

Short communication

Variability studies in papaya (*Carica papaya* L.)

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Received 24 September 2016; received in revised form 2 December 2016; accepted 18 December 2016

Abstract

Systematic collection of forty papaya types was done out in central zone of Kerala to assess the variability in respect of morphological, flowering, fruiting and biochemical characters in papaya. It was observed that wide range of variability exists in papaya grown in the homesteads of Kerala. The plant height of forty collections varied from 2.1 to 6.6 m and collar girth varied from 30.00 to 88.16 cm. Fruit weight and fruit volume of the collections varied from 440 to 3,130 g and 400 to 3,280 ml, respectively. Flesh thickness of the collections ranged from 1.9 to 4.3 cm. Fruits showed variation in flesh colour from light yellow to scarlet. Biochemical analysis indicated that the total soluble solids (TSS) varied from 3.80 °Brix to 14 °Brix.

Keywords: Biochemical characters, Fruit characters, Kerala, Morphological characters, Papaya, Variability

Papaya (*Carica papaya* L.) belonging to the family Caricaceae, is an important fruit crop of tropical and subtropical regions of the world. It is easy to grow papaya and are produced fruits within a year. Fruit is rich in alkaloids, pectin, volatile compounds and proteolytic enzymes (Ram, 2005). Papaya fruit is consumed as fresh fruit and vegetable. Now it is recognized as highly nutritive, economic and important medicinal fruit crop. In India, papaya is cultivated in an area of 1.33 lakh ha with a production of 56.39 lakh tonnes (NHB, 2011). In Kerala, papaya is basically a homestead crop.

Homestead gardening is a traditional practice of growing crops and rearing livestock in small land holdings. Wide range of variability is observed in papaya grown in the homesteads of Kerala. This variability is mainly due to seed propagation and cross-pollinated nature of the crop. Variability has been reported in plant and fruit characters like plant height, fruiting height, fruit size and quality of the fruit. Therefore, the present investigation on “Variability studies in papaya (*Carica papaya* L.)”

was undertaken in central zone of Kerala with an objective of exploring the variability for the improvement of this crop.

A detailed survey was conducted in the homesteads of Thrissur, Palakkad and Ernakulam districts of Kerala to assess the variability in papaya. Based on the general vigour of the plants, 75 plants were tagged in different locations namely Kodakara, Viyyur, Alathur, Mannarkad, Chittur, Muvattupuzha and Aluva. Based on the different biometric, flowering and fruiting characters, 40 plants out of 75 were selected. Fruits from these 40 plants were collected and subjected to quantitative and qualitative analysis. These were serially numbered from Coll. 1 to Coll. 40. These 40 collections aged from one to three years formed the material for this study.

Observations on morphological, flowering, fruiting and biochemical characters were recorded as per the methods described in IBPGR descriptor for papaya (IBPGR, 1988). Morphological characters

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Table 1. Morphological characters of papaya collections

