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Genetic Analysis of Avocado (*Persea americana* L.) Genotypes for Fruit and Nutritive Traits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Avocado (*Persea americana* Mill.) or butter fruit is one the important nutritious sub tropical fruit native to Central America. Fruits are rich in nutrients, vitamins and phytochemicals. Fruit pulp is rich in fat and low in sugar content. Avocado exhibits wider variability due to protogyny nature of flower. However exploitation of this variability is very meager. The present study was conducted at Horticultural Research Station, Tamil Nadu Agricultural University, Thadiyankudisai to study and to find out suitable genotypes for further crop improvement programme. A field survey was conducted in Lower Pulney hills area and identified more than 100 genotypes and subjected to fruit characterization by using IPBGR descriptor. Sixteen genotypes were selected out of 100 genotypes based on the fruit characters and did nutritive analysis. Among the sixteen genotypes the avocado genotype TKDPA 93 recorded higher values for fruit length, fruit diameter, peduncle length, peduncle diameter and fruit weight. The genotype TKDPA 87 showed overall superior performance for nutritive traits viz. fat, dietary fibre, carbohydrate, carotene, vitamin C, calcium and phosphorus. The estimates of genetic parameters showed that the highest phenotypic variance was observed with the traits fruit weight, phosphorus content, fat content and peduncle length. Similarly the highest genotypic variance was observed with fruit weight, peduncle length and fat content. The maximum phenotypic co efficient of variance was noted with fruit weight, peduncle length, peduncle diameter, carotene content and pedicle length. The maximum genotypic co efficient of variance was noted with fruit weight, peduncle length, peduncle diameter, carotene content and pedicel length. GCV: PCV values were near unity for the traits fruit weight, peduncle length, peduncle diameter,

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carotene content, pedicel length and fruit diameter suggested that these traits are less influenced by the environment and can be used as a selection indices for avocado genetic improvement programme.

Keywords: Avocado; Persea americana; genetic analysis; PCV; GCV.

1. INTRODUCTION

Avocado (*Persea americana* Mill.) popularly known as butter fruit belongs to the family Lauraceae, is originated in Mexico, or possibly Central or South America [1] and cultivated in almost all tropical and subtropical regions worldwide. Avocado fruit is rich in lipids, proteins, minerals, vitamins, and other nutrients and phytochemicals (Dreher and Davenport [1] and Galvão et al. [2]). The avocado fruit has a wide range of nutrients and composition of photochemical which is important in a healthy diet. Avocados also are an important nutritional source of folate, which is essential during pregnancy for healthy foetal development. The fruit pulp rich in fat, dietry fibre, energy, minerals (phosphorus, sodium, potassium, calcium, and magnesium) and vitamins (vitamin C, vitamin E, carotene, etc.). The lipid content can comprise 15-30% of the fresh weight of the fruit depending on the cultivar, season, and growing conditions [3]. It is found is that the lipids in avodado fruit contain more than 60% monounsaturated fatty acids and more than 13% essential fatty acids such as oleic acid, palmitic acid, linoleic and linolenic acid, which are beneficial to human cardiovascular health [4,5,6 and 7]. In contrast to lipid content, the sugar content of avocado fruit is relatively low [8] and is recommended for diabetes because it is a high-energy food [9]. Avocado fruit contains more phenolic compounds than other kinds of tropical and subtropical fruits [10,11,9].

