Evaluation of yield and yield contributing characters of F2 population of papaya (*Carica Papaya* L) under Coimbatore, Tamil Nadu conditions

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ABSTRACT

Yield and yield contributing characters of segregating F2 population of papaya with eight cross combinations and six parents were studied under the agro-climatic conditions of Coimbatore district, Tamil Nadu. Plant biometric parameters, fruit physical attributes and yield characters of the population were evaluated by comparing the mean performance. The highest number of fruits (40.20) was recorded in CO 8 x CP 96 combination followed by CO 2 x Pusa Nanha (39.23). CO 2 x CP 111 had the maximum fruit weight (1.17 kg). The yield of the total F2 population had a range of 3.99-121.42 kg/tree. The correlation of yield with biometric parameters and the fruit physical attributes and path coefficient were also analysed. The potential selections from this population were chosen and forwarded to the next generation. The correlation of yield with biometric parameters and the fruit physical attributes and path coefficient were also analyzed.

Keywords: Papaya; F2 population; yield; correlation; path coefficient

INTRODUCTION

Papaya (*Carica papaya* L) is the single economically important species of the family Caricaceae and the sole member of the genus *Carica*. It has been extensively cultivated all over the tropical regions of the world for its delicious and nutritious fruits. Papain, the digestive enzyme present in the white latex of papaya has industrial and pharmaceutical applications (Sankat and Maharaj1997).

Papaya was introduced from tropical America and has become a major fruit crop in India. It is considered as a breeder-friendly crop well suited to improvement by conventional methods though it has high heterozygosity and complicated sex expression (Manshardt 2007). Since it is highly cross-pollinated its flowering and fruiting characters vary and as a result variation occurs in fruit size, fruit shape, quality, flavour and colour of the fruits.

Papaya is polygamous with three main sex types namely pistillate or female, staminate or male and hermaphrodite or bisexual (Storey 1941). The first one is stable and the other two are sexually ambivalent in nature. Since it is highly out-crossed its flowering and fruiting characters vary and as a result variation occurs in size, shape, quality, taste, flavour and colour of fruits. To create the desired variability, hybridization between selected parents is a useful tool and uniformity in the required characters can be attained by continuous sib-mating and selection. Yield is the most important economical trait and it is necessary to give more selection pressure on yield and its component characters. According to Borem and Miranda (2009) the success of the breeding methods that exploit the selfing of individuals is in the amount of genetic variability and uniformity of the trait. In case of papaya wide variability has been observed from F2 to F4 populations which maximizes the potential for selection in these generations (Karunakaran et al 2010, Oliveira et al 2012). The present study was conducted at Tamil

Nadu Agricultural University, Coimbatore, Tamil Nadu during 2011-2013 to evaluate the segregating F2 population of eight papaya cross-combinations along with their six parental varieties to determine the genetical basis for major yield attributes to select the desirable progenies based on yield.

MATERIAL and METHODS

Inter-varietal crosses between six parental varieties of papaya were made for the production of eight F1 hybrids. The best performed plants were self-pollinated to produce the F2 population. This F2 population of papaya with 72 plants in each of the eight cross-combinations viz CP 96 x CO 8, CP 96 x CO 7, CO 8 x CP 96, CO 2 x Pusa Nanha, CO 7 x Pusa Nanha, CO 2 x CP 111, CO 7 x CP 111 and CO 8 x CP 111 in non-replicated blocks were grown beside their six parents with four replications. All the plants were uniformly nurtured under the package of practices recommended by Tamil Nadu Agricultural University.

