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Manjunath Sharanappa Tondihal
 Ph.D Scholar, College of Horticulture, Junagadh Agricultural University, Junagadh, Gujarat, India

DK Varu
 Principal and Dean, College of Horticulture, Junagadh Agricultural University, Junagadh, Gujarat, India

GU Kulkarni
 Associate Professor, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India

Sandip Makhmale
 Research Associate, College of Horticulture, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
Manjunath Sharanappa Tondihal
 Ph.D Scholar, College of Horticulture, Junagadh Agricultural University, Junagadh, Gujarat, India

Evaluation of F₁ crosses of papaya under Saurashtra conditions in Gujarat

Manjunath Sharanappa Tondihal, DK Varu, GU Kulkarni and Sandip Makhmale

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Abstract

The present investigation was undertaken at the Department of Fruit Science, College of Horticulture, Junagadh Agricultural University, Junagadh, to assess the mean performance of papaya hybrids developed through a half-diallel manner. A total of 15 F₁ crosses were evaluated for various parameters. Significant differences were observed for all physical, yield and biochemical parameters except for titratable acidity. The hybrids Arka Prabhat x CO-7 (142 days) and Arka Surya x GJP-1 (145 days) were showed earliness in fruit maturity. The highest yield per plant was observed in the crosses GJP-1 x Pusa Dwarf (26.78 kg) and GJP-1 x CO-8 (26.76 kg). These hybrids can be utilized in further breeding programmes.

Keywords: Papaya, hybrid, yield, TSS

Introduction

Papaya (*Carica papaya* L.) is a significant tropical fruit that is extensively cultivated in our country. Originally native to tropical America (Kaibing *et al.*, 2011) [9], it was introduced to India in the 16th century from the Philippines via Malaysia. The fruit is highly nutritious, being rich in vitamins A and C, as well as minerals, particularly calcium. Due to its high pectin content, papaya pulp is widely used as a key ingredient in the fruit processing industry. Moreover, papaya boasts a high ascorbic acid content, with about 100 g of fresh fruit providing 108 mg, surpassing the levels found in oranges (67 mg/100 g of fresh fruit) (Lim *et al.*, 2007) [11]. Papain, a proteolytic enzyme extracted from papaya latex, is utilized as a meat tenderizer and has applications in cosmetics, pharmaceuticals and fabric weaving.

Papaya thrives well in many regions of India, like Gujarat, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. In Gujarat, prominent cultivation areas include Ahmedabad, Anand, Baroda, Bhavnagar, Kheda, Mahesana, and Junagadh districts. In India total area under papaya cultivation is around 1.47 L ha and total annual production of 52.27 L MT with productivity 37.94 MT/ha (Anon., 2023a) [1]. The leading producer of papaya in India is Gujarat which is followed by Andhra Pradesh. In Gujarat, papaya is cultivated on estimated area of 0.18 L ha with 10.67 L MT of production with productivity 58.38 MT/ha (Anon., 2023b) [2].

India is the largest producer of papaya in the world but productivity is lower than the other countries like Brazil, Indonesia and Mexico. One of the main reasons is the absence of high yielding, disease resistant hybrid varieties. Since papaya is a seed propagated crop, it can be improved by developing pure lines, inbreds or hybrids. Hybrid breeding, which yields heterozygous F₁ hybrids, proves superior to pure lines due to the increased variability for high yield and fruit quality, as well as enhanced genetic buffering against environmental and biotic stresses. In the present study, the F₁ hybrids developed through half-diallel crosses were evaluated for mean performance under Saurashtra conditions of Gujarat and the better performing hybrid combinations can be utilized in further breeding programmes.