Avocado being a cross pollinated crop it exhibits wider variability. Though, the wider variability present in avocado, exploitation of variability is very meager. In Tamil Nadu particularly in lower Pulney hills (1000 m MSL) of Western Ghats avocados are grown as shade tree for coffee plantation. After realization of its importance the avocado cultivation in these areas geared up. However the avocado trees available in these areas are seedling progeny and it exhibits wide variability for different traits like fruit shape, size, peel colour, pulp colour and yield. There is a great scope for exploitation of these variations in avocado to develop a suitable variety with desirable traits. Evaluation of the potentialities of the existing cultivars is essential because it depicts the genetic diversity of the base materials on which depends the promise for further improvement. The success of a breeding programme for the improvement of quantitative attributes depends to a great extent on the magnitude of genetic variability existing in the germplasm. Burton [12] suggested that genetic variability along with heritability should be considered for assessing the maximum and accurate effect of selection. Studies on the variability using genetic parameters like genotypic coefficient of variation (GCV), heritability and genetic advance are essential for initiating an efficient breeding programme. High yield can be achieved by selection of those characters that have high heritability values coupled with high genetic advance. Selection is an indispensable component of the variety development process. Breeders search for dependable parameters that are less affected by the environment. With this aim the present study was conducted.

2. MATERIALS AND METHODS

The present study on Genetic Variability of Avocado (*Persea americana* L.) genotypes in Lower Pulneys for fruit and nutritive traits was conducted at Horticultural Research Station, Thadiyankudisai, Tamil Nadu, India during 2018-2020. Preliminary survey was conducted in lower Pulney hills area to identify suitable avocado genotypes for commercial cultivation. Fruits were collected from identified trees of different location of lower Pulney hills and considered as individual genotypes. Fruit characterization was done by using IBPGR descriptor. Totally 16 avocado genotypes were identified and fruit characterization was done for the traits *viz.*, fruit length (cm), fruit diameter (cm), peduncle length (cm), peduncle diameter (mm), pedicel length (cm) and fruit weight (g). Nutritive analysis for fat (g), dietry fibre (g), carbohydrate, carotene, vitamin C, calcium and phosphorus were done for individual genotypes. The experiment was laid out in a completely randomized block design with four replications. Biometrical observations on fruit length (cm), fruit diameter (cm), peduncle length (cm), peduncle diameter (mm), pedicel

length (cm) and fruit weight (g), fat (g), die try fiber (g), carbohydrate, carotene, vitamin C, calcium and phosphorus were taken from randomly selected 10 fruits and were subjected to statistical analysis. Determination of the crude fiber, and fat were carried out according to AOAC procedure [13]. Vitamin C content was determined using the modified. 2, 6-dichlorophenolindophenol method [14].

Total carotenoid content was measured spectrophotometrically at 445 nm using a Shimadzu UV-1800 spectrophotometer. The experiments were carried out in triplicate. Data were subjected to analysis of variance technique to split the total phenotypic variation into casual components. The components of variance were estimated using the method described by Singh and Narayanan [15]. The mean data obtained were used for determining genotypic co-efficient of variation and phenotype co-efficient of variation as suggested by Burton [12], heritability in broad sense was computed as reported by Hanson et al. [16], and the expected genetic advance was calculated by using the formula suggested by Johnson et al. [17].

3. RESULTS AND DISCUSSION

3.1 Fruit Characters

Analysis of variance for different fruit traits (Tables 1 & 2) of avocado revealed that the genotype mean sum of square was highly significant for all the traits indicated that presence of appreciable genetic variability and can be exploited through breeding programme.

