

The rating (3 to 7) given to the full-sib hybrids and parental mango cultivars for pigmentation of new vegetative flush and inflorescence axis showed significant variation ($p \leq 0.05$, LSD = 0.40, Fig. 1). Regarding pigmentation of new vegetative flush, hybrids H-1-10, H-13-1 and H-13-4 had maximum pigmentation (7.00 rating). Rating of new vegetative flushes pigmentation showed that 30% hybrids including male parent 'Sensation' were considered as high pigmentation (rated 5-7). Similarly, 30% mango hybrids including 'Amrapali' were rated as medium pigmented hybrids (rated 3-5). Whereas, remaining 40% hybrids had no pigmentation on newly emerged vegetative flush. This result inferred that equal number of hybrids distributed for medium and high pigmentation intensity indicated

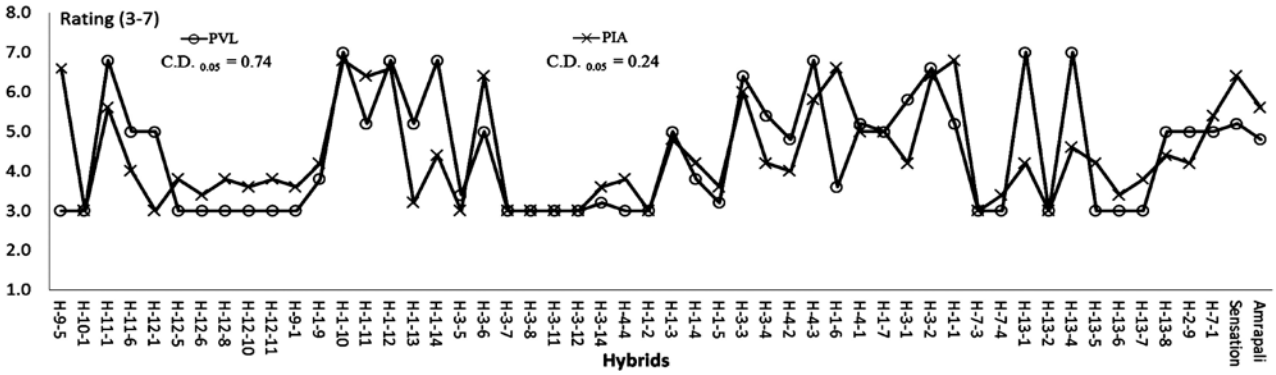

Fig. 1. Pigmentation of newly emerged vegetative flush (PVL) and inflorescence axis (PIA) of full-sib mango hybrids of 'Amrapali × Sensation' (data pooled over two years).

equal influence of both the parents. Regarding pigmentation of panicles, maximum inflorescence pigmentation (6.80) was recorded in H-1-10 and H-1-1. Furthermore, 24% hybrids were regarded as high inflorescence pigmentation (rated >5). However, 56% hybrids were grouped as medium inflorescence pigmentation (rated 3-5). While the remaining 20% hybrids showed low inflorescence pigmentation. It was interesting to note that both the parent cultivars had high pigmented panicles (5-7 rating). Majority of the hybrids (80%) possessed medium to high anthocyanin pigmentation of inflorescence axis might be due to influence of high pigmented parents on their hybrids. The variation among hybrids and parents for pigmentation intensity might due to genetically effects.

Flowering characteristics of full-sib mango hybrids and their parents showed significant variation ($p \leq 0.05$, LSD = 0.40, Table 2). Maximum inflorescence length was recorded in H-13-4 (31.74 cm) and minimum in H-3-8 (12.10 cm). Among parents, 'Amrapali' (28.49 cm) recorded longer panicle than 'Sensation' (20.25 cm). It was notice that 64% hybrids had inflorescence length more than their male parent, while only 8% had more than female parent. This indicated that 'Amrapali' as female parent had more influence on hybrids for inflorescence length. Maximum inflorescence width was recorded in H-3-1 (23.60 cm) and minimum in H-3-8 (6.26 cm). Furthermore, 32% hybrids had bigger inflorescence size than 'Sensation' as compared to 12% over 'Amrapali', which might be due to greater effect of female parent.

Table 2. Flowering and yield characteristics of full-sib mango hybrids of Amrapali × Sensation (data pooled over 2010-11 and 2011-12).

