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Studies on morphological characterization of 72 avocado (*Persea Americana* Mill.) accessions

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Abstract
The 72 avocado accessions were characterized for 25 qualitative morphological characters using IPGRI descriptors. The results depicted vast diversity among accessions for all morphological traits, of which, 2 characters had dimorphic and remaining 23 characters had polymorphic in nature. The highest number of accessions showed the presence of rough trunk surface (45.83%), oval leaf shape (47.22%), acute leaf base (84.72%) and acute leaf apex (72.22%). With respect to fruit traits, the majority of accessions confronted with obovate fruit shape (26.38%), depressed fruit base (48.61%), high uniformity in fruit size (73.61%), no ridges on fruit (59.72%). Peel traits revealed the dominance of light green fruit colour (37.50%) with smooth peel surface (51.38%). The Pearson correlation analysis showed that trunk surface had positive correlation with fruit size uniformity and leaf shape and negative correlation with fruit size uniformity (r=-0.249). The fruit shape had strong positive correlation with fibre in pulp (r=0.239), however, fruit apex shape showed positive correlation with fruit skin surface (r=0.302). The accessions depicting important horticultural traits *viz.* fruit size, shape, pulp quality, peel colour, peel thickness etc. may form the basis for future Avocado breeding programme.

Keywords: Avocado, leaf shape, peel colour, fruit traits

Introduction

Avocado, *Persea americana* (Mill.) is one of the most nutritious cultivated fruit crop with the history of more than 10,000 years (Galindo-Tovar *et al.*, 2007) [5]. The Avocado fruits are often referred as 'Alligator pear', 'Green Gold' and 'Butter fruit' owing its creamy texture, unique taste and immense nutritional values (Anonymous, 2021) [2]. It is originated in Tropical America, probably from more than one wild species (Dreher and Davenport, 2013) [4]. The genus *Persea* consists of 81 species and two sub-genus namely *Eriodaphne* and *Persea* and is thought to be native to Western Hemisphere from Mexico south to the Andean regions, except *Persea indica*, which is native to Canary Islands (Popenoe and Zentmyer, 1963) [12]. Presently, Avocados are commercially cultivated in more than 50 countries worldwide of which Mexico, Dominican Republic, Peru, Colombia, Indonesia, Kenya, Brazil, Haiti, Chile, and Israel are major Avocado producing countries (Anonymous, 2021) [2]. Mexico is the largest producer, while USA is the largest importer in the world. Over the last one decade, the global avocado production has increased by +85.2% with an average annual rate of +8.5% (Anonymous, 2020) [2].

Avocado is often considered as the most important contribution of the New World to human diet, owing to its high nutritive index. About 100 g of Avocado pulp consists of 73% water, 160 calories, 14.7% fat, 8.5% Carbohydrates, 2% protein, 0.66 g sugar, which includes glucose, fructose, sucrose and galactose and 6.7 g fibre (Anonymous, 2021) [2]. The considerable amount of fat in avocados helps to which prevents the risk of heart diseases (Méndez-Zúñiga *et al.*, 2019) [14]. Recent findings also revealed that the avocados are good for vision, prevents osteoporosis and also reduces the risk colon and stomach (Gunnars, 2021) [7]. In India, it was introduced from Sri Lanka in the early part of the 20th century and its cultivation is confined to Tamil Nadu, Kerala, and Karnataka in the south-central India and in the eastern Himalayan state of Sikkim (Gosh, 2000) [6]. In Kodagu, avocado is grown as one of the mixed crops in coffee-based cropping system. Almost each house is maintaining few plants of avocado and lots of variability of Avocado is existed in Coorg and adjoining areas (Tripathi *et al.*, 2014) [13]. Varietal improvement in Avocado has so far been limited to selection of regular bearing and high yielding genotypes with improved fruit quality. Major constraints faced by Avocado growers are non-availability of vegetative propagated, true to type planting materials in large numbers, long juvenile period and less productivity due to seedling origin. Further, there are only few released varieties for the commercial cultivation in our country which is having huge demand. Further, presently cultivated genotypes in India by growers are purely seedling origin and has adapted to a wide range of topography, habitats and climates, as a result, a vast diversity has existed in this germplasm. Therefore, keeping in above views, the present study was conceptualized to assess the genetic diversity of Avocado germplasm through morphological characterization.