Per se performance of avocado genotypes for fruit characters are presented in the Table 3. From the table it was observed that fruit length ranged from 11.10 cm to 18.30 cm. The highest fruit length value was registered by TKDPA 93 (18.30 cm) and it was followed by TKDPA 87 (17.10 cm) and TKDPA 85 (16.20 cm) and TKDPA (16.20 CM). Whereas the lowest fruit length value was registered by TKDPA 83 (11.10 cm). Fruit diameter ranged from 6.20 cm to 12.10 cm. Higher fruit diameter value was registered by TKD PA 93 (12.10 cm) and it was followed by TKDPA 92 and TKDPA 89 (10.80 cm) and TKDPA 87 (10.10 cm). Whereas lower fruit diameter value was registered by TKDPA 86 (6.20 cm). The trait peduncle length ranged from 6.89 cm to 18.40 cm. The highest peduncle length was recorded by TKD PA 93 (18.40 cm) and it was followed by TKDPA 92 (17.30 cm) and TKDPA 97 (14.70 cm). The lowest peduncle length was recorded by TKDPA 82 (6.89 cm). For the trait peduncle diameter the value ranged from 4.70 mm to 9.49 mm. Maximum peduncle diameters was observed by the genotype TKD PA 93 (9.49 mm) and it was followed by TKDPA 92 (9.29 mm) and TKDPA 91 (9.10 mm). While the, minimum peduncle diameter was observed by the genotype TKDPA 97 (4.70 mm). Pedicel length ranged from 0.90 cm to 1.90 cm. The maximum pedicel length was registered by TKDPA 95 (1.90 cm) and it was followed by TKDPA 88 and TKDPA 89 (1.80 cm) and TKDPA 87 (1.70 cm). While the, minimum pedicel length was registered by TKDPA 93 (0.90 cm). Fruit weight ranged from 250.03 g to 780.03 g. The highest fruit weight was observed by the genotype TKDPA 93 (780.03 g) and it was followed by TKDPA 89 (640.03 g) and TKDPA 87 (600.00 g). Whereas the, lowest fruit weight was observed by the genotype TKDPA 84 (250.03 g). From the results it was observed that the genotype TKDPA 93 an oblate fruit registered higher values for all the characters except pedicel length. TKDPA 87 a normally obovate fruit registered higher fruit length, fruit diameter, pedicel length and fruit weight. The genotype TKDPA 89 spheroid in fruit shape registered higher values for fruit diameter, pedicel length and fruit weight. These genotypes can be exploited to develop a new variety with good yield traits.

Table 1. Analysis of variance for fruit characters in avocado

Total	DF	Mean sum of square					
		Fruit length	Fruit diameter	Peduncle length	Peduncle diameter	Pedicel length	Fruit weight
Total	47	4.730	2.858	10.439	3.215	0.105	24984.596
Replication	2	2.980	0.877	1.723	0.584	0.029	1812.500
Genotype	15	11.560	7.758	10.439	9.279	0.295	74855.828
Error	30	1.432	0.555	1.021	0.358	0.015	1593.787

Table 2. Analysis of variance for nutritive characters in avocado

Total	DF	Mean sum of square						
		Fat	Fibre	Carbohydrate	Carotene	Vit.C	Calcium	Phosphorus
Total	47	11.529	0.458	0.024	3.478	0.507	4.683	19.620
Replication	2	7.865	0.572	0.047	1.378	1.257	10.053	59.203
Genotype	15	29.733	0.908	0.034	9.891	0.394	4.640	2.818
Error	30	2.672	0.225	0.018	0.412	0.514	4.319	25.382

Table 3. *Per se* performance of avocado genotypes for fruit characters

S. No.	Genotypes	Fruit shape	Fruit length (cm)	Fruit diameter (cm)	Peduncle length (cm)	Peduncle diameter (mm)	Pedicel length (cm)	Fruit weight (g)
1.	TKDPA80	Spheroid	12.70	8.25	6.89	5.20	1.20	310.00
2.	TKDPA81	Rhomboidal	11.70	7.16	9.10	5.09	1.00	308.00
3.	TKDPA82	Normally obovate	14.20	8.10	12.20	5.30	1.30	324.98
4.	TKDPA83	Normally obovate	11.10	6.80	9.60	5.20	1.10	302.00
5.	TKDPA84	Ellipsoid	14.30	8.20	7.40	5.10	1.20	250.03
6.	TKDPA85	Ellipsoid	16.20	8.40	14.20	6.70	1.50	500.00
7.	TKDPA86	Ellipsoid	13.09	6.20	11.20	7.00	1.59	380.00
8.	TKDPA87	Normally obovate	17.10	10.10	10.20	8.70	1.70	600.00
9.	TKDPA88	Spheroid	16.10	9.90	12.30	8.30	1.80	510.00
10.	TKDPA89	Spheroid	15.10	10.80	13.10	8.10	1.80	640.03
11.	TKDPA90	High Spheroid	15.10	10.10	10.40	8.20	1.69	284.97
12.	TKDPA91	Spheroid	13.10	8.40	10.60	9.10	1.60	290.00
13.	TKDPA92	Spheroid	14.70	10.80	17.30	9.29	1.60	580.03
14.	TKDPA93	Oblate	18.30	12.10	18.40	9.49	0.90	780.03
15.	TKDPA95	Oblate	13.59	8.60	12.40	8.20	1.90	445.00
16.	TKDPA97	Spheroid	16.20	9.70	14.70	4.70	1.20	550.00
	SED		0.976	0.608	0.825	0.428	0.1005	32.59
	CD (5%)		1.995	1.242	1.685	0.997	0.2053	66.57