Hybrid	Age group (yr)	Inflorescence		Flowers per panicle			Sex ratio (H:M)	Flowering duration (days)	No. of fruits per panicle at harvest	No. of fruits per tree	Fruit wt. (g)	Yield (kg/ tree)
		Length (cm)	Width (cm)	Total	Herma-phrodite	Male						
H-9-5	6-7	21.56	14.62	1486.75	361.25	1125.50	0.32	19.25	0.60	10.00	223.36	2.23
H-10-1	6-7	21.72	18.37	628.85	60.30	568.55	0.11	15.38	0.40	9.00	125.91	1.14
H-11-1	6-7	28.89	16.42	878.30	256.78	621.53	0.41	15.78	1.30	26.50	185.05	4.93
H-11-6	6-7	28.10	17.42	457.83	44.93	412.90	0.11	14.18	1.10	29.00	177.87	5.19
H-12-1	9-10	24.10	12.40	1097.00	242.50	854.50	0.28	17.75	0.20	5.00	117.62	0.59
H-12-5	9-10	23.96	10.22	1001.25	108.50	892.75	0.12	16.75	1.00	35.00	176.09	6.16
H-12-6	9-10	20.38	13.00	1113.25	81.50	1031.75	0.08	18.00	1.80	29.00	132.66	3.85
H-12-8	9-10	24.55	10.70	1365.65	298.93	1066.73	0.28	16.45	1.10	12.00	149.79	1.81
H-12-10	9-10	18.43	12.00	502.60	98.55	404.05	0.24	10.43	1.10	85.50	115.73	10.06
H-12-11	9-10	24.02	16.00	775.95	142.70	626.00	0.23	11.50	1.00	31.00	85.14	2.64
H-9-1	8-9	20.38	10.25	356.45	48.20	258.90	0.38	14.23	0.60	9.50	167.53	1.59
H-1-9	14-15	22.71	13.44	451.25	152.50	298.75	0.51	15.75	1.40	183.00	172.23	31.52

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Table 2 Contd...

Hybrid	Age group (yr)	Inflorescence		Flowers per panicle			Sex ratio (H:M)	Flowering duration (days)	No. of fruits per panicle at harvest	No. of fruits per tree	Fruit wt. (g)	Yield (kg/ tree)
		Length (cm)	Width (cm)	Total	Herma-phrodite	Male						
H-1-10	14-15	22.63	11.30	438.93	131.08	307.85	0.43	15.25	1.50	37.00	91.32	3.38
H-1-11	14-15	19.90	15.00	395.08	167.10	227.98	0.80	15.15	1.30	33.00	241.43	8.08
H-1-12	14-15	17.50	9.91	349.45	54.85	294.60	0.19	15.00	1.00	83.50	79.05	6.56
H-1-13	14-15	16.79	11.38	251.93	87.95	163.98	0.54	13.60	1.20	81.00	123.35	10.35
H-1-14	14-15	23.55	11.69	1263.18	211.95	1051.23	0.20	20.68	1.90	94.00	143.78	13.80
H-3-5	14-15	20.02	11.58	237.25	114.75	122.50	0.94	12.25	1.00	73.00	95.96	7.01
H-3-6	14-15	18.88	15.17	163.85	72.28	91.58	0.79	10.95	0.50	13.00	142.79	1.87
H-3-7	14-15	20.86	8.34	352.75	88.25	264.50	0.33	13.00	1.20	45.00	185.08	8.33
H-3-8	14-15	12.10	6.26	217.50	75.00	142.50	0.53	11.50	0.60	37.00	173.45	6.42
H-3-11	14-15	19.02	12.08	498.75	127.25	371.50	0.34	15.25	1.00	36.00	169.88	6.12
H-3-12	14-15	23.18	13.60	626.00	142.25	483.75	0.29	15.75	1.00	57.00	158.80	9.05
H-3-14	14-15	23.30	13.51	667.60	87.95	554.95	0.20	14.90	1.00	48.00	145.43	7.20
H-4-4	14-15	14.98	7.76	143.00	69.25	73.75	0.91	11.50	1.00	32.00	121.87	3.90
H-1-2	15-16	18.40	12.96	700.25	269.75	430.50	0.63	16.00	1.40	234.00	92.25	21.59
H-1-3	15-16	22.57	12.07	558.08	109.33	448.75	0.24	16.55	1.40	74.00	182.49	13.47
H-1-4	15-16	25.44	13.54	829.00	185.25	643.75	0.29	16.50	2.00	115.00	146.23	16.82
H-1-5	15-16	19.17	14.28	610.90	254.18	356.73	0.71	15.58	1.00	25.00	315.43	7.96
H-3-3	15-16	19.48	11.51	226.00	66.60	164.93	0.37	13.03	0.80	61.00	137.77	8.42
H-3-4	15-16	26.18	17.16	1307.25	173.25	1134.00	0.15	19.00	1.20	29.00	145.90	4.23
H-4-2	15-16	19.06	9.00	317.88	62.35	267.43	0.19	14.78	0.50	6.50	205.04	1.34
H-4-3	15-16	17.02	9.01	261.80	114.80	169.73	0.54	11.95	0.80	28.50	204.55	5.95
H-1-6	16-17	20.76	13.10	618.70	242.88	375.83	0.65	17.20	1.50	82.00	215.33	17.68
H-4-1	16-17	30.60	23.22	821.18	74.15	747.03	0.10	17.35	0.80	37.00	202.63	7.63
H-1-7	17-18	20.30	14.90	738.25	54.00	684.25	0.09	16.25	1.40	53.00	132.56	7.03
H-3-1	18-19	26.84	23.60	1211.25	150.75	1060.50	0.14	18.00	2.00	340.00	87.31	29.69
H-3-2	18-19	21.38	8.83	483.28	74.78	408.50	0.18	15.35	1.40	74.00	178.93	13.22
H-1-1	19-20	28.90	16.26	988.38	362.48	627.30	0.58	17.63	2.20	231.00	192.21	44.26
H-7-3	26-27	15.82	8.96	624.25	221.50	402.75	0.55	15.75	0.80	47.00	161.21	7.58
H-7-4	26-27	17.88	8.08	315.00	112.25	202.75	0.55	12.50	1.40	55.00	143.91	7.92
H-13-1	28-29	25.50	14.92	1237.83	194.75	1034.00	0.20	20.20	1.20	108.00	278.44	30.07
H-13-2	28-29	20.12	9.06	321.00	88.75	232.25	0.38	13.00	1.00	97.00	141.54	13.73
H-13-4	28-29	31.74	19.04	1095.50	169.25	926.25	0.18	14.25	1.00	85.00	240.74	20.46
H-13-5	28-29	25.92	14.02	1627.65	167.25	1478.25	0.12	19.20	0.80	52.00	211.76	11.01
H-13-6	28-29	24.64	13.16	667.75	150.00	511.50	0.28	16.00	1.40	143.00	141.76	20.27
H-13-7	28-29	24.76	13.00	1028.75	254.75	774.00	0.33	17.00	1.60	108.00	196.57	21.23
H-13-8	28-29	21.28	10.17	1065.95	196.83	869.13	0.23	16.65	0.90	63.00	196.79	12.51
H-2-9	29-30	26.84	12.64	1760.75	261.25	1499.50	0.17	19.25	1.60	163.00	147.76	24.09
H-7-1	31-32	17.88	8.66	536.75	194.00	342.75	0.57	15.50	1.20	71.00	82.58	5.86
Sensation	30-31	20.25	13.80	413.20	56.55	356.65	0.16	15.83	0.70	41.00	163.65	6.73
Amrapali	25-26	28.49	16.45	1053.25	197.58	855.68	0.23	20.43	2.20	72.50	159.84	11.58
$CD_{0.05}$	-	1.17	0.75	47.91	9.53	45.46	0.04	0.98	0.58	15.38	3.67	10.05