Observations were taken on the growth characters like first fruiting height (from the base of the plant to the first fruiting node), plant height at first harvest (from the base of the plant to the growing tip at the time of first harvest), stem girth at first harvest (from the base 15 cm above the soil surface), number of leaves at harvest (all the fully opened and physiologically active leaves at the time of harvest), days taken for first harvest (from the date of transplanting to the date of first harvest) and physical attributes of the fruits like fruit length taken from the stalk end to the base, fruit circumference taken from the middle region of the fruit and pulp thickness taken from the middle region of the longitudinally-cut fruit. For calculating cavity index, volume of the fruit was measured by water displacement immersing the whole fruit in known volume of water and the volume of the cavity was measured by scooping the seeds out and quantifying the amount of water in the cavity in milliliters. The ratio of the volume of the cavity to the volume of the fruit was worked out as cavity index and was expressed in per cent. Yield characters like number of fruits at the first harvest and the fruit weight were used to find out the yield per plant in each entry of the population. The mean, range, standard deviation, standard error and coefficient of variation were the statistical tools engaged to evaluate the population. Simple correlation coefficients were computed and path coefficient analysis was done for different characters to find out direct and indirect effects from the correlation coefficient as suggested by Dewey and Lu (1959). Residual effect 'R' was calculated using the formula:

$$R = 1 - \sum P_{iY} - r_{iY}$$

where i= Independent character, Y= Dependent character, r_{iY} = Correlation coefficient between 'i' and 'Y', P_{iY}= Direct effect between 'i' and 'Y'

RESULTS and DISCUSSION

Breeding for higher yield is the main objective of any crop improvement programme.Yield is the most important economical attribute and it is necessary to give more selection pressure on yield and its component characters. Papaya is a polygamous cross-pollinated plant. Hybridization and crop improvement efforts in it often encounter difficulties due to its complex sex expression and high degree of segregation with unfavorable attributes (Storey 1953). Papaya fruit yield is positively correlated with fruit weight and number of fruits per plant (Ram and Majumder 1984). Evaluation of the segregating population was done for growth characters, fruit physical attributes and the yield characters by comparing the mean of each cross combination. First fruiting height is an indication of the economic lifespan of the plant. Low first fruiting or bearing height enhances early and easy harvest of the fruits and extraction of latex. This trait showed wide variation among the hybrid population as reported earlier by Singh and Kumar (2010) and Jayachandran Nair et al (2010). The population mean for the first fruit height was 111.93 and 204.77 cm for plant height at first harvest. Among the cross combinations the CP 96 x CO 7 had the lowest first flowering height (83.51 cm) and plant height at first harvest (145.98 cm). Pusa Nanha had the lowest first fruiting height and plant height at first harvest (90.18 and 163.25 cm respectively) among the parents (Fig 1). The highest stem girth was recorded in CO 8 x CP 111 (37.76 cm) and CP 111 (33.43 cm) in cross-combinations and the parents respectively. Number of leaves was high (24.26) in CO 7 x Pusa Nanha among the cross-combinations and Pusa Nanha (29.72) among the parents. CO 2 x Pusa Nanha cross combination had the lowest number of days taken for harvest (330.04). The population had a range of 278.00-378.00 days for initial harvest.

Fruit physical characters were recorded from the average of five representative fruits from each plant