Materials and Methods

The present study was conducted at the Department of Fruit Science, College of Horticulture, Junagadh Agricultural University, Junagadh, during the period 2023-2024. The total of fifteen F₁ crosses of papaya were evaluated for different parameters under the Saurashtra

region of Gujarat. These F₁ crosses were developed by crossing six papaya parents in a half-diallel manner. The list of all fifteen crosses is given in Table 1. The F₁ crosses were evaluated for various parameters like, Plant height (cm), stem diameter (cm), bearing height (cm), length of the mature leaf petiole (cm), length of the mature leaf (cm), width of the mature leaf (cm), days to flowering, days to fruit maturity, fruit length (cm), fruit diameter (cm), fruit weight (g), fruit central cavity index (%), thickness of pulp (cm), number of fruits per plant, fruit yield per plant (kg), fruit yield (t/ha), fruit firmness (kg/cm²), titratable acidity (%), ascorbic acid (%), total sugars (%), reducing sugars (%), non-reducing sugars (%) and total soluble solids (°Brix).

Results and Discussion

The data revealed that there was a significant difference among the 15 crosses for various parameters of papaya. Lower plant height is a desirable characteristic in papaya as it allows for the accommodation of more plants, facilitates easier cultural operations, and simplifies harvesting. Among 15 crosses, the cross Arka Prabhath x Pusa Dwarf recorded the lowest height (144.31 cm) which was at par with the Arka Prabhath x CO-8 (167.31 cm), while the hybrid, CO-7 x Pusa Dwarf recorded the highest height (222.61 cm). For stem diameter, the highest stem diameter was observed in the hybrid Pusa Dwarf x CO-8 (29.70 cm) which was at par with the Arka Surya x GJP-1, Arka Surya x Pusa Dwarf, GJP-1 x CO-8, Arka Surya x Arka Prabhath, CO-7 x Pusa Dwarf and Arka Prabhath x CO-7. The lowest stem diameter was recorded in Arka Prabhath x CO-8 (18.07 cm). Plant lodging is a significant problem in papaya, with plants often falling due to heavy bearing under field conditions. Therefore, a thicker stem diameter is preferred in papaya as it supports the bearing plant and prevents lodging. Lower bearing height is a desirable feature in papaya because the lower the bearing height, the greater the fruit-bearing area. In the present study, the lowest bearing height was observed in Arka Prabhath x CO-8 (117.51 cm) which was at par with GJP-1 x Arka Prabhath, GJP-1 x CO-7, GJP-1 x Pusa Dwarf and Pusa Dwarf x CO-8, while, the highest bearing height was recorded in Arka Surya x GJP-1 (173.11 cm). Leaf parameters, which are crucial as they affect the photosynthesis of a crop, showed that the hybrid Arka Surya x GJP-1 had the highest petiole length (84.01 cm), while Arka Surya x Arka Prabhath recorded the highest leaf length (48.50 cm) and the highest leaf width (54.53 cm) (Table 2). Singh *et al.* (2006) [15] reported the significant variations among physical parameters of papaya. Kore *et al.* (2017) [10] studied 12 genotypes of papaya for various parameters and also reported the significant differences.

Among the 15 hybrids, the fewest days to flowering were observed in Arka Prabhath x CO-8 (66.20 days), CO-7 x CO-8 (70.80 days) and Arka Prabhath x CO-7 (71.88 days). Similar results were reported by Chalak *et al.* (2016) [4], who noted a minimum of 70.40 days and a maximum of 85 days for days to flowering. Early maturity is a desirable feature in papaya. Among the 15 hybrids, the minimum days for fruit maturity was observed in Arka Prabhath x CO-7 (142.00) which was at par with Arka Surya x GJP-1 (145.00), while the hybrid CO-7 x CO-8 (191.33) took maximum days for fruit maturity. These results are accordance with the findings of Kore *et al.* (2017) [10] and Suvalaxmi *et al.* (2019) [16]. The range of fruit length in hybrids varied from 14.61 cm to 20.11 cm. Among the evaluated hybrids, the maximum fruit length was found in CO-7 x CO-8 (20.11

