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GENOTYPIC RESPONSE ON GROWTH AND YIELD IN PAPAYA

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ABSTRACT
The present investigation was undertaken to study the genetic variability of 9 genotypes of papaya along with Pusa Dwarf as a check for various horticultural characters. Fruit yield is the main trait commercially useful to the farmers. The number of fruits and fruit yield per plant were recorded significantly highest (36.38 and 33.81 kg/pl. and 84.52 t/ha, respectively) in genotype selection-4. Significantly highest fruit length and weight (25.02 cm and 1832 g) were noted in Selection-6, whereas, highest fruit girth (47.3 cm) was noted in Pusa Dwarf but was observed at par with Selection-4. While, the highest pulp weight (1327.93 g) and pulp seed ratio (1230.56) were noted in Selection-4, but highest pulp-peel ratio (5.74) was noted in Selection-8. In case of growth, bearing and plant height have also a great role to check the lodging of plants which were performed better (59.42 and 148.16 cm, respectively) in Pusa Dwarf but, highest stem girth (38.40 cm) in Selection-6 which were observed at par with Selection-4.

INTRODUCTION

A wide range of fruit biodiversity is available in the Saurashtra region of Gujarat. Among various fruit crops, papaya belongs to the genus Carica, which is monotypic and only includes the species *Carica papaya* L, which is the most important species from the family Caricaceae (Badillo, 2000). Papaya is one of the important fruit crops of the region due to higher remuneration as well as easy to cultivate with more production per unit area. It has a high nutritive and medicinal value especially vitamin A (2020 IU/l00g) (Azad, *et al*., 2012). It also possesses vitamin B, folate, and pantothenic acid besides minerals like potassium and magnesium (Popenoe, 1974). It is an excellent source of beta carotene which may prevent cancer, diabetes, and heart disease (Aravind *et al*., 2013) and it is also utilized in the pharmaceutical and cosmetic industries (Retuta *et al*., 2012). Papain is also the most important product prepared from the dried latex of its immature fruits used as raw materials of various industries.

In Saurashtra, the papaya cultivars most commonly grown are those of indigenous groups which is dioecious. Genotypes of these groups present fruits for good characters like size, shape and weight of fruit as well as pulp color of the fruit. However, no released varieties available for planting in the region may lead to greater vulnerability to diseases, pests, and edaphoclimatic variations, compromising the crop sustainability, due to the high genetic variability. It is vital to know about the intensity of genetic variation in commercially grown papaya genotypes to help growers selecting appropriate management practices, as well as providing information about papaya breeding. The estimation of genetic parameters (*i.e.* morpho-agronomic and fruit quality traits) in papaya genotypes, allows choosing suitable methods, e.g. simple breeding methods such as mass selection (Foltran *et al*.,1993). Also, the selection in the segregating populations may reveal great chances of success, due to the wide genotype variability and high heritability values (Silva *et al*., 2008).

The agro-climatic condition of the region is also coupled with papaya genotypes provided opportunity for the commercial cultivation . The yield and quality of local types grown by the farmers are good and competent with national varieties. Hence, the promising papaya genotype in the region is an option for increasing the production and productivity of papaya as there is nothing any public variety in the region as well as in the state.

Taiwan grouped varieties like Red Leady, 786, Sweet Charley, *etc*. are from private sectors under cultivation in the region. Some drawbacks in these varieties with the higher price of planting materials as well as susceptibility against the virus with poor fruit set were observed from the farmers' feedback. So that there is a need to identify season stable uniform papaya genotypes valuable for local as well as export markets that may prove highly remunerative to the papaya growers. Therefore, it felt essential to evaluated these genotypes along with commercial cultivar for selection of promising variety under the Saurashtra region. To study variability among fruit crops, plant growth, yield, and fruit quality are important traits (Aulakh, 2005 and Pandey *et al*., 2007). That means comparison of various physicochemical traits associated with the fruit quality of different papaya genotypes or cultivar is necessary for the identification of promising papaya cultivar. According to the above considerations, the present study aimed to investigate the performance of these genotypes along with commercial cultivar to fulfill the objective like to know the genotypic performance on growth, flowering, and fruit

yield in papaya under the Crop Improvement Project in the papaya at Department of Horticulture, College of Agriculture, JAU, Junagadh.