Materials and Methods

Avocado improvement work was started at ICAR – IIHR-Central Horticultural Experiment Station, Chettalli during 2000 with an objective to identify high yielding type with regular in bearing type. Surveys were made in Southern tropical states like Tamil Nadu, Kerala and Karnataka (Kodagu) for the identification of high yielding accession with regularity in bearing, as irregularity in bearing is major hindrance in avocado cultivation. These collected accessions are being maintained at experimental farms of ICAR – IIHR – Central Horticultural Experiment Station, Chettalli with regular orchard management practices. A total adds of 72 accessions were characterized for morphological characterization. All the avocado accessions were characterized for tree, leaf, fruit and seed characters as per the descriptor developed for avocado by Bioversity International (IPGRI, 1995) [8].

The 72 avocado accessions were replicated thrice for morphological characterization. Frequency distribution for different morphological and biochemical characters were worked out in MS Excel and results were expressed in percentage. Correlations between the different biochemical traits were analysed using the Pearson correlation coefficients by SPSS 16.0 software.

Results and Discussion

Tree morphology

The trunk surface for 72 accessions were recorded and score was given as per the descriptor developed by IPGRI. Among the studied accessions, 33 accessions (45.83%) had rough trunk surface, 28 accessions (38.89%) had very rough trunk surface while 11 accessions (15.27%) had smooth trunk surface (Fig.1). The maximum number of accessions had oval leaf shape (47.22%) followed by lanceolate (23.61%), oblong lanceolate (20.83%), roundish (6.95%) and narrowly obovate (1.38%) and 61 accessions (84.72%) exhibited acute leaf base shape, while 11 accessions (15.26%) had obtuse leaf base shape. Further, the results also revealed that, 52 accessions (72.22%) represented acute leaf apex shape, 15 accessions (20.83%) had very acute leaf shape and 5 accessions (6.94) exhibited obtuse leaf apex shape. Similarly, Abraham *et al.* (2018) [1] classified the avocado accessions of Ghana based on trunk surface and reported that 64.2% of the accessions had rough trunk surface, similarly, Juma *et al.* (2020) [9] also reported that 38.9% of the accessions had very rough trunk surface and 36.9% rough surface in Tanzanian avocados. The dominance of acute leaf base shape and acute apex shape in avocado germplasm has also been reported by earlier workers in avocado accessions grown in other parts of the world (Nkansah *et al*., 2013; Abraham *et al*., 2018) [11, 1].

Fruit morphology

The variability for the different fruit shapes were studied among 72 accessions and score was given as per the descriptor developed by IPGRI. The higher number of accessions (19) had obovate fruit shape followed by narrowly obovate (13), clavate (12), rhomboidal (7) and it was minimum in spheroid fruit shape (4). With respect to frequency of occurrence, the obovate fruit shape had maximum occurrence of frequency (26.38%) followed by narrowly obovate (18.05%), clavate (16.67%), while lowest frequency of occurrence was noticed in spheroid fruit shape (5.56%) (Fig. 2). Among the accessions under study, 35 accessions had depressed fruit base shape with maximum frequency of occurrence (48.61%) compared with other accessions, 28 accessions had inflated fruit base shape with 38.89 percent frequency of occurrence. In the present study, 43 accessions (59.72%) had no ridges on the fruits, 28 accessions (38.89%) had partial ridges, while the accession, CHES-PA-II-6 (1.38%) had entire ridges on fruit. The maximum number of accessions (43) had asymmetric fruit apex position, while 29 accessions central fruit apex position. Further, among the 72 accessions, 37 accessions (51.38%) had strong gloss of fruit skin, while 32 accessions (44.45%) had medium gloss of fruit skin. Most of the accessions (51.38%) confronted with smooth fruit skin surface followed by intermediate (47.23%) and rough fruit skin surface (1.38%) (Fig. 3).