cm) followed by GJP-1 x CO-7 (18.96 cm) and Arka Prabhath x CO-8 (18.81 cm). The minimum fruit length was observed in GJP-1 x Arka Prabhath (14.61 cm) followed by Pusa Dwarf x CO-8 (14.85 cm) and Arka Surya x GJP-1 (15.24 cm). Fruit diameter had exhibited significant differences among the hybrids. The maximum fruit diameter was observed in Arka Surya x CO-8 (14.78 cm) which was at par with GJP-1 x CO-7, Pusa Dwarf x CO-8, GJP-1 x CO-8, Arka Surya x CO-7, GJP-1 x Pusa Dwarf, Arka Surya x Arka Prabhath and Arka Surya x GJP-1 (Table 3). There was a significant difference among the papaya hybrids for fruit weight. The average value of fruit weight ranged from 802 g to 1668.33 g among papaya hybrids. The highest fruit weight was observed in GJP-1 x Pusa Dwarf (1668.33 g) followed by GJP-1 x CO-7 (1470 g), GJP-1 x CO-8 (1391.67 g) and Arka Surya x Arka Prabhath (1374.33 g). The lowest fruit weight was recorded in Arka Prabhath x Pusa Dwarf (802 g). The hybrids with lowest cavity index were Arka Prabhath x CO-7 (18.49%), GJP-1 x CO-8 (18.93%) and GJP-1 x CO-7 (19.60%) whereas the largest cavity index was recorded in Arka Prabhath x Pusa Dwarf (29.66%). The highest pulp thickness was observed in Arka Prabhath x CO-8 (2.44 cm) which was at par with Arka Surya x Pusa Dwarf, Arka Surya x CO-7 and GJP-1 x CO-7. The lowest pulp thickness was observed in the hybrid GJP-1 x Arka Prabhath (1.83 cm) (Table 4). These results are in agreement with findings of Singh *et al.* (2006) [15], Nirujogi and Dinesh (2012) [12], Das (2013) [5], Davamani *et al.* (2013) [6], Saran *et al.* (2015) [14] and Emede *et al.* (2016) [7]. The number of fruits per plant in hybrids varied from 13.32 to 22.41. The maximum number of fruits per plant was observed in Arka Surya x Arka Prabhath (22.41) which was at par with GJP-1 x CO-8. The minimum number of fruits per plant in the hybrids was recorded in GJP-1 x Arka Prabhath (13.32) (Table 4). The results are also in conformity with that of Kore *et al.* (2017) [10] who reported an average of 28 fruits per plant and 19 marketable fruits per plant, respectively, in papaya. There was a significant difference among the papaya hybrids in terms of fruit yield per plant. The average fruit yield per plant ranged from 11.03 to 26.78 kg. Among the 15 hybrids, GJP-1 x Pusa Dwarf had the maximum fruit yield per plant (26.78 kg) which was at par with GJP-1 x CO-8. The minimum yield per plant was observed in Arka Prabhath x Pusa Dwarf (11.03 kg). A similar trend was observed for fruit yield per hectare, with the highest yield recorded in the cross GJP-1 x Pusa Dwarf (82.64 t/ha) and the lowest in Arka Prabhath x Pusa Dwarf (34.03 t/ha). These results are similar to the findings of Kore *et al.* (2017) [10], who reported papaya yields ranging from 11.85 kg to 26.08 kg per plant and from 17.06 tonnes to 41.72 tonnes per hectare (Table 5). Similarly, Ara *et al.* (2013) [3] reported papaya yields ranging from 28.00 t/ha to 89.82 t/ha. There was no significant difference among the papaya hybrids in terms of titratable acidity content. The average titratable acidity among hybrids ranged from 0.11% to 0.17%, with a total mean of 0.14%. Total soluble solids (TSS) is the crucial fruit quality parameter that influences both palatability and consumer acceptability. The average content of TSS in fruit pulp of hybrids ranged from 7.37 to 9.91 °B. The hybrids with the highest TSS were CO-7 x CO-8 (9.91°B), GJP-1 x Arka Prabhath (9.51°B), GJP-1 x CO-8 (9.47°B) and Arka Surya x CO-8 (9.14°B). The lowest TSS was observed in Arka Prabhath x CO-7 (7.37°B). The mean percentage of ascorbic acid in fruit pulp of papaya hybrids ranged from 36.08% to 52.63%. Among