MATERIALS AND METHODS

The experiment was conducted at the Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh. Nine different genotypes and one cultivar Pusha Dwarf (check) were evaluated in Randomized Block Design (RBD) with three replications and data were analyzed. The seeds treated with carbendazim before sowing of different genotypes of papaya were sown in polythene bags to raise the seedlings under the control condition. The pits of 30 × 30 × 30 cm in dimensions were dug at the spacing of 1.8 × 1.8 meters each way. The seedlings having uniform growth of about 20 to 30 cm height were selected and three seedling were transplanted in each pit at the spacing of 15 cm apart in a triangular fashion. All plants were given uniform cultural operation as per the recommended package of practices. The soil of the experimental field was sandy loam to alluvial type. The selected plants were marked with a metal tag for recording observation. The observations on growth, flowering, and yield parameters were recorded. At the time of maturity, the fruits of different selections and cultivar were harvested at maturity indices with twisting the fruit keeping a small intact pedicel with each fruit. The various parameters were recorded. The chemical analysis for estimating reducing, non- reducing and total sugars was done by titrimetric methods of Lane and Eynon described by Ranganna (1979). The data were statistically analyzed by the method of analysis of variance using RBD as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Fruit yield and attributes

Fruit yield is the most important and polygenic character. Besides, better management of orchard, genetic diversity *i.e.* variety is another important factor influencing the yield. The present study showed significant variation among the various genotypes and cultivar with respects to yield and yield attributes. It is revealed from the table 1 that, the highest number of fruit per plant and fruit yield (36.38, 33.81 kg/pl. and 84.52 ton/ha, respectively) was recorded in Selection-4 during all three years as well as pooled, but was observed at par with Selection-6 and 8 during pooled. The variations in yield and yield attributes might be due to different genetic sources with respect to their genetic makeup. It might be also due to various physiological phenomenon, *viz*. photosynthetic efficiency, rate of translocation of photosynthates from source to sink and photo-respiration that took place in the plant body and different genetic constitution of varieties, which are responsible for expression of genetic characters under a particular set of environment. This is in conformity with the findings of Kumar *et al*. (2015), Tyagi *et al*. (2015), Varu (2019), Anh *et al*. (2011), Varu (2020) and Meena *et al*. (2012) in papaya; Deshmukh *et*

Table 1 : Evaluation of different selections and cultivar on number of fruits/pls. and fruit yield

Selections	No. of fruits/pls.				Fruit yield (kg/pls.)				Fruit yield (t/ha)			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Selection-1	31	30.8	27.67	29.82	26.2	24.09	16.18	22.16	65.51	60.22	40.45	55.39
Selection-2	32.33	31.87	30.33	31.51	29.04	21.51	17.49	22.68	72.6	53.78	43.73	56.7
Selection-3	33.33	30.97	29.55	31.28	21.27	15.36	20.27	18.97	53.17	38.4	50.68	47.42
Selection-4	38.33	37.03	33.77	36.38	37.08	34.39	29.96	33.81	92.69	85.97	74.89	84.52
Selection-5	29.33	29.53	27.92	28.93	31.13	18.85	21.06	23.68	77.83	47.13	52.66	59.21
Selection-6	30.67	33.2	33.67	32.51	30.39	23.36	25.7	26.49	75.98	58.41	64.25	66.21
Selection-7	22	20.67	24.55	22.41	16.77	18.8	22	19.19	41.92	46.99	54.99	47.97
Selection-8	37	32.27	28	32.42	31.39	26.99	23.26	27.21	78.48	67.48	58.14	68.03
Pusa Dwarf	35.4	33.13	26.17	31.56	27.9	20.02	15.84	21.25	69.75	50.04	39.59	53.13
S.Em.+	1.678	1.385	1.279	1.605	1.643	1.185	0.785	2.498	4.106	2.963	1.963	6.246
C. D. at 5%	5.03	4.15	3.84	4.81	4.92	3.55	2.35	7.49	12.31	8.88	5.88	18.73
YxT/S.Em.+	-	-	-	1.457	-	-	-	1.844	--	-	3.135	
C. D. at 5%	-	-	-	4.15	-	-	-	5.25	--	-	8.92	
C. V. %	9.04	7.72	7.62	8.21	10.19	9.08	6.38	9.08	10.19	9.08	6.38	9.08