Among the studied accessions, 27 accessions exhibited light green skin surface with highest frequency of occurrence (37.50%) followed by green (23.61%), purple (22.21%), and dark green (5.54%). Further, no accessions had black and speckled fruit skin surface. In the present study, only the two pulp textures *viz*. buttery and pastose were observed in 72 accessions. Of which, 65 accessions (90.27%) had buttery pulp texture while 7 accessions (9.72%) (Fig. 4) had pastose pulp texture. The low bitterness was recorded in 39 accessions (54.16%), followed by intermediate bitterness in 33 accessions (45.83%), while none of accessions had high bitterness. The similar results were also observed by Juma *et al*., (2020) [9] while working in Tanzanian avocado accessions. Furthermore, Abraham *et al*. (2018) [1] also reported more than 70% of avocado germplasm exhibited the medium to strong glossiness of peel in Ghana.

Seed morphology

The 72 accessions were scored in to five groups based on seeds shapes *viz*. spheroid, ovate, broadly ovate, base flattened and apex rounded, and base flattened and apex conical (Fig. 5). Among the studied accessions, the fruits of 22 accessions (30.54%) had base flattened and apex rounded seed shape and 15 accessions (20.83%) depicted base flattened and apex conical seed shape. Among the 72 accessions, 44 accessions (61.12%) exhibited apical seed position in fruit followed by central seed position in 27 accessions (37.49%). The results revealed that the 41 accessions (56.93%) had seed not free, coat not attached to flesh followed by seed free, coat not attached to flesh in 23 accessions (31.94%). The maximum accessions (57) had intermediate cotyledon surface with higher frequency of occurrence (79.16%) followed by rough and smooth cotyledon surface in 9 and 6 accessions (12.49% and 8.34%)

respectively. Among the accessions under study, in 62 accessions (74.70%) exhibited the presence of seed shaking, while, in 21 accessions (25.30%) no shaking of seeds was observed. Similarly, Bergh, (1992) [3] observed that rough cotyledon surface is most common in West Indian types and smooth cotyledon surfaces are more common in Guatemalan and Mexican types. The above results are in agreement with Abraham *et al*. (2018) [1] and Juma *et al*. (2020) [9] as they reported five types of seed shapes were reported in Ghana accessions while 17 seed shapes in Tanzania accessions.

Correlation coefficients for morphological traits

To establish interrelationships among 72 accessions for 25 morphological qualitative traits, a correlation matrix was developed (Table 12). Significantly (p<0.05) strong correlation was observed for most of morphological traits. Trunk surface showed positive correlation with fruit size uniformity and leaf shape and negative correlation with fruit size uniformity (r=-0.249). The fruit shape had strong positive correlation with fibre in pulp (r=0.239), however, fruit apex shape showed positive correlation with fruit skin surface (r=0.302), indicating that fruit surface and fruit apex shape are inter correlated with each other. Further, the fruit apex position had strong positive correlation with pedicel position of fruit and seed position of fruit. The ridges on fruit was found to be positively correlated with bitterness of pulp, however, gloss of fruit skin was negatively correlated with bitterness of pulp.

Furthermore, the pedicel shape has shown negative correlation with fibres in pulp (r=-0238) and positive correlation with seed position of fruit. Similarly, the cotyledon surface had positive correlation with seed position of fruit. The correlation between useful traits could be important for early selection of plants having improved characters, or can be used for selecting more than one trait simultaneously. The indirect selections for less complex characters with high heritability and easy evaluation can save costs and enhance the rate of genetic progress of related complex traits compared to their direct selection (Silva *et al*., 2016) [15].