Collection No.	Plant height (m)	Collar girth (cm)	No. of fully developed leaves	Leaf area (cm ²)	Petiole length (cm)	Colour of petiole	Time of flowering
Coll. 1	3.5	40.00	25.00	2106.0	57.00	Normal Green	Oct – Nov
Coll. 2	5.4	47.00	28.00	1158.0	70.00	Pale green	Sep – Oct
Coll. 3	6.2	72.50	56.00	5604.0	99.00	Normal Green	Oct – Nov
Coll. 4	5.3	88.16	53.00	5816.0	91.00	Green	Sep – Oct
Coll. 5	5.5	60.50	24.00	6770.0	110.00	Purple	Sep – Oct
Coll. 6	4.8	58.00	44.00	3272.0	64.00	Normal Green	Oct – Nov
Coll. 7	4.6	57.00	42.00	5180.0	78.00	Pale green	Sep – Oct
Coll. 8	3.9	43.00	23.00	3060.0	80.00	Normal Green	Sep – Oct
Coll. 9	5.5	50.00	22.00	3272.0	92.00	Pale green	Oct.
Coll. 10	3.6	64.00	40.00	3060.0	62.00	Normal Green	Oct.
Coll. 11	6.6	61.00	22.00	2424.0	93.00	Normal Green	Sep – Oct
Coll. 12	4.2	49.00	30.00	3484.0	70.00	Green and Shades of red purple	Oct – Nov
Coll. 13	3.6	30.00	15.00	1576.0	65.00	Normal Green	Oct – Nov
Coll. 14	5.1	52.00	29.00	2954.0	68.00	Pale green	Sep – Oct
Coll. 15	3.8	67.00	43.00	3166.0	60.00	Green and Shades of red purple	Oct – Nov
Coll. 16	4.5	73.00	39.00	4014.0	90.00	Normal Green	Oct- Nov
Coll. 17	2.1	35.00	16.00	2212.0	60.00	Normal Green	Dec.
Coll. 18	4.5	68.50	38.00	4332.0	110.00	Pale green	Sep – Oct
Coll. 19	2.1	44.00	38.00	6452.0	42.00	Normal Green	Sep – Oct
Coll. 20	2.1	30.00	15.00	1682.0	60.00	Normal Green	Oct.
Coll. 21	4.3	31.00	26.00	2212.0	60.00	Normal Green	Sep – Oct
Coll. 22	4.3	50.00	32.00	3802.0	73.00	Normal Green	Oct – Nov
Coll. 23	4.5	35.00	16.00	1894.0	60.00	Normal Green	Sep – Oct
Coll. 24	4.0	42.50	26.00	2530.0	75.00	Normal Green	Oct – Nov
Coll. 25	3.7	40.00	20.00	2742.0	78.00	Purple	Oct – Nov
Coll. 26	4.2	53.70	20.00	2530.0	75.00	Normal Green	Oct
Coll. 27	4.4	54.00	40.00	3484.0	62.00	Normal Green	Sep – Oct
Coll. 28	3.6	74.00	38.00	2212.0	70.00	Pale green	Oct- Nov
Coll. 29	5.1	67.00	40.00	1152.0	63.00	Normal Green	Oct- Nov
Coll. 30	3.0	48.00	12.00	2212.0	75.00	Normal Green	Oct- Nov
Coll. 31	6.0	69.00	32.00	940.0	60.00	Normal Green	Sep – Oct
Coll. 32	3.6	59.00	48.00	3590.0	120.00	Purple	Oct.
Coll. 33	2.7	40.00	18.00	2106.0	67.00	Normal Green	Oct.
Coll. 34	3.0	37.00	36.00	3802.0	120.00	Normal Green	Dec.
Coll. 35	4.1	44.00	29.00	3166.0	70.00	Pale green	Oct.
Coll. 36	3.9	45.50	28.00	3908.0	65.00	Normal Green	Sep – Oct
Coll. 37	4.5	51.00	34.00	1152.0	85.00	Normal Green	Oct – Nov
Coll. 38	3.6	30.00	16.00	3272.0	90.00	Pale green	Oct- Nov
Coll. 39	4.5	52.00	32.00	3802.0	80.00	Normal Green	Oct.
Coll. 40	5.6	62.00	24.00	2636.0	85.00	Red Purple	Oct – Nov

like plant height, collar girth, number of leaves, length and colour of petiole, and leaf area were recorded.

Plant height was measured from the ground level up to the growing point using a graduated pole, and collar girth was taken using a measuring tape at 10 cm above the ground level. Leaf area was calculated using the equation described by Karikari (1973).

Petiole length of the fifth leaf from the top was measured and expressed in cm. Flowering characters like time of flowering and sex expression of plant were recorded. Fruit characters like weight, length, volume, shape and circumference of the fruit, flesh colour, flesh thickness, number of seeds per fruit and 100 seed weight were also recorded. Biochemical analysis of the fruit was done as per the procedure described by Ranganna (1986).