Table 2 : Evaluation of different selections and cultivar on growth parameters

Selections	Plant height (cm)				Bearing height (cm)				No. of leaves per plant			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Selection-1	184	166	181.33	177.11	68.4	64.57	75.53	69.5	28.53	26.4	36.21	30.38
Selection-2	181.67	151.53	163	165.4	77.33	69.27	57.6	68.07	29.53	23.53	36.67	29.91
Selection-3	189	164.67	175.67	176.44	82.67	62.97	61.67	69.1	32	25.67	35	30.89
Selection-4	185	159.17	172.67	172.28	75.67	66.03	56.8	66.17	38.6	28.53	42.02	36.38
Selection-5	187.33	149.4	184.33	173.69	66.67	61.3	68.13	65.37	31.2	29.87	44.33	35.13
Selection-6	241.33	179.6	254	224.98	86.93	88	83.47	86.13	32.4	31.6	50.42	38.14
Selection-7	210.33	157.37	205.67	191.12	107.6	74.03	82.53	88.06	30.6	34.53	50.3	38.48
Selection-8	199	167.97	163.33	176.77	94.13	71.13	59.57	74.94	33.27	37.6	37.33	36.07
Pusa Dwarf	158	137.13	149.33	148.16	63.87	60.47	53.93	59.42	48.33	33.2	42.78	41.44
S.Em.+	8.312	6.505	8.056	9.15	2.216	2.325	2.921	5.708	1.541	1.642	2.266	3.026
C. D. at 5%	24.92	19.5	24.15	27.43	6.64	6.97	8.76	17.11	4.62	4.92	6.79	9.07
YxT/S.Em.+	-	-	-	7.617	-	-	-	1.844	-	-	-	1.844
C. D. at 5%	-	-	-	21.68	-	-	-	5.25	-	-	-	5.25
C. V. %	7.46	7.08	7.61	9.33	4.78	5.87	7.6	7.63	7.89	9.45	9.42	12.01

Table 3 : Evaluation of different selections and cultivar on growth parameters

Selections	No. of node per pl.				Length of inter node (cm)				Stem girth (cm)			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Selection-1	32	27.33	28.67	29.33	5.27	4.8	5.1	5.06	31.8	25.22	24.63	27.21
Selection-2	21.17	18.5	19.5	19.72	4.33	4.17	4.62	4.37	35.9	27.13	25.22	29.42
Selection-3	22.33	19.33	20.33	20.67	5.43	4.97	4.03	4.81	38	26.88	31.78	32.22
Selection-4	19.33	17.67	18.33	18.44	4.27	4.13	5.03	4.48	36.13	27.12	31.42	31.56
Selection-5	20.33	21.33	23.33	21.67	3.53	3.62	3.74	3.63	36.07	27.35	31.22	31.55
Selection-6	27.33	23.5	24.5	25.11	7.3	7.02	7.49	7.27	45.93	32.6	36.66	38.4
Selection-7	24	21.17	22.17	22.44	6.77	6.22	7.1	6.69	40.6	35.44	37.67	37.9
Selection-8	22.17	19.83	20.83	20.94	4.17	4.27	4.17	4.2	37.67	29.52	28	31.73
Pusa Dwarf	22.33	21.33	23	22.22	3.5	3.58	4.18	3.76	40.07	26.88	30.58	32.51
S.Em.+	0.931	0.978	1.152	0.592	0.167	0.177	0.101	0.215	1.611	1.538	1.373	2.313
C. D. at 5%	2.79	2.93	3.45	1.68	0.5	0.53	0.3	0.64	4.83	4.61	4.12	6.94
YxT/S.Em.+	-	-	-	1.025	-	-	-	0.152	-	-	-	1.51
C. D. at 5%	-	-	-	NS	-	-	-	0.433	-	-	-	NS
C. V. %	6.88	8.03	8.95	10.15	5.85	6.44	3.47	6.53	7.34	9.29	7.72	8.05

Table 4 : Evaluation of different selections and cultivar on fruit length, girth and weight