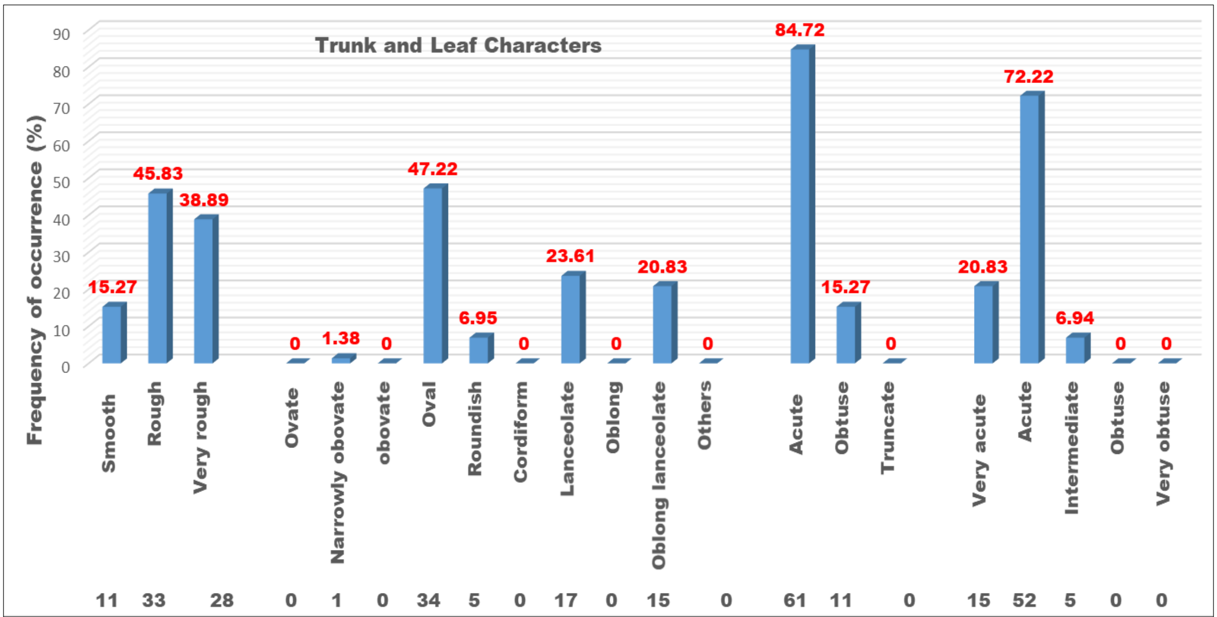

Fig 1: Frequency distribution of trunk and leaf characters in Avocado

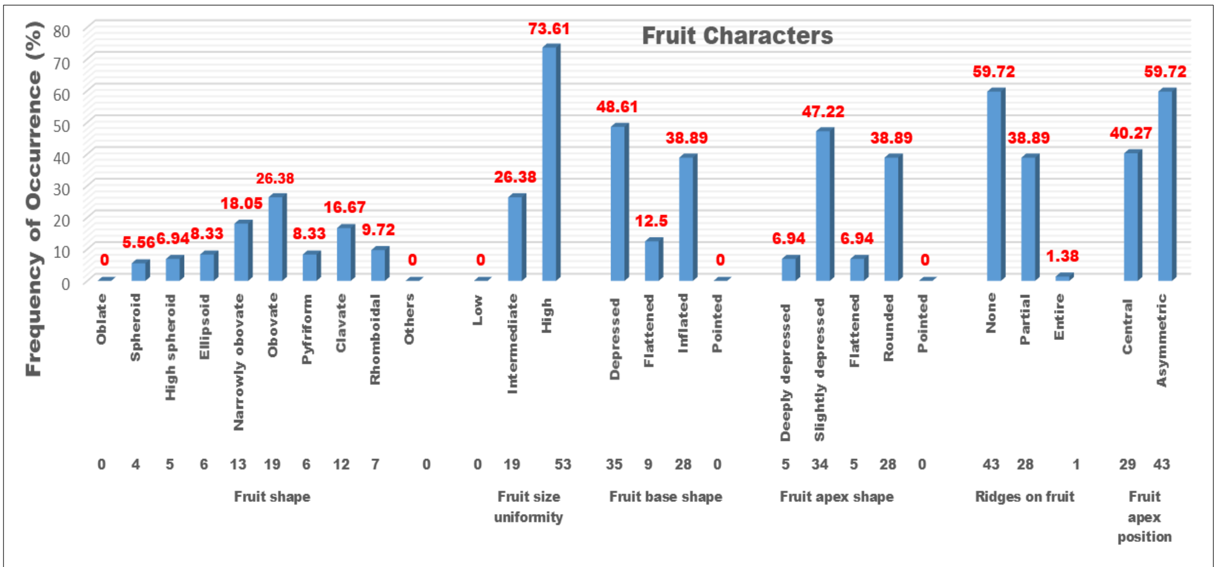

Fig 2: Frequency distribution for fruit characters in Avocado accessions

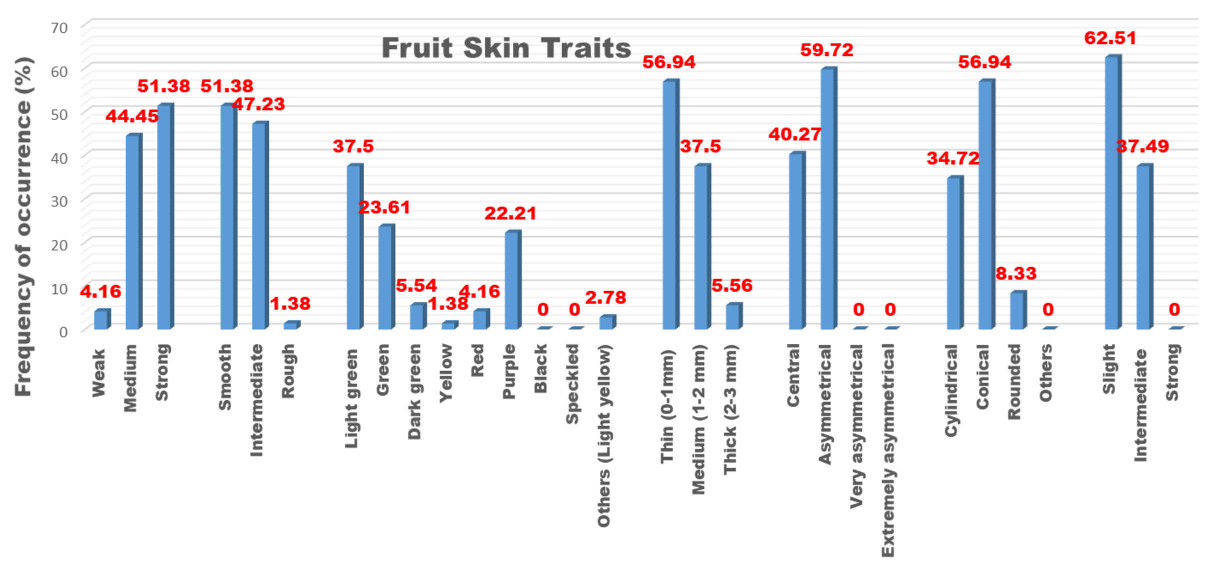

Fig 3: Frequency distribution for fruit skin characters in Avocado accessions

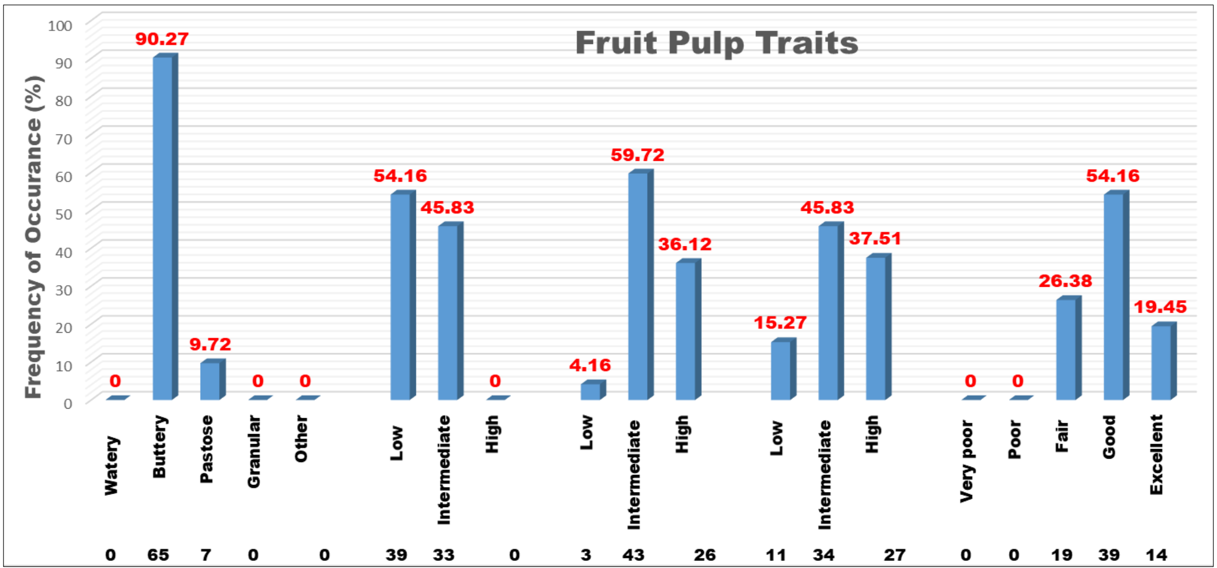

Fig 4: Frequency distribution for fruit pulp characters in Avocado accessions

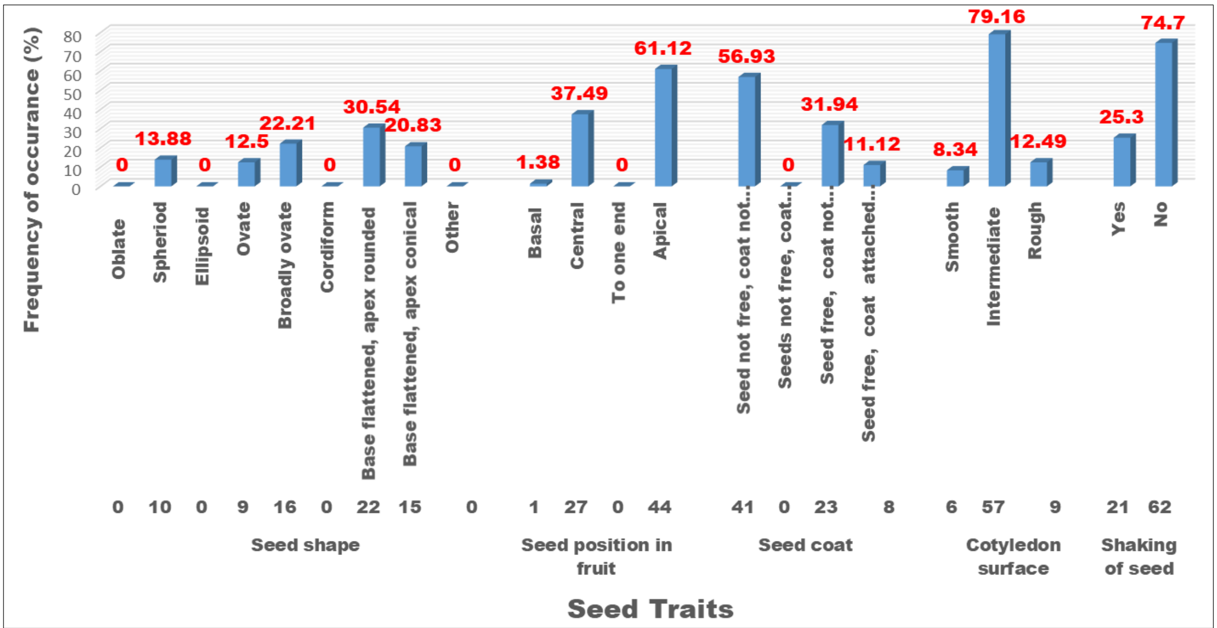

Fig 5: Frequency distribution for seed characters in Avocado accessions

Table 1: Correlation Coefficient for Qualitative Morphological characters

Variables	TS	LS	LAS	LBS	FS	FAS	FBS	FSU	FAP	RF	GFS	FSS	FSC	PS	PPF	APS	PT	PB	NTP	FP	GTP	SS	CS	SPF	SC
TS	1																								
LS	**0.336**	1																							
LAS	-0.129	0.032	1																						
LBS	-0.021	-0.089	0.035	1																					
FS	0.071	0.035	0.033	-0.123	1																				