Table 2. Flowering and fruiting characters of papaya collections

Collection No.	Sex expression of plant	Fruit weight (g)	Fruit length (cm)	Fruit volume (ml)	Fruit shape	Circumference of fruit (cm)
Coll. 1	Hermaphrodite	440.0	18.90	500.0	Pear shaped	25.40
Coll. 2	Female	1275.0	25.50	1310.0	Acron	38.70
Coll. 3	Hermaphrodite	955.0	21.20	1029.0	Oblong – ellipsoid	39.00
Coll. 4	Female	1500.0	25.00	1720.0	Round	50.00
Coll. 5	Hermaphrodite	1220.0	26.00	1300.0	Elongate	38.00
Coll. 6	Hermaphrodite	640.0	20.00	700.0	Pear shaped	15.00
Coll. 7	Hermaphrodite	985.0	16.00	1100.0	Elongate	36.00
Coll. 8	Female	1340.0	24.50	1410.0	Oval	44.40
Coll. 9	Hermaphrodite	765.0	19.50	800.0	Blossom end tapered	35.50
Coll.10	Hermaphrodite	1630.0	31.50	1720.0	Pear shaped	37.50
Coll. 11	Female	595.0	19.00	630.0	Oval	30.50
Coll. 12	Female	1150.0	23.00	1280.0	Acron	38.00
Coll. 13	Female	1500.0	27.00	1740.0	High round	24.50
Coll. 14	Female	740.0	24.00	830.0	Acron	29.00
Coll. 15	Female	909.0	25.20	1012.0	Acron	33.50
Coll. 16	Hermaphrodite	1620.0	24.00	1800.0	Pear shaped	46.00
Coll. 17	Hermaphrodite	1060.0	25.00	1180.0	Pear shaped	34.50
Coll. 18	Hermaphrodite	985.0	16.00	1025.0	Lengthened cylindrical	36.00
Coll. 19	Hermaphrodite	3130.0	35.00	3280.0	Lengthened cylindrical	51.00
Coll. 20	Female	975.0	22.50	1010.0	Oval	38.40
Coll. 21	Hermaphrodite	595.0	19.00	685.0	Acron	30.50
Coll. 22	Female	680.0	19.00	740.0	Elliptic	33.50
Coll. 23	Female	1500.0	27.00	1680.0	Round	24.50
Coll. 24	Female	860.0	20.30	920.0	Round	37.50
Coll. 25	Hermaphrodite	1380.0	27.50	1500.0	Oblong	24.00
Coll. 26	Hermaphrodite	1465.0	27.50	1590.0	Acron	36.00
Coll. 27	Hermaphrodite	950.0	23.70	1100.0	Oblong	36.50
Coll. 28	Hermaphrodite	735.0	21.00	900.0	Acron	26.00
Coll. 29	Hermaphrodite	1020.0	25.60	1300.0	Pear shaped	39.50
Coll. 30	Hermaphrodite	900.0	24.00	990.0	Acron	39.00
Coll. 31	Hermaphrodite	440.0	18.90	570.0	Oval	25.40
Coll. 32	Hermaphrodite	2105.0	27.50	2220.0	Acron	52.00
Coll. 33	Female	1110.0	21.00	1180.0	Oval	39.00
Coll. 34	Female	560.0	24.00	680.0	Round	29.00
Coll. 35	Hermaphrodite	855.0	20.00	950.0	Blossam end tapered	39.40
Coll. 36	Hermaphrodite	880.0	23.00	980.0	Acron	35.00
Coll. 37	Hermaphrodite	640.0	29.00	720.0	Oval	24.50
Coll. 38	Female	380.0	24.00	400.0	Round	27.00
Coll. 39	Hermaphrodite	850.0	23.00	910.0	Club shaped	41.00
Coll. 40	Female	820.0	22.00	880.0	Acron	34.00

Biochemical characters like acidity, total soluble solids (TSS), reducing, non-reducing and total sugars were recorded.