Table 4. *Per se* performance of avocado genotypes for nutritive characters

S. No	Genotypes	Fat	Fibre	Carbohydrate	Carotene	Vit.C	Calcium	Phosphorus
1.	TKDPA82	21.32	6.49	1.53	10.27	8.85	26.21	62.89
2.	TKDPA81	16.28	5.24	1.74	8.58	8.34	27.32	61.26
3.	TKDPA82	18.27	5.12	1.64	7.64	9.05	26.42	61.67
4.	TKDPA83	18.27	5.24	1.51	6.78	8.32	24.89	61.47
5.	TKDPA84	20.41	6.16	1.46	8.23	8.56	26.53	60.26
6.	TKDPA85	22.64	5.89	1.68	9.57	8.93	26.78	62.35
7.	TKDPA86	23.42	6.31	1.74	8.72	9.12	24.67	61.31
8.	TKDPA87	24.64	5.47	1.68	10.56	9.16	26.45	62.96
9.	TKDPA88	19.32	5.47	1.47	7.23	8.65	24.56	62.34
10.	TKDPA89	17.26	5.38	1.53	5.22	8.42	24.56	61.19
11.	TKDPA90	18.25	6.16	1.64	6.43	9.04	22.95	61.72
12.	TKDPA91	24.19	6.53	1.75	10.12	9.18	26.18	60.29
13.	TKDPA92	13.62	5.69	1.63	6.15	8.79	26.25	62.72
14.	TKDPA93	16.43	6.58	1.48	5.26	8.18	24.37	60.41
15.	TKDPA95	16.89	4.98	1.72	5.43	8.12	23.76	60.12
16.	TKDPA97	19.78	5.28	1.72	6.78	8.94	24.89	62.43
	SED	**1.334**	**0.387**	**NS**	**0.523**	**NS**	**NS**	**NS**
	CD (5%)	**2.725**	**0.790**		**1.070**			

Table 5. Mean, range and estimates of genetic parameters of avocado genotypes

Characters	Mean	Range	GV	PV	GCV	PCV	GCV:PCV	H^2	GA in % of mean
Fruit length	14.537	11.10-18.30	3.376	4.808	12.639	15.083	0.838	70.20	21.82
Fruit diameter	8.977	6.20-12.10	2.401	2.956	17.261	19.152	0.901	81.20	32.05
Peduncle length	11.875	6.89-17.30	9.806	10.827	26.370	27.709	0.952	90.60	51.70
Peduncle diameter	7.106	5.10-9.49	2.974	3.332	24.268	25.687	0.945	89.30	47.23
Pedicel length	1.444	0.90-1.90	0.093	0.109	21.173	22.826	0.928	86.10	40.46
Fruit weight	440.942	250.0-780.0	24420.680	26014.467	35.440	36.579	0.969	93.90	70.74
Fat	14.437	13.62-24.64	9.020	11.693	15.452	17.592	0.878	77.20	27.96
Fibre	5.750	4.98-6.58	0.228	0.453	8.301	11.699	0.709	50.30	12.13
Carbohydrate	1.621	1.46-1.75	0.005	0.023	4.535	9.441	0.480	23.10	4.49
Carotene	7.685	5.22-10.56	3.160	3.572	23.129	24.590	0.941	88.50	44.82
Vitamin C	8.728	8.12-9.18	-0.040	0.474	2.286	7.887	0.289	-8.40	-1.36
Calcium	25.424	22.95-27.32	0.109	4.426	1.286	8.275	0.155	2.40	0.41
Phosphorus	61.586	60.12-62.96	-7.521	17.861	4.453	6.862	0.649	-42.10	-5.95