FAS	0.061	0.153	0.012	-0.008	0.047	1																			
FBS	0.061	0.099	0.081	-0.061	0.049	-0.184	1																		
FSU	**-0.249**	-0.147	0.083	0.058	0.211	0.081	0.064	1																	
FAP	-0.081	-0.144	0.055	-0.058	0.185	-0.024	0.084	0.188	1																
RF	0.039	-0.072	-0.173	-0.009	0.046	-0.050	-0.066	0.037	-0.063	1															
GFS	0.129	0.002	-0.006	0.010	0.223	0.151	0.049	0.122	**0.312**	-0.074	1														
FSS	-0.019	-0.104	0.065	-0.076	0.123	**0.302**	-0.110	-0.030	0.106	0.020	-0.114	1													
FSC	**0.354**	0.215	-0.073	-0.062	0.059	0.055	-0.034	0.023	-0.012	0.173	0.160	-0.025	1												
PS	-0.054	-0.138	-0.063	-0.031	0.090	-0.027	-0.114	-0.037	0.065	0.109	0.103	-0.082	0.036	1											
PPF	-0.060	-0.122	0.023	-0.080	0.173	-0.069	0.087	0.095	**0.946**	-0.108	**0.265**	0.158	-0.026	0.000	1										
APS	-0.045	-0.003	-0.010	-0.072	-0.110	-0.031	0.026	-0.070	0.025	0.164	0.140	-0.071	-0.023	0.000	0.000	1									