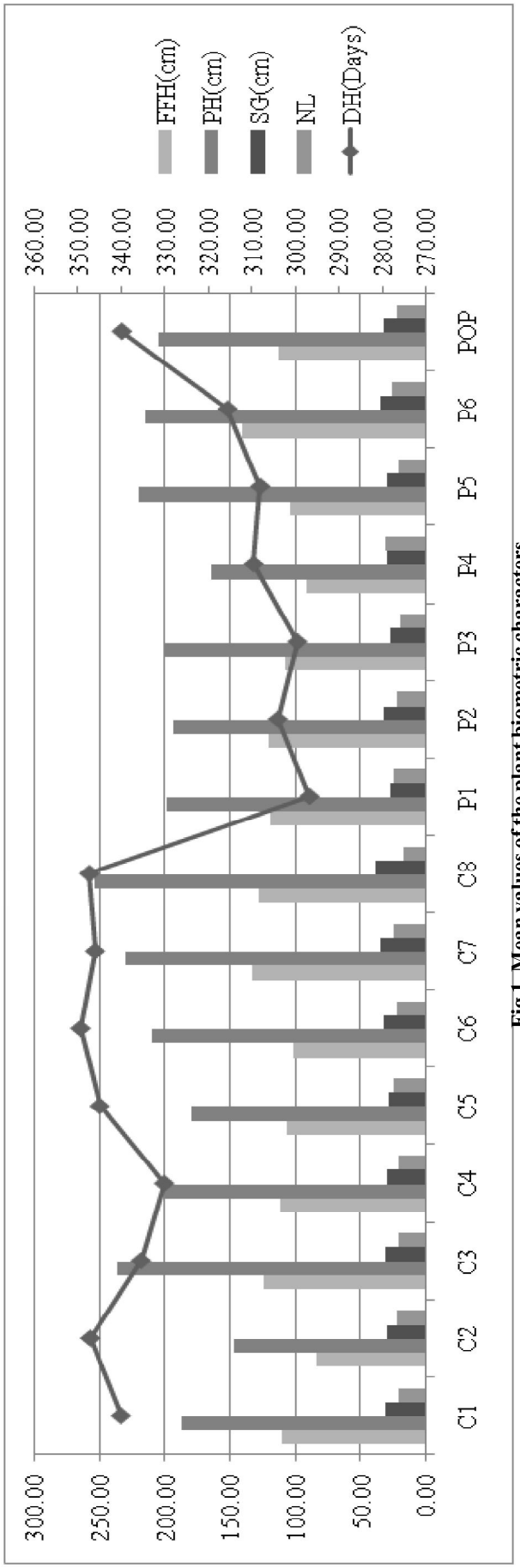

Fig 1. Mean values of the plant biometric characters

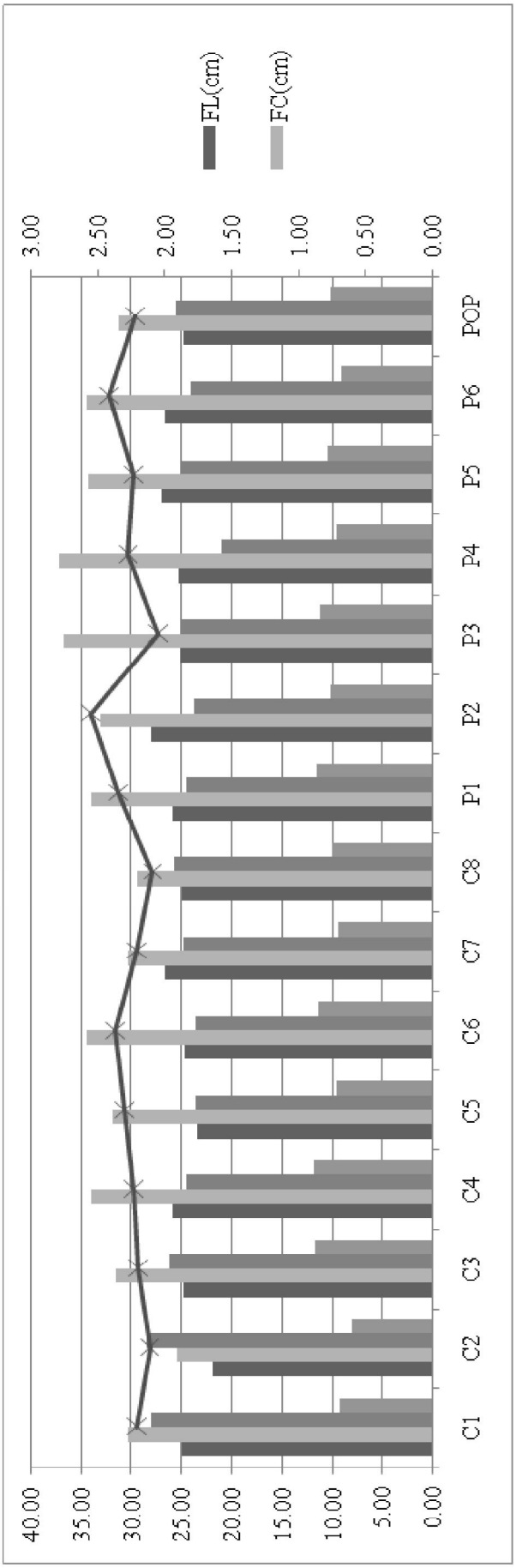

Fig 2. Mean values of the fruit physical attributes

of every cross-combination. The fruit length varied from 13.0 to 34.2 cm in the population. The longest fruits were observed in CO 7 x CP 111 (26.62 cm) in cross-combinations and CO 7 (27.98 cm) in parents (Fig 2). Fruit circumference was highest (34.40 cm) in CO 2 x Pusa Nanha. Among the parents Pusa Nanha had the broadest fruits (37.05 cm). Pulp thickness ranged from 1.10 to 3.30 cm in the population. CO 2 x CP 111 had the highest pulp thickness of 2.37 cm. A lower cavity index is always preferable for a good variety. Among the cross combinations CO 2 x Pusa Nanha had the lowest cavity index of 24.45 per cent and Pusa Nanha had the least cavity index among the parents (20.94%).

Number of fruits and fruit weight are the two factors which determine the yield of any fruit crop. In the present study the number of fruits of the population varied from 10.00 to 77.00. The highest number of fruits (40.20) was recorded in CO 8 x CP 96 combination followed by CO 2 x Pusa Nanha (39.23). Among the parents Pusa Nanha had the highest number of fruits (30.32). CO 2 x CP 111 had the maximum fruit weight (1.17 kg) while the population mean was 0.90 kg (Table 1). Fruit weight had a wide variation in the population ranging from 0.16 to 1.87 kg. Fruit yield per tree is the product of number of fruits and fruit weight. The yield of the population had a range of 3.99 to 121.42 kg. Among the cross combinations CO 2 x CP 111 had the highest yield (43.65 kg/tree) followed by CO 2 x Pusa Nanha (41.92 kg/tree) and among the parents CP 96 recorded the highest yield of 36.67 kg/tree.

Days to harvest were positively correlated to first fruiting height (0.117). It also registered significant negative correlation with number of fruits, fruit length, fruit circumference and mean fruit yield (Table 2). First fruiting height was significantly and positively associated with plant height (0.626), stem girth (0.294), fruit length (0.218) and fruit circumference (0.126). High positive correlation between plant height and stem girth, number of fruits, fruit length and fruit circumference was observed. Plant height was also significantly and positively correlated with the fruit yield (0.265).