Qualitative characters such as flesh colour, fruit shape, sex expression of plant, time of flowering and petiole colour were analysed using NTs software. Agglomerative hierarchical clustering was performed with these five characters. The dendrogram was then constructed for forty

collections.

There was significant variation in plant height (2.1 to 6.6 m), collar girth (30.00 to 88.16 cm) and number of leaves (12 to 30). The diversity was caused by the compatibility between several genera and species of the family which leads to the production of natural hybrids (Mekako and Nakasone, 1975; Kamalkumar et al., 2010; Singh et al., 2010). Such complex hybrid population is

Table 3. Biochemical characters of papaya collections

Collection No.	TSS (^o Brix)	Reducing sugar (%)	Total sugar (%)	Flesh thickness (cm)	Flesh colour
Coll. 1	14.00	9.82	11.04	2.50	Deep yellow to orange
Coll. 2	13.00	8.33	8.60	3.00	Bright yellow
Coll. 3	3.80	3.50	5.40	2.20	Bright yellow
Coll. 4	14.00	10.32	12.12	3.00	Bright yellow
Coll. 5	12.20	10.06	10.91	3.00	Bright yellow
Coll. 6	12.20	7.60	8.00	2.50	Bright yellow
Coll. 7	4.60	4.10	4.97	1.90	light yellow
Coll. 8	11.20	8.00	10.81	3.00	Bright yellow
Coll. 9	11.00	8.00	10.81	3.90	Deep yellow to orange
Coll.10	11.00	8.69	9.75	4.30	Bright yellow
Coll. 11	4.90	5.82	5.99	2.30	light yellow
Coll. 12	11.00	7.60	8.90	3.00	Bright yellow
Coll. 13	5.20	5.71	6.50	2.80	Bright yellow
Coll. 14	11.20	6.60	7.40	3.00	Bright yellow
Coll. 15	10.40	7.69	7.84	2.80	Bright yellow
Coll. 16	6.00	4.92	5.05	2.40	light yellow
Coll. 17	10.00	6.50	7.54	3.00	Deep yellow to orange
Coll. 18	6.00	5.09	6.42	2.20	Deep yellow to orange
Coll. 19	10.00	5.34	6.44	4.00	Scarlet
Coll. 20	10.80	5.12	7.54	2.60	Reddish orange
Coll. 21	5.80	4.24	5.30	2.50	light yellow
Coll. 22	10.40	6.66	6.95	2.80	Scarlet
Coll. 23	6.00	5.23	6.40	2.50	light yellow
Coll. 24	11.20	7.40	8.88	3.20	Deep yellow to orange
Coll. 25	10.00	7.69	8.00	2.00	Deep yellow to orange
Coll. 26	4.40	5.71	6.20	2.90	Bright yellow
Coll. 27	12.40	8.33	9.41	3.00	Reddish orange
Coll. 28	6.00	4.60	5.90	2.50	Deep yellow to orange
Coll. 29	7.00	5.40	5.90	2.70	Bright yellow
Coll. 30	13.00	9.30	9.80	2.00	Bright yellow
Coll. 31	6.00	4.70	5.40	2.00	light yellow
Coll. 32	10.00	7.69	7.84	3.20	Bright yellow
Coll. 33	9.40	7.40	7.69	3.00	Bright yellow
Coll. 34	5.00	3.80	4.50	2.40	light yellow
Coll. 35	9.80	6.76	7.86	2.80	Bright yellow
Coll. 36	11.80	7.23	7.98	2.80	Scarlet
Coll. 37	4.40	3.10	3.90	2.10	Bright yellow
Coll. 38	3.80	4.90	5.40	1.90	Bright yellow
Coll. 39	12.00	7.90	8.20	2.90	Bright yellow
Coll. 40	11.80	7.78	8.92	2.60	Bright yellow

the reason for morphological and genetic variability (Jana et al., 2010).