Selections	Fruit length (cm)				Fruit girth (cm)				Fruit weight (kg)			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Selection-1	26.27	19.98	23.83	23.36	43.17	32.73	39.33	38.41	1269.07	1126.53	1454.67	1283.42
Selection-2	20.6	19.53	14.7	18.28	47.2	45.71	47.93	46.95	1317.2	1060.6	1248.33	1208.71
Selection-3	24.27	18.88	16.79	19.98	44.8	38.83	44.17	42.6	1174.6	797.93	1455	1142.51
Selection-4	24.23	23.71	20.95	22.97	46.23	42.61	45.1	44.65	1810.4	1384.03	1744.33	1646.26
Selection-5	21.27	17.49	16.45	18.4	47.6	45.71	44.77	46.03	1297.7	916.53	1220.33	1144.86
Selection-6	28	24.61	22.45	25.02	45.93	45.17	46.12	45.74	1686.4	1444.8	1832	1654.4
Selection-7	23.07	21.22	20.6	21.63	37.13	39.2	44.57	40.3	1528.33	1325.87	1717.67	1523.96
Selection-8	23.5	20.3	19.49	21.1	45.6	43.73	43.37	44.23	1620.8	1369.13	1268.33	1419.42
Pusa Dwarf	18.67	20.15	18.82	19.21	44.73	46.2	50.96	47.3	1164	1045	1536.67	1248.56
S.Em.+	0.83	0.62	0.771	1.103	0.938	1.025	1.058	1.505	69.998	55.495	64.031	94.162
C. D. at 5%	2.49	1.86	2.39	3.31	2.81	3.07	3.17	4.51	209.86	166.38	191.97	282.31
YxT/S.Em.+	-	-	-	0.745	-	-	-	1.008	-	-	-	0.063
C. D. at 5%	-	-	-	2.12	-	-	-	2.87	-	-	-	0.18
C. V. %	6.16	5.2	6.9	6.12	3.63	4.2	4.06	3.97	8.48	8.26	7.41	8.06

Table 5 : Evaluation of different selections and cultivar on pulp, peel and seed weight

Selections	Pulp weight (g)				Peel weight (g)				Seed weight (g)			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Selection-1	938.83	831.07	1122.33	964.08	221.33	224	292	245.78	98.23	106	106.93	103.72
Selection-2	1056.67	799.93	951.67	936.09	148.27	189.67	160.37	166.1	100.07	88.05	96.38	94.83
Selection-3	917.2	552.87	1141.93	870.67	141.87	140.93	247.6	176.8	98.4	87.85	109.18	98.47
Selection-4	1448.47	1131.53	1403.8	1327.93	251.73	226.23	282.51	253.49	79.2	103.9	109.01	97.37
Selection-5	1104	666.67	1043.73	938.13	231.67	152.43	195.92	193.34	72.67	69.1	71.05	70.94
Selection-6	1392.87	1077	1492.74	1320.87	279.13	272.27	294.1	281.83	82.83	110.85	125.33	106.34
Selection-7	1160.67	979.6	1394.25	1178.17	158.67	275	308.13	247.27	49.53	60.51	80.83	63.63
Selection-8	1331.73	1074.6	1053.33	1153.22	203.2	191.83	215.25	203.43	82.27	72.44	79.04	77.92
Pusa Dwarf	861	804.33	1080.7	915.34	221.33	224	292	259.4	98.23	106	106.93	94.18
S.Em.+	39.904	33.021	46.502	79.918	8.515	10.987	14.823	24.543	1.601	2.957	3.343	6.923
C. D. at 5%	119.64	99	139.42	239.61	25.53	32.94	44.44	73.58	4.8	8.87	10.02	20.76
YxT/S.Em.+	-	-	-	40.188	-	-	-	6.981	3.36	5.86	5.83	6.72
C. D. at 5%	-	-	-	114.38	-	-	-	19.87	-	-	-	8.04
C. V. %	6.09	6.5	6.78	6.52	6.28	4.74	5.03	5.4	4.08	5.86	5.83	5.4

al. (2013) in guava; Chaudhry *et al*. (2014) in grapes; Thapa *et al*. (2012) and Lyngdoh *et al*. (2013) in Okra. The bearing height of the plant is good to shine for the economic value of the crop and the check variety Pusa Dwarf performed with the lowest bearing height but was also found at par with Selection-4.