the 15 hybrids, the highest ascorbic acid content was observed in Arka Prabhath x CO-8 (52.63%) followed by CO-7 x CO-8 (51.47%), Arka Prabhath x Pusa Dwarf (50.52%) and GJP-1 x CO-8 (50.00%), whereas the lowest ascorbic acid was recorded in Arka Surya x Arka Prabhath (36.08%). For total sugar content, the highest sugar content was observed in Arka Prabhath x CO-8 (7.18%) followed by GJP-1 x Arka Prabhath (6.87%) and GJP-1 x CO-8 (6.67%). The lowest total sugar content was found in Arka Prabhath x CO-7 (4.35%). Among the 15 hybrids, the highest reducing sugars content was observed in Arka Surya x CO-8 (5.89%)

followed by GJP-1 x Arka Prabhath (5.19%), GJP-1 x CO-8 (5.14%) and Arka Surya x Arka Prabhath (5.13%), whereas the lowest reducing sugars content was recorded in Arka Prabhath x CO-7 (4.06%). While, the highest content of non-reducing sugars was found in Arka Prabhath x CO-8 (2.11%) and lowest was found Arka Prabhath x CO-7 (0.29%) (Table 6). These results are in agreement with findings of Singh *et al.* (2006) [15], Meena *et al.* (2012) [12], Davamani *et al.* (2013) [6], Saran *et al.* (2015) [14] and Chalak *et al.* (2016) [4].

Table 1: List of F₁ hybrids of papaya used in the study

Sr. No.	Hybrids/crosses	Sr. No.	Hybrids/crosses
1	Arka Surya x GJP-1	9	GJP-1 x CO-8
2	Arka Surya x Arka Prabhath	10	Arka Prabhath x CO-7
3	Arka Surya x CO-7	11	Arka Prabhath x Pusa Dwarf
4	Arka Surya x Pusa Dwarf	12	Arka Prabhath x CO-8
5	Arka Surya x CO-8	13	CO-7 x Pusa Dwarf
6	GJP-1 x Arka Prabhath	14	CO-7 x CO-8
7	GJP-1 x CO-7	15	Pusa Dwarf x CO-8
8	GJP-1 x Pusa Dwarf		

Table 2: Mean performance of papaya parents and hybrids for plant height, stem diameter, bearing height, length of the mature leaf petiole and length of the mature leaf

Sr. No	Genotypes	Plant height (cm)	Stem diameter (cm)	Bearing height (cm)	Length of the mature leaf petiole (cm)	Length of the mature leaf (cm)
1	A. Surya x GJP-1	211.96	29.62	173.11	84.01	43.65
2	A. Surya x A. Prabhath	210.33	27.14	146.44	81.03	48.50
3	A. Surya x CO-7	204.30	24.26	150.67	73.11	37.17
4	A. Surya x P. Dwarf	221.28	29.37	158.35	70.77	37.39
5	Arka Surya x CO-8	197.30	24.34	140.60	76.65	36.52
6	GJP-1 x A. Prabhath	186.66	21.50	118.84	64.01	35.87
7	GJP-1 x CO-7	182.00	19.86	120.27	59.71	34.01
8	GJP-1 x P. Dwarf	213.00	24.48	121.18	66.98	35.08
9	GJP-1 x CO-8	200.63	29.26	145.72	68.29	36.53
10	A. Prabhath x CO-7	198.52	25.93	133.19	65.13	37.01
11	A. Prabhath x P. Dwarf	144.31	18.69	136.88	53.51	33.47
12	A. Prabhath x CO-8	167.31	18.07	117.51	60.07	36.32
13	CO-7 x P. Dwarf	222.61	27.03	166.78	65.98	35.99
14	CO-7 x CO-8	215.13	24.47	148.07	69.12	37.70
15	P. Dwarf x CO-8	219.02	29.70	128.95	68.67	37.90
	SEm±	10.60	1.62	9.49	3.13	1.47
	C.D (at 5%)	30.72	4.69	27.50	9.09	4.28
	C.V.	9.20	11.26	11.71	7.94	6.81