PT	-0.207	0.052	**0.293**	0.063	0.139	-0.160	0.063	0.117	0.207	-0.080	0.175	-0.093	-0.026	-0.077	0.196	-0.088	1								
PB	-0.044	0.002	-0.006	0.149	-0.164	0.008	0.074	0.122	0.071	**0.336**	-0.042	0.068	0.069	0.141	0.024	0.140	0.005	1							
NTP	0.098	0.115	0.045	0.139	0.035	0.004	0.008	0.125	-0.046	-0.075	0.084	-0.076	0.055	-0.177	-0.133	0.012	0.068	-0.054	1						
FP	0.058	0.190	0.030	0.078	**0.239**	0.058	0.064	-0.022	-0.159	-0.039	0.216	-0.132	0.052	**-0.288**	-0.139	-0.223	0.137	-0.060	-0.022	1					
GTP	0.052	-0.068	-0.071	0.118	-0.039	0.165	-0.130	0.127	-0.009	-0.027	-0.104	-0.073	0.011	-0.121	-0.039	**-0.294**	-0.106	-0.205	-0.091	0.003	1				
SS	0.047	-0.176	0.103	-0.002	-0.075	-0.107	0.003	-0.071	-0.025	0.204	0.144	0.027	0.077	0.168	-0.014	0.032	0.090	0.057	-0.151	0.004	**-0.260**	1			
CS	-0.062	0.036	-0.132	-0.024	-0.104	0.011	-0.213	-0.032	0.003	-0.001	-0.101	0.056	-0.126	-0.115	0.000	0.132	-0.012	0.001	-0.149	-0.107	0.050	0.057	1		