The leaf area varied from 940 to 6770 cm² and petiole length varied from 42 to 120 cm (Table 1). Singh and Kumar (2010) reported wide range of variability in papaya cultivars for plant height (138.4 to 240.6 cm), fruiting height (46.4 to 142.4 cm) and plant girth (28.02 to 36.8 cm). According to Singh et al. (2006) traits that varied significantly were plant

height (mean 2.09 m) and collar girth (mean 0.33 m) in papaya types. With respect to petiole colour, the plants showed variations. Five types of petiole colour viz., pale green, normal green, dark green, green and shades of red purple and purple red were observed in the collections.

The peak flowering season of these collections ranged from September to December. During the survey, it was interesting to notice that different sex



Coll . 4



Coll . 7



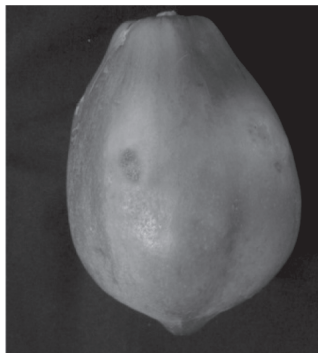
Coll . 11



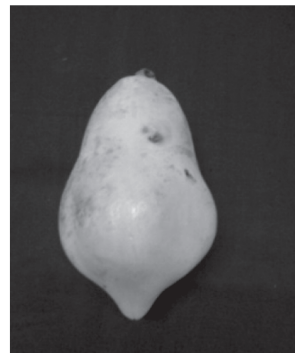
Coll . 18



Coll . 22



Coll . 23



Coll . 33



Coll . 40

forms including female, hermaphrodite, male and sex reversing male plants existed in papaya. Only female and hermaphrodite plants were selected for the study (Table 2).

Fruit weight and fruit volume of the collections varied from 440 to 3,130 g and 400 to 3,280 ml, respectively. It was also found that the fruit weight was positively correlated with fruit volume. Our results were similar to the findings of Singh and Kumar (2010) who reported that fruit weight of papaya plants ranged from 0.48 to 2.20 kg and length of the fruit ranged from 16 to 35 cm. Fruits showed wide variation with respect to shape also. Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong – ellipsoid and club shapes were observed during the survey (Plate 1). Circumference of fruit varied from 15 to 52 (cm).

Highest flesh thickness was recorded in Coll. 10

(4.3 cm) and the lowest in Coll. 7 (1.9 cm). Fruits showed variation in flesh colour, ranging from light yellow to scarlet. The variation in fruit diameter, flesh thickness, fruit length, number of fruits/ plant, fruit weight might be due to various physiological phenomena which take place in the plant body and genetic make-up of plant variety (Meena et al., 2006).

Wide variation was noticed among the collections in terms of total soluble solids (TSS). The TSS was found to vary from 3.80 °Brix to 14 °Brix. Coll. 4 recorded the highest reducing sugar (10.32%) and total sugar (12.12%) whereas the Coll. 37 recorded the lowest reducing sugar of 3.10 per cent and total sugar of 3.90 per cent (Table 3).

Hierarchical clustering depicted by dendrogram revealing the relationships among the forty collections is presented in Figure 1. The analysis separated the forty collections with Euclidian

Dendrogram using Average Linkage (Between Groups)