A.= Arka, P.= Pusa

Table 3: Mean performance of papaya parents and hybrids for width of the mature leaf, days to flowering, days to fruit maturity, fruit length and fruit diameter

Sr. No	Genotypes	Width of the mature leaf (cm)	Days to flowering	Days to fruit maturity	Fruit length (cm)	Fruit diameter (cm)
1	A. Surya x GJP-1	50.04	79.13	145.00	15.24	13.64
2	A. Surya x A. Prabhath	54.53	72.90	187.67	17.27	13.67
3	A. Surya x CO-7	50.26	78.93	157.00	17.17	13.73
4	A. Surya x P. Dwarf	50.85	82.10	152.67	15.75	13.00
5	Arka Surya x CO-8	50.88	74.33	158.00	18.19	14.78
6	GJP-1 x A. Prabhath	49.14	73.97	161.67	14.61	12.15
7	GJP-1 x CO-7	48.09	77.25	167.33	18.96	14.68
8	GJP-1 x P. Dwarf	48.68	76.99	162.33	17.78	13.70
9	GJP-1 x CO-8	51.85	75.83	169.00	17.86	14.15
10	A. Prabhath x CO-7	50.05	71.88	142.00	17.92	13.22
11	A. Prabhath x P. Dwarf	45.42	78.91	157.67	18.24	13.12
12	A. Prabhath x CO-8	40.77	66.20	159.33	18.81	12.87
13	CO-7 x P. Dwarf	48.45	73.33	189.67	18.21	12.52
14	CO-7 x CO-8	50.92	70.80	191.33	20.11	10.86
15	P. Dwarf x CO-8	46.22	76.92	173.33	14.85	14.46
	SEm±	1.59	1.49	2.95	0.38	0.47
	C.D (at 5%)	4.61	4.34	8.55	1.10	1.36
	C.V.	5.61	3.44	3.10	3.80	6.12

A.= Arka, P.= Pusa

Table 4: Mean performance of papaya parents and hybrids for fruit weight, fruit central cavity index, thickness of pulp and number of fruits per plant

Sr. No	Genotypes	Fruit weight (g)	Fruit central cavity index (%)	Thickness of pulp (cm)	No. of fruits per plant
1	A. Surya x GJP-1	1104.00	20.31	2.20	20.25
2	A. Surya x A. Prabhath	1374.33	22.25	2.12	22.41
3	A. Surya x CO-7	851.67	20.60	2.36	14.87
4	A. Surya x P. Dwarf	929.67	24.26	2.36	14.47
5	Arka Surya x CO-8	1369.67	21.77	2.29	18.46
6	GJP-1 x A. Prabhath	1183.33	22.56	1.83	13.32
7	GJP-1 x CO-7	1470.00	19.60	2.34	14.87
8	GJP-1 x P. Dwarf	1668.33	22.65	2.18	19.96
9	GJP-1 x CO-8	1391.67	18.93	2.21	22.26
10	A. Prabhath x CO-7	1195.00	18.49	2.14	14.57
11	A. Prabhath x P. Dwarf	802.00	29.66	2.05	14.01
12	A. Prabhath x CO-8	1168.33	22.92	2.44	19.39
13	CO-7 x P. Dwarf	1054.00	27.87	1.99	16.23
14	CO-7 x CO-8	906.00	20.93	2.28	14.72
15	P. Dwarf x CO-8	1233.00	24.02	2.23	18.40
	SEm±	46.30	0.41	0.03	0.48
	C.D (at 5%)	134.14	1.18	0.10	1.40
	C.V.	6.79	3.16	2.73	4.87