3.2 Nutritive Characters

Mean values of fruit nutritive traits are presented in the Table 4. the results showed that the trait fat content of the fruit pulp ranged from 13.62 g (per 100 g of fruit pulp) to 24.64 g (per 100 g of fruit pulp), The highest fat content was recorded by TKDPA 87 (24.64 g per 100 g of fruit pulp). It was followed by TKDPA 91 (24.19g per 100 g of fruit pulp) and TKDPA 86 (23.42g per 100 g of fruit pulp). Whereas the, lowest fat content was recorded by TKDPA 92 (13.62 per 100 g of fruit pulp). Dietry fibre content of the fruit ranged from 4.98 g to 6.58 g. The maximum dietary fibre content was recorded by TKDPA 93 (6.58g) and it was followed by TKDPA 91 (6.53g). While the lowest dietary fibre content was recorded by TKDPA 95 (4.98 g). Carotene content of fruit pulp ranged from 5.22 to 8.9. Higher carotene content of 10.56 was registered by TKDPA 87 and it was followed by TKDPA 82 (10.27). Whereas lower, carotene content value of 5.22 was registered by TKDPA 89. Vitamin C content of avocado genotypes ranged from 8.12 mg per 100 g pulp to 9.18 mg per 100 g of fruit pulp. The highest vitamin C content of 9.18 mg per 100 g pulp was recorded by TKDPA 91 and it was followed by TKDPA 87 (9.16 mg per 100 g of fruit pulp) and TKDPA 86 (9.12 mg per 100 g of fruit pulp). Whereas the, lowest vitamin C content of 8.12 mg per 100 g of fruit pulp was recorded by TKDPA 95. Calcium content of fruit pulp ranged from 27.32 mg to 27.32 mg. The genotype TKDPA 81 registered the maximum calcium content of 27.32 mg and it was followed by TKDPA 84 (26.53 mg) and TKDPA 87 (26.45 mg). The genotype TKDPA 90 registered the lowest calcium content of 22.95mg. The phosphorus content ranged from 60.12 mg to 62.96 mg. The highest phosphorus content of 62.96 mg was recorded by TKDPA 87 and it was followed by TKDPA 82 (62.89 mg) and TKDPA 92 (62.72). Meanwhile the, lowest phosphorus content of 60.12 mg was recorded by TKDPA 95.