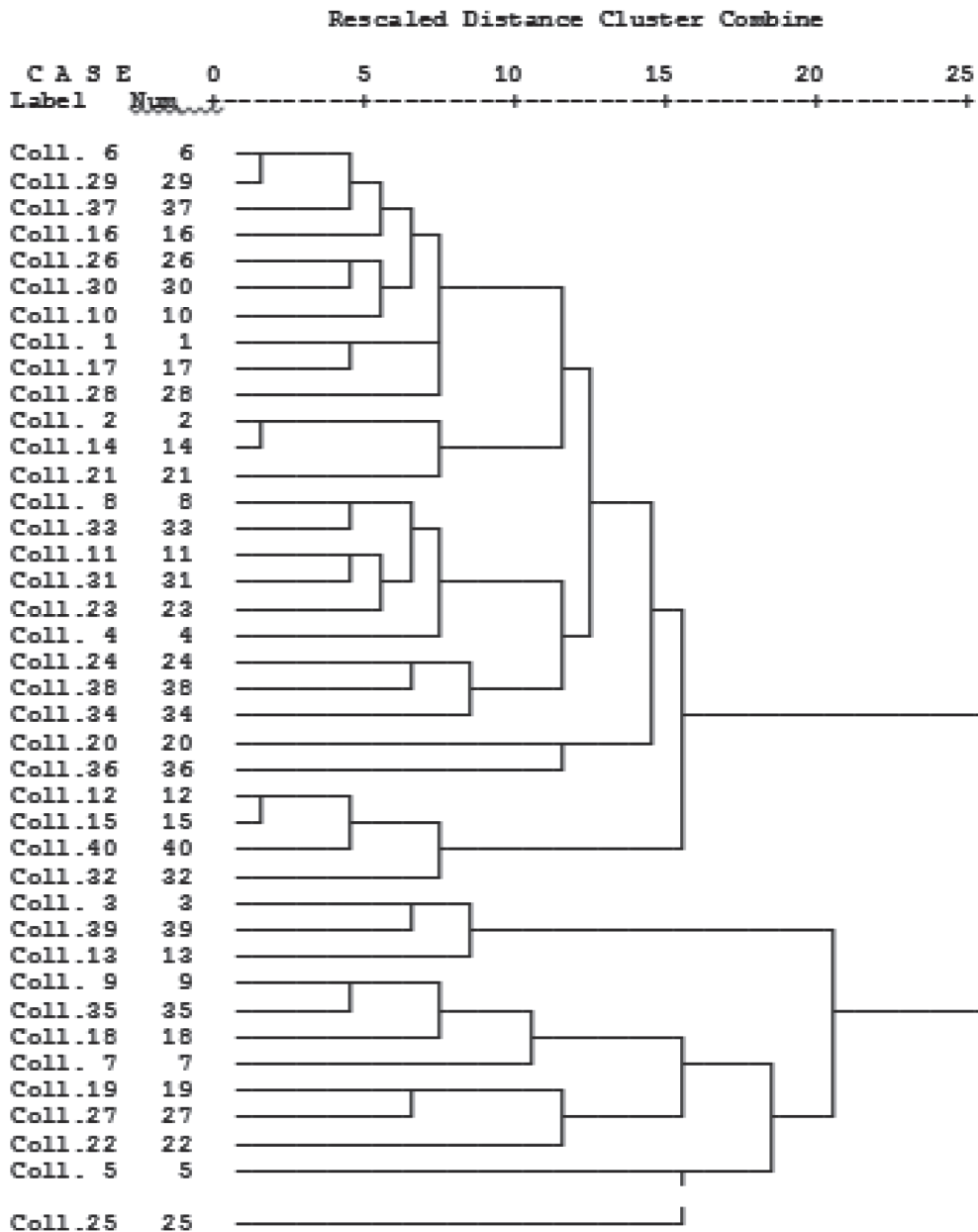


Figure 1. Hierarchical dendrogram showing relationship among forty collections of papaya

similarity distance. Nine clusters were obtained from the dendrogram within which cluster I had maximum number of 19 collections. Cluster IV and cluster VIII consisted of four collections. Cluster II

and cluster IX included three collections each. Cluster III consisted of two collections. Cluster VI and VII had one collection each.

Acknowledgement

The authors hereby acknowledge the financial assistance and research facilities extended by the Kerala Agricultural University.

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