Positive association of number of leaves and number of fruits with stem girth was observed in the study. Highly significant association of stem girth with mean fruit yield was also observed. Number of leaves registered highly significant and positive correlation with number of fruits and mean fruit yield (0.228). Number of fruits was correlated to mean fruit weight (0.139) and yield (0.133). Mean fruit weight registered highly significant and positive association with fruit yield (0.133) while fruit length and fruit circumference registered positive association with fruit weight as well as yield. It had a negative association with cavity index.

Fruit length was correlated positively to fruit circumference, pulp thickness and yield but had a significant negative association with cavity index (-0.149). Fruit circumference also had a negative association with cavity index as well as positive significant association with pulp thickness and fruit yield. Negative association of cavity index with both pulp thickness and mean fruit yield was revealed. Pulp thickness registered significant positive association with yield (0.115).

Thus the mean fruit yield in papaya was significantly and positively associated with plant height, stem girth, number of leaves, number of fruits, mean fruit weight, fruit length, fruit circumference as well as pulp thickness. Both days to harvest and cavity index registered significant and negative association with yield. The results are concomitant with the findings of Ram and Majumder (1984), Singh and Kumar (2010) and Davamani (2010).

The correlation coefficient of yield per tree with biometric and fruit physical attributes was partitioned into direct and indirect effects by path coefficient analysis (Table 3). The low residual effect (0.247) estimated indicated validity of inclusion of most of the selected characters in the path analysis.