A.= Arka, P.= Pusa

Table 5: Mean performance of papaya parents and hybrids for fruit yield per plant, fruit yield, fruit firmness, titratable acidity and ascorbic acid

Sr. No.	Genotypes	Fruit yield per plant (kg)	Fruit yield (t/ha)	Fruit firmness (kg/cm ²)	Titratable acidity (%)	Ascorbic acid (%)
1	A. Surya x GJP-1	21.34	65.85	6.86	0.16	38.77
2	A. Surya x A. Prabhath	24.88	76.77	4.14	0.13	36.08
3	A. Surya x CO-7	12.13	37.43	4.06	0.16	41.43
4	A. Surya x P. Dwarf	12.26	37.83	6.61	0.17	46.88
5	Arka Surya x CO-8	21.98	67.84	4.94	0.14	48.74
6	GJP-1 x A. Prabhath	13.70	42.27	4.88	0.14	44.98
7	GJP-1 x CO-7	20.63	63.67	6.11	0.17	37.08
8	GJP-1 x P. Dwarf	26.78	82.64	3.16	0.16	41.73
9	GJP-1 x CO-8	26.76	82.59	3.57	0.13	50.00
10	A. Prabhath x CO-7	15.32	47.27	5.92	0.17	36.33
11	A. Prabhath x P. Dwarf	11.03	34.03	4.98	0.14	50.52
12	A. Prabhath x CO-8	21.49	66.30	5.86	0.13	52.63
13	CO-7 x P. Dwarf	16.25	50.13	6.04	0.17	40.09
14	CO-7 x CO-8	12.65	39.04	6.22	0.11	51.47
15	P. Dwarf x CO-8	21.13	65.21	4.69	0.13	48.66
	SEm±	0.68	2.12	0.27	NS	1.12
	C.D (at 5%)	1.99	6.16	0.79		3.25
	C.V.	6.43	6.44	9.17		4.38

A.= Arka, P.= Pusa

Table 6: Mean performance of papaya parents and hybrids for total sugars, reducing sugars, non-reducing sugars and total soluble solid

Sr. No.	Genotypes	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total soluble solids (°Brix)
1	A. Surya x GJP-1	6.03	4.94	1.09	8.15
2	A. Surya x A. Prabhath	6.35	5.13	1.22	8.01
3	A. Surya x CO-7	5.55	4.63	0.93	8.03
4	A. Surya x P. Dwarf	6.26	4.90	1.35	8.16
5	Arka Surya x CO-8	6.55	5.89	0.66	9.14
6	GJP-1 x A. Prabhath	6.87	5.19	1.68	9.51
7	GJP-1 x CO-7	5.08	4.65	0.43	7.65
8	GJP-1 x P. Dwarf	5.17	4.17	1.01	8.13
9	GJP-1 x CO-8	6.67	5.14	1.53	9.47
10	A. Prabhath x CO-7	4.35	4.06	0.29	7.37
11	A. Prabhath x P. Dwarf	5.22	4.44	1.14	8.43
12	A. Prabhath x CO-8	7.18	5.06	2.11	8.80
13	CO-7 x P. Dwarf	4.61	4.27	0.34	8.12
14	CO-7 x CO-8	6.50	4.45	2.04	9.91
15	P. Dwarf x CO-8	5.86	4.85	1.01	8.76
	SEm±	0.17	0.15	0.04	0.26
	C.D (at 5%)	0.52	0.45	0.13	0.75
	C.V.	5.29	5.67	7.37	5.32

A.= Arka, P.= Pusa

Conclusion

Among the 15 evaluated hybrids, the combinations GJP-1 x CO-8, GJP-1 x Pusa Dwarf and Arka Surya x Arka Prabhath performed better in terms of yield and quality parameters, making them suitable for further breeding programs.

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Competing Interests

Authors have declared that no competing interests exist.

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