Maximum number of hermaphrodite flowers per panicle was produced in hybrid H-1-1 (362.48) and minimum in hybrid H-11-6 (44.93). It was interesting to note that 92% of the hybrids had more number of hermaphrodite flowers than 'Sensation' (56.55) as compared to 24% over 'Amrapali' (197.58). Maximum number of male flowers was observed in hybrid H-2-9 (1499.50) and minimum number in hybrid H-4-4 (73.75). It was noted that 66% hybrids had more number of male flowers than 'Sensation' (356.65), while 24% over 'Amrapali' (855.68). Total number of flowers was maximum in hybrid H-2-9 (1760.75) and minimum in hybrid H-4-4 (143.00). Out of 50 hybrids, 72% showed more number of flowers than 'Sensation' (413.20) and 24% hybrids than 'Amrapali' (1053.25). The sex ratio calculated in the present study is indicative of presence of more hermaphrodite flowers per male flowers. The highest sex ratio was observed in hybrid H-3-5 (0.94), while, lowest was recorded in hybrid H-12-6 (0.08). The sex ratio of parental cultivars 'Sensation' (0.16) and 'Amrapali' (0.23) was low. Majority of the hybrids (82%) showed higher sex ratio than 'Sensation' while, 62% of the hybrids produced more sex ratio than 'Amrapali'. In all the flowering parameters, maximum of the hybrids showed higher value than 'Sensation' as compared to 'Amrapali'. This might due to the fact that 'Amrapali' inherited its high flowering traits to its progenies, since 'Amrapali' itself recorded better flowering characters than 'Sensation'. The variation in sex ratio and other flowering characters of mango hybrids was also reported by Kanpure *et al*. (5).