Among the twelve yield components mean fruit weight and number of fruits at first harvest recorded highly positive direct effect on yield per tree. Number of days taken for harvest, stem girth, number of leaves, fruit length, fruit circumference and pulp thickness showed positive direct effect to fruit yield. The path coefficient analysis estimated that number of fruits and mean fruit weight had high direct effect on yield. Mean fruit weight had high correlation with fruit yield but path analysis revealed that its influence was through high indirect effect of number of fruits. The number of leaves had a direct positive effect on yield indirectly contributed via number of fruits and mean fruit weight. This was expected since leaves are major source for carbohydrate assimilates and serve to the developing fruits on the leaf axils. Pulp thickness also had a positive direct effect on yield contributed via indirect effects

Table 1. Number of fruits, mean fruit weight and yield per plant of the segregating F2 population of papaya

	Number of fruits					Mean fruit weight (kg)					Mean fruit yield (kg/tree)				
	Mean	Range	SD	SE	CV%	Mean	Range	SD	SE	CV%	Mean	Range	SD	SE	CV%
Crosses															
C1 (CP 96 x CO 8)	25.33	10.00-51.00	7.83	1.24	30.93	0.79	0.16-1.62	0.33	0.05	41.92	19.25	4.90-42.20	9.85	1.56	51.16
C2 (CP 96 x CO 7)	25.46	13.00-58.00	7.86	1.23	30.09	0.55	0.20-1.39	0.25	0.04	44.12	14.69	3.99-55.60	10.04	1.57	66.48
C3 (CO 8 x CP 96)	40.20	18.00-70.00	12.79	1.83	32.07	0.86	0.25-1.50	0.28	0.04	31.38	33.39	5.50-65.99	12.26	1.75	38.73
C4 (CO 2 x Pusa Nanha)	39.23	20.00-57.00	9.71	1.42	24.20	1.06	0.31-1.57	0.30	0.04	28.34	41.92	8.90-78.40	17.01	2.48	40.34
C5 (CO 7 x Pusa Nanha)	27.13	10.00-67.00	11.60	1.86	42.57	0.92	0.37-1.80	0.33	0.05	37.93	24.76	7.38-49.98	11.80	1.89	49.33
C6 (CO 2 x CP 111)	35.47	10.00-77.00	17.09	2.55	48.18	1.17	0.62-1.87	0.25	0.04	21.13	43.65	9.65-121.42	28.46	4.24	65.19
C7 (CO 7 x CP 111)	28.02	10.00-67.00	14.92	2.30	53.23	0.78	0.24-1.40	0.23	0.04	29.88	21.84	4.55-56.202	12.75	1.97	58.37
C8 (CO 8 x CP 111)	29.63	10.00-60.00	11.77	1.84	39.70	0.86	0.33-1.37	0.26	0.04	30.80	25.93	6.57-66.12	14.14	2.21	54.53
Parents															
P1 (CO 2)	27.06	25.00-30.00	2.60	1.30	9.61	1.32	1.30-1.34	0.02	0.01	1.46	35.62	31.85-40.87	3.85	1.92	10.81
P2 (CO 7)	25.86	21.00-30.00	3.92	1.96	15.15	1.23	1.18-1.29	0.05	0.02	3.82	31.88	25.65-37.50	4.91	2.45	15.39
P3 (CO 8)	25.57	24.00-26.00	0.98	0.49	3.84	1.31	1.30-1.32	0.01	0.00	0.73	35.32	34.13-36.90	1.17	0.59	3.32
P4 (Pusa Nanha)	30.32	28.00-33.00	1.87	0.94	6.18	0.85	0.82-0.86	0.02	0.01	2.22	34.82	25.20-39.50	6.52	3.26	18.72
P5 (CP 96)	29.25	27.00-31.00	1.71	0.85	5.84	1.25	1.19-1.30	0.04	0.02	3.49	36.67	32.26-39.20	3.03	1.52	8.28
P6 (CP 111)	25.74	25.00-26.00	0.80	0.40	3.09	0.87	0.85-0.86	0.02	0.01	1.81	22.33	21.60-23.10	0.65	0.33	2.93
Population	31.44	10.00-77.00	12.94	0.67	41.15	0.90	0.16-1.87	0.33	0.02	36.54	29.01	3.99-121.42	17.96	0.93	61.92

Table 2. Simple correlation coefficient of biometrical traits and fruit physical attributes with tree yield