SPF	-0.150	0.012	-0.120	-0.003	-0.118	-0.046	0.012	-0.033	**0.304**	0.071	0.041	0.119	**-0.253**	-0.092	**0.236**	**0.280**	0.057	0.113	0.112	0.051	-0.006	-0.016	**0.313**	1	
SC	-0.128	-0.188	-0.224	-0.073	-0.044	-0.130	-0.126	-0.024	-0.068	0.107	-0.075	0.099	0.066	-0.071	-0.052	0.129	0.103	0.084	0.001	0.109	0.047	0.016	-0.011	0.230	1

Values in bold are different from 0 with a significance level alpha=0.05

TS-Trunk surface, LS-Leaf shape, LAS-Leaf apex shape, LBS-Leaf base shape, FS-Fruit shape, FAS-Fruit apex shape, FBS-Fruit base shape, FSU-Fruit size uniformity, FAP-Fruit apex position, RF-Ridges on fruit, GFS-Gloss of fruit skin, FSS-Fruit skin surface, FSC-Fruit skin colour, PS-Pedicel shape, PPF-Pedicel position of fruit, APS-Adherence of pulp to skin, PT-Pulp texture, PB- Pulp bitterness, NTP-Nut taste of pulp, FP-Fibres in pulp, GTP-General taste of pulp, SS-Seed shape, CS-Cotyledon surface, SPF-Seed position of fruit, SC-seed coat