Flowering duration is indicating the period required for opening of first flower to opening of last flower on a particular panicle. Flowering duration among mango hybrids and parental mango cultivars differed significantly ($p \leq 0.05$, LSD = 0.53, Table 2). The longest flowering duration was obtained in hybrids H-1-14 (20.68 days). However, the shortest flowering duration was recorded in hybrid H-12-10 (10.43 days). Flowering duration recorded in seed parent 'Amrapali' was longer than pollen donor parent 'Sensation' (15.83 days). Among hybrids, 42% had longer flowering duration than 'Sensation', while remaining had shorter duration than 'Amrapali', with exception in H-1-14. This might be due to unique genetical constitution of each hybrids and parents and their genotypic interaction with the environmental factors. The variation in flowering duration among hybrids had also been reported by Avilan *et al*. (1).

The yield characteristics showed significant variation among hybrids and their parents (Table 2). Number of fruits retained per panicle at harvest was highest (2.20) in 'Amrapali' and H-1-1. However, minimum was noticed in H-12-1 (0.20). The variation in fruit retention at harvest might have been due to genetic factors. A similar finding was also obtained by Chauhan (3) in mango hybrids. Maximum fruit weight was observed in hybrid H-1-5 (315.43 g) followed by hybrid H-12-11 (278.44 g). However, the minimum fruit weight was noted in hybrid H-1-12 (79.05 g). It was interesting to note that 46 and 48% hybrids had larger fruit weight than 'Sensation' and 'Amrapali', respectively. This indicated that both the parents have influenced equivalently upon their hybrids. There was a wide variation in fruit weight among the hybrids, which had also been reported by Selvan *et al*. (8). This might be attributes to transgressive segregation of genes controlling fruit weight in mango. Number of fruits per tree among different age groups varied significantly. In the age group 6-7 years, maximum number of fruit per tree (29) and yield (5.19 kg/ tree) was recorded in H-11-6. Among the 9-10 years age group, H-12-10 recorded maximum number of fruit per tree (85.50) and yield (10.06 kg/ tree). In the age group 14-15 years, maximum number of fruit per tree (183.00) and yield (31.52 kg/ tree) was recorded in H-1-9. Among age group 15-16 years, maximum number of fruit per tree (234.00) and yield (21.59 kg/ tree) was recorded in H-1-2. Among age group 16-17 years, H-1-6 gave maximum number of fruit per tree (82) and yield (17.68 kg/ tree). For the age group 18-19 years, maximum number of fruit per tree (340) and yield (29.69 kg/ tree) was recorded in H-3-1. H-7-4 showed maximum number of fruit per tree (55.00) and yield (7.92 kg/ tree) among age group 26-27 years. Among age group 28-29 years, H-13-6 noted maximum number of fruit per tree (143) and yield (20.27 kg/ tree). Irrespective of age, H-3-1 recorded maximum number of fruits (340.00), while maximum yield was noted in H-1-1 (44.25 kg/ tree). It is evident that 58 and 38% of hybrids produced more fruit number than 'Sensation' and 'Amrapali', respectively. All the hybrids that produced less number of fruit per tree over male parent are of age below 16-17 years, which is younger than their male parent (30-31 years). However, in case of female parent (25-26), even older hybrids such as H-13-5 (28-29), H-7-4 (26-27), H-13-8 (28-29) and H-7-1 (31-32) produced lower number of fruits than 'Amrapali'. This indicated that all the hybrids have higher potential yield than 'Sensation'. Regarding yield in term of kg per tree, 32% hybrids gave more yield than 'Amrapali' and it was observed that even younger hybrids, *viz*., H-3-2, H-1-3, H-1-14, H-1-4, H-1-6, H-1-2, H-3-1, H-1-9, H-1-1 had higher yield over 'Amrapali'. Similarly, 60% hybrids produced higher yield over their male parent. This indicates that larger number of hybrids gave higher yield over their parents. The variations

in fruit yield attributes have also been reported due to change in inherent genetic factors (Srivastava *et al.*, 9; Selvan *et al*., 8).

Based on the present results, it can be concluded that the traits distribution pattern with respect to growth, flowering and yield characters showed significant variation among the full-sib families. It was also evident that for a particular trait, the maternal effect was pronounced, however for some traits paternal effect was prominent. On the basis of overall assessment of 50 hybrids, 13, namely, H-1-1, H-1-5, H-1-6, H-3-2, H-13-1, H-1-2, H-1-13, H-3-1, H-3-12, H-7-3, and H-13-8 were identified as better performing hybrids. Of these, H-1-1, H-1-6 and H-13-1 though released, deserve a place in mango varietal trial under different agro-climatic regions of the country. Results suggested that the quantification of traits could help to understand the potential of hybrids and in selection of desirable hybrids for domestic and export markets as well for selection of potential parents for future utilization in improvement programmes. The leads obtained in the present study would aid in molecular characterization using different DNA markers systems, which would further be useful for deciphering the trait locus association and development of linkage maps in mango.

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