3.3 Genetic Parameters

The estimates of genetic parameters are presented in the Table 5. It is evident that the phenotypic variance ranged from 0.023 to 26014.467. The highest phenotypic variance was observed with the traits fruit weight (26014.467), phosphorus content (17.861), fat content (11.693) and peduncle length (10.827). Similarly the highest genotypic variance was observed with fruit weight (24420.680), peduncle length (9.806) and fat content (9.020). Phenotypic co efficient of variance ranged from 6.862 to 36.579. the maximum phenotypic co efficient of variance was noted with fruit weight (36.579), peduncle length (27.709), peduncle diameter (25.687), carotene content (24.590) and pedicle length (22.826). Genotypic co efficient of variance ranged from 1.286 to 35.440. The maximum Genotypic co efficient of variance was noted with fruit weight (35.440), peduncle length (26.370), peduncle diameter (24.268), carotene content (23.129) and pedicel length (21.173). GCV and PCV ratio ranged from 0.155 to 0.969. The highest GCV: PCV values were noticed with fruit weight (0.969), peduncle length (0.952), peduncle diameter (0.945), carotene content (0.941), pedicel length (0.928) and fruit diameter (0.901). Higher PCV and GCV values registered by the traits fruit diameter, peduncle length, peduncle diameter, pedicel length, fruit weight and carotene indicating higher magnitude of variability for these characters. These findings are in line with the findings of Mohamed et al. [18]. Heritability values ranged from -8.40 per cent to 93.90 per cent. High heritable value was recorded by fruit weight (93.90%), peduncle length (90.60 %), peduncle diameter (89.30%), carotene (88.5%), pedicel length (86.10%), fruit diameter (81.20%), fat (77.20%) and fruit length (70.20%). Fibre content of fruit pulp recorded moderate heritable value of 50.30 per cent. Whereas low heritable values, were recorded by carbohydrate (23.10%), calcium (2.40%), vitamin C (-8.4%) and phosphorus (-42.10%). The estimates of heritability in broad sense for all the studied characters were high except carbohydrate, vitamin C, calcium and phosphorus. Nevertheless, the results seem to be encouraging for the breeders, however focus may be given to the characters coupled with high genetic advance. Genetic advance as per cent of mean ranged from -1.36 to 70.74. The maximum GA as percentage of mean was recorded by fruit weight (70.74%), peduncle length (51.50%), peduncle diameter (47.23%), carotene (44.82%), pedicel length (40.46%), fruit diameter (32.05%), fat (27.96%) and fruit length (21.82%). Meanwhile minimum GA as percentage of mean was recorded by fibre (12.13%), carbohydrate (4.49%), calcium (0.41%), phosphorus (-5.95%) and vitamin C (-1.36%). It was evident that the PCV values were higher than GCV values for all the characters of the present study. However the GCV:PCV values were near unity for the traits fruit weight (0.969), peduncle length (0.952), peduncle diameter (0.945), carotene content (0.941), pedicel length (0.928) and fruit diameter (0.901) suggested that these traits are less

influenced by the environment and can be used as a selection indices for avocado genetic improvement programme. Other traits viz., fruit length, fat, fibre, carbohydrate, vitamin C, calcium and phosphorus were showed high PCV values than GCV values indicated that these traits are highly influenced by environment. Traits whose expression was environmentally dependent may not be reliable descriptor for morphological characterization [19].

According to Johnson et al*.* [17] high heritability estimates along with high genotypic coefficient of variation and genetic advance is usually more useful in predicting the response of an individual for selection than heritability values alone. In the present study high heritability (broad sense) values coupled with high genetic advance as percent of mean was recorded by fruit diameter (81.20% & 32.05%), peduncle length (90.60 % & 51.70%), pedicel diameter (89.30% & 47.23%), pedicel length (86.10% & 40.46%), fruit weight (93.90% & 70.74%) and carotene (88.50% & 44.82%) indicating that these traits are controlled by additive gene action which is highly useful in selection. Similar results were noticed by Pujari et al*.* [20], Parvinder et al. [21], Aradhana et al. [22] and Singh et al*.* [23] and Shashikanth et al. [24] in tomato. The traits viz., fruit length (70.20% & 21.82%) and fat (77.20% & 27.96%) recorded high heritable values and moderate GA as percent of mean indicating that these traits are governed by dominant gene action and heterosis breeding may be useful in improvement of these traits.

4. CONCLUSION

From the results it was evident that the there is a great genetic variability present in the study materials. The traits viz., fruit diameter, peduncle length, peduncle diameter, pedicel length, fruit weight and carotene content can be used as a selection indices in avocado as these traits registered high heritable as well as high genetic advance as percent of mean. However, these study warrants an extensive survey, collection and evaluation of avocado genotypes available at Pulney hills, Dindigul district of Tamil Nadu state, India, since, there is a wide variability present in avocado and has to be commercially exploited.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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