Fig 6: Genetic diversity in avocado for different morphological traits

Conclusion

The 72 avocado accessions were characterized for 25 qualitative morphological characters using IPGRI descriptors. The results depicted vast diversity among accessions for all morphological traits, of which, 2 characters had dimorphic and remaining 23 characters had polymorphic in nature. The results of present study revealed that wide of genetic diversity existed in the Indian avocadoes, which could be probably due to the higher heterozygosity among accessions and seed propagation. Further, the results also confronted that the accessions under study had the characters of all three botanical races of avocado *viz.* West Indian, Mexican, Guatemalan races and admixtures. Furthermore, Further, the quantum of genetic variability among accessions of avocado evaluated through morphological characterization may form the basis for future Avocado breeding programme.

References

1. Abraham JD, Abraham J, Takrama JF. Morphological characteristics of avocado (*Persea americana* Mill.) in Ghana. Afr. J Plant Sci. 2018;12(4):88-97.
2. Anonymous. Green gold: Avocado farming on the rise in Africa. Available online: https://www.dw.com/en/green-gold-avocado-farming-on-the-rise-in-africa/a 57390367, 2021.
3. Bergh B. The origin, nature, and genetic improvement of the avocado. Calif. Avocado Soc. Year book. 1992;76:61-75.
4. Dreher ML, Davenport AJ. Hass avocado composition and potential health effects. Crit. Rev. Food Sci. Nutr. 2013;53:738-750.
5. Galindo-Tovar ME, Milagro-Pa PA, Alejandre-Rosas JA, Leyva-Ovalle OR, Landero-Torres I, Lee-Espinosa HE,

et al. Genetic relationships within avocado (*Persea americana* Mill.) in seven municipalities of Central Veracruz, using microsatellite markers. Trop. Subtrop. Agroecosyst. 2011;13(3):339-346.

6. Ghosh SP. Avocado Production in India, In: Avocado production in Asia and the Pacific, FAO Corporate Document Repository; c2000.
7. Gunnars K. 12 Proven Health Benefits of Avocado; c2021. Available online: https://www.healthline.com/nutrition/12-provenbenefits-of-avocado #TOC_TITLE_HDR_2, 2021.
8. IPGRI. Descriptors for Avocado (*Persea* spp.); International Plant Genetic Resources Institute: Rome, Italy; c1995. p. 52.
9. Juma I, Nyomora A, Hovmalm HP, Fatih, M Geleta M, Carlsson AS, *et al*. Characterization of Tanzanian avocado using morphological traits. Diversity. 12(2):64.
10. Mendez-Zuniga SM, Corrales-Garcia JE, Gutierrez-Grijalva EP, Garcia-Mateos R, Perez-Rubio V, Heredia JB. Fatty acid profile, total carotenoids, and free radical-scavenging from the lipophilic fractions of 12 native Mexican Avocado accessions. Plant Foods for Hum. Nutr. 2020;74(4):501-507.
11. Nkansah GO, Ofosu-Budu KG, Ayarna AW. Genetic diversity among local and introduced avocado germplasm based on Morpho-agronomic traits. Int. J Plant Breed. Genet. 2013;7:76-91.
12. Popenoe W, Zentmyer GA. Early history of the avocado. Calif. Avocado Soc. Yearbook. 1963;47:19-24.
13. Tripathi PC, Karunakaran G, Sakthivel T, Sankar V, Senthil Kumar R. Avocado cultivation in India. Technical Bulletin. 2/2014.
14. Méndez-Zúñiga SM, Corrales-García JE, Gutiérrez-Grijalva EP, García-Mateos R, Pérez-Rubio V, Heredia JB. Fatty acid profile, total carotenoids, and free radical-scavenging from the lipophilic fractions of 12 native Mexican avocado accessions. Plant Foods for Human Nutrition. 2019 Dec;74:501-507.
15. Silva BA, Gross CT, Gräff J. The neural circuits of innate fear: detection, integration, action, and memorization. Learning & memory. 2016 Oct 1;23(10):544-555.