Growth attributes

Variation in growth parameters like plant height and number of leaves per plant were found significant (Table 2) and the lowest plant height (148.16 cm) and a maximum number of leaves per plant (41.44) were recorded in Pusa Dwarf. However, it was on par with Selection-2, 4 and 5. The number of nodes per plant and the length of the internode is also important traits influencing the number of fruits per plant. Similarly, stem girth affecting the lodging of plants. The minimum number of nodes per plant (18.44), length of internode (3.63 cm), and highest stem girth (38.40 cm) were recorded in Selection-4, 5 and 6, respectively. Several workers

Table 6 : Evaluation of different selections and cultivar on pulp peel, pulp seed ratio and TSS

Selections	Pulp peel ratio				Pulp seed ratio			
	2013-14	2014-15	2015-16	Pooled	2013-14	2014-15	2015-16	Pooled
Selection-1	4.25	3.71	3.85	3.94	840.61	725.07	1015.4	860.36
Selection-2	6.45	4.21	4.96	5.21	956.6	711.89	855.28	841.26
Selection-3	5.18	3.67	6.01	4.96	818.8	465.02	1032.75	772.19
Selection-4	5.81	5.01	5.93	5.58	1369.27	1027.63	1294.79	1230.56
Selection-5	6.97	4.37	5.74	5.69	1031.33	597.57	972.68	867.19
Selection-6	5	3.96	5.08	4.68	1310.03	966.15	1367.41	1214.53
Selection-7	4.26	3.57	5.43	4.42	1111.13	919.09	1313.42	1114.55
Selection-8	6.57	5.75	4.9	5.74	1249.47	1002.16	974.29	1075.31
Pusa Dwarf	3.32	4.07	3.37	3.58	782.07	716.41	965.03	821.17
S.Em.+	0.265	0.226	0.237	0.402	39.834	33.543	45.371	77.066
C. D. at 5%	0.79	0.68	0.71	1.21	119.43	100.57	136.03	231.05
YxT/S.Em.+	-	-	-	0.243	-	-	-	39.876
C. D. at 5%	-	-	-	0.69	-	-	-	113.5
C. V. %	8.63	9.18	8.16	8.64	6.56	7.33	7.22	7.07

hitherto have compared varieties by Narasing *et al*.,1958; Nakasone *et al*., 1972; Selvaraj *et al*., 1975, Ito *et al*. 1977 and Varu (2019 and 2020) in papaya; Chaudhry *et al*. (2014) in grapes; Thapa *et al*. (2012) and Lyngdoh *et al*. (2013) in Okra.

Fruit attributes

Length, girth, and weight of fruits were the major components of fruit size under the present study (Table 4). The result was also found significant and the highest fruit length and weight (25.02 cm and 1832 g, respectively) were noted in Selection-6, but at par with Selection-4. Whereas, the highest fruit girth (47.30 cm) was noted in Pusa Dwarf and was observed at par with Selection-2and 4, 5, 6 and 8. The variation in fruit length, girth, and weight might be based on the fact that every genotype has its nature in the development of fruits. It also might be attributed to the genetic constitution of the plants. It may also be due to phenotypic and genotypic interactions among the selections. Similar findings were reported by Kumar *et al*. (2015); Das (2013), Das and Dinesh (2014), Chalak *et al*. (2016); Goenaga *et al*. (2001),Tyagi *et al*. (2015) and Varu (2019 and 2020) in papaya; Deshmukh *et al*. (2013) in guava and Chaudhry *et al*. (2014) in grapes; Thapa *et al*. (2012) and Lyngdoh *et al*. (2013) in Okra.

Likewise, the highest pulp weight (1327.93 g) and pulp seed ratio (1230.56) were noted in Selection-4 and observed at par with Selection-6,7 and 8. The lowest peel weight (166.10 g) and seed weight (63.63 g) were registered in Selection-2 and 7, respectively. However, the highest pulp-peel ratio (5.74) was noted in Selection-8 and which was found at par with Selection-4, 2, 5 and 6. Such variation among the selections in pulp, peel and seed characters may be attributed to the genetic makeup of the plants. Seed weight might be due to pollen availability, stigmatic fertility,and effective fertilization. Variations in those characters in papaya fruit were also observed by Nakasone *et al*., 1972; Selvaraj *et al*., 1975; Sulikeri *et al*., 1977; Pal *et al*., 1980; Allan, 1981 and Sundarrajan and Krishnan, 1984 in papaya.

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