	1	2	3	4	5	6	7	8	9	10	11	12
1	1											
2	0.117*	1.000										
3	0.017	0.626**	1.000									
4	0.040	0.294**	0.545**	1.000								
5	-0.041	0.074	0.107	0.179**	1.000							
6	-0.177**	0.070	0.306**	0.302**	0.139**	1.000						
7	-0.100	0.090	0.168**	0.044	0.044	0.172**	1.000					
8	-0.114*	0.218**	0.185**	0.109	0.006	0.002	0.256**	1.000				
9	-0.180**	0.126*	0.110*	0.060	0.033	0.191**	0.508**	0.423**	1.000			
10	0.006	-0.087	-0.067	-0.080	-0.041	-0.045	-0.268**	-0.149**	-0.300**	1.000		
11	0.055	0.090	0.015	-0.042	0.027	-0.046	0.258**	0.135*	0.297**	-0.379**	1.000	
12	-0.179**	0.038	0.265**	0.228**	0.133*	0.778**	0.697**	0.171**	0.444**	-0.206**	0.115*	1

*Significant at 5%, **Significant at 1%

1= Days to harvest, 2= First fruiting height, 3= Plant height, 4= Stem girth, 5= Number of leaves, 6= Number of fruits, 7= Mean fruit weight, 8= Fruit length, 9= Fruit circumference, 10= Cavity index, 11= Pulp thickness, 12= Mean fruit yield

Table 3. Path coefficient analysis for biometric traits and fruit physical attributes

	1	2	3	4	5	6	7	8	9	10	11	12
1	**0.0139**	-0.0080	-0.0003	0.0006	-0.0007	-0.1201*	-0.0565	-0.0035	-0.0039	-0.001	-0.0006	-0.179**
2	0.0016	**-0.0683**	-0.0104	0.0048	0.0012	0.0475	0.0515	0.0067	0.0027	0.0020	-0.0010	0.038
3	0.0002	-0.0427	**-0.0166**	0.0089	0.0018	0.2078**	0.0958	0.0057	0.0024	0.0015	-0.0002	0.265**
4	0.0006	-0.0201	-0.0090	**0.0164**	0.0030	0.2054**	0.0251	0.0034	0.0013	0.0018	0.0005	0.228**
5	-0.0006	-0.0051	-0.0018	0.0029	**0.0165**	0.0948	0.253**	0.0002	0.0007	0.0009	-0.0004	0.133*
6	-0.0025	-0.0048	-0.0051	0.0049	0.0023	**0.6801****	0.0974	0.0001	0.0041	0.0010	0.0004	0.778**
7	-0.0014	-0.0062	-0.0028	0.0007	0.0007	0.1168*	**0.5670****	0.0079	0.0110	0.0060	-0.0031	0.697**
8	-0.0016	-0.0149	-0.0031	0.0018	0.0001	0.0013	0.1453**	**0.0308**	0.0091	0.0033	-0.0016	0.171**
9	-0.0025	-0.0086	-0.0018	0.0010	0.0005	0.1291*	0.2882**	0.0130	**0.0216**	0.0067	-0.0035	0.444**
10	0.0007	0.0059	0.0011	-0.0013	-0.0007	-0.0300	-0.1518**	-0.0046	-0.0065	**-0.0225**	0.0044	-0.206**
11	0.0007	-0.0060	-0.0003	-0.0006	0.0005	-0.0260	0.1482**	-0.0042	0.0065	0.0086	**0.0117**	0.115*

Residual effect= 0.2476, Diagonal values in bold indicates direct effect, *Significant at 5%, **Significant at 1%
1= Days to harvest, 2= First fruiting height, 3= Plant height, 4= Stem girth, 5= Number of leaves, 6= Number of fruits, 7= Mean fruit weight, 8= Fruit length, 9= Fruit circumference, 10= Cavity index, 11= Pulp thickness, 12= Mean fruit yield

of mean fruit weight. The findings are in accordance with the results of Davamani (2010).

Single plant selections were made based primarily on the yield performance in the evaluated segregating populations under each cross combination. The potential selections made from the present evaluations have to be studied further in F3 generation for yield and quality.

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