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Estimates of genetic variability, heritability, genetic advance, correlation coefficients and their prospects for crop improvement in guava (*Psidium guajava* L.)

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Abstract

The study was conducted to assess the genetic variability, heritability, genetic advance and correlation coefficient among 35 guava (*Psidium guajava* L.) genotypes, evaluated for tree, vegetative, reproductive, fruit and seed characters during 2010 to 2013. Wide range of phenotypic variability in the studied material was observed as phenotypic coefficients of variation for different traits ranged from 8.17 for fruit width to 35.00 for number of seeds per fruit. Genotypic coefficient of variation for all the characters ranged from 6.95 to 33.11 percent. Heritability ranged from 73.97 to 99.77 percent. Very high heritability estimates were obtained for fruit length to width ratio. The genetic advance as per cent of mean was highest for number of seeds per fruit (64.52 %). Characters like seed weight per 100 g fruit, seed weight per fruit, 100-seed weight, thickness of outer flesh and fruit weight had high heritability and higher genetic advance, which indicate that the expression of these characters is governed by additive gene action. Genotypic correlation coefficients, in general, were higher in magnitude than the corresponding phenotypic correlation coefficients indicating an inherent association among various characters under study. Presence of genetic variability along with high heritability and genetic advance indicate that these genotypes can be further utilized in guava breeding programme, keeping in mind the inherent association of various agronomical important traits to combine the desired traits into a single line/cultivar.

Key words: *Psidium guajava* L., genetic variability, heritability, genetic advance, correlation

Introduction

Psidium guajava L., commonly known as guava, is an important perennial fruit tree grown in tropical and sub-tropical regions of the world. Guava fruit contains high amounts of vitamins C (100-300 mg/ 100 g of pulp), A, B_1 (thiamin) and B_2 (riboflavin) and fair amount of minerals. Red-fleshed guava also contains β-carotene, lycopene and phenolic compounds along with high vitamin C, all with antioxidant activities. Due to these facts, as well as the low cultivation costs, the guava crop is economically important in various tropical and sub-tropical countries (Rodriguez *et al.,* 2010a). In India, at present, it is grown throughout the length and breadth of the country right from sea level to 1300 m altitude, and is so acclimatized that though guava is an introduced crop in India, so much genetic diversity is available that it seems like a native of India. It ranks 5th in area (205 thousand hectares) after mango, citrus, banana and apple comprising nearly about 3.2 per cent of area under the fruit crops in the country. As of now, there are about 160 cultivars available in India, among which Allahabad Safeda, Sardar, Nagpur Seedless, Banarsi, Chittidar, Hafsi, Behat Coconut, Red Fleshed, Arka Amulya, Arka Mridula, Kamsari, Dharwar etc. varieties are mainly cultivated. Crop improvement work attempted in India has resulted in release of several superior selections or hybrids. Despite these advantages and its high nutritive value, guava is facing several agronomic and horticultural problems such as susceptibility to many pathogens; particularly guava wilt caused by *Fusarium oxysporium psidii*, low fruit growth, short shelf life, high seed content and stress sensitivity (Rai *et al.*, 2010). A medium tall tree with coloured fruit having good keeping quality and low seed content and tree having resistance to guava wilt disease is the need of the day **(**Chandra *et al.*, 2007**)**. High heterozygosity and frequent cross pollination resulted in the present day variability in seedling populations from which promising genotypes have been selected (Dinesh and Vasugi, 2010a). Genetic variability studies based on metrical characteristics of leaf and fruit may indicate genetically divergent genotypes with suitable traits for crop improvement (Nogueira *et al.,* 2012). The basic information which a plant breeder usually needs for improvement in a particular crop species is the nature and magnitude of genetic variation present in the available germplasm, extent to which the desirable characters are heritable and association and co-heritability of important traits. Keeping in view, the present investigation was aimed to assess 35 genotypes of guava for genetic variability, heritability, genetic advance and correlation for different vegetative, reproductive, fruit and seed characters so that the guava germplasm available at Punjab Agricultural University can be utilized in guava breeding programmes in an efficient way.

Materials and methods

The experiment was carried out during the years 2010 to 2013 on the non juvenile trees grown and maintained in the New Orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana and Regional Fruit Research Station, Bahadurgarh, Patiala, Punjab. Observations on 35 genotypes (Table 1) for morphological characters and fruit physio-chemical characters on basis of UPOV descriptors (Rodriguez *et al.,* 2010b) were made and the data generated was further

analyzed for various genetic divergence components and correlation studies as given forth.

Genotypic and phenotypic coefficients of variation: The genotypic and phenotypic coefficients of variation, heritability in broad sense and expected genetic advance were calculated as suggested by Burton and Devane (1953) and Johnson *et al.* (1955).

Heritability [h^2 (bs)]: Heritability (per cent) in broad sense was calculated by formula given by Allard (1960).

Genetic advance (GA): Genetic Advance was calculated by formula used by Miller *et al.* (1958).

Table 1. Guava genotypes used for diversity analysis

Genotype	Pedigree/origin
Allahabad Safeda	Open pollinated seedling
Apple Colour	Seedling selection of Allahabad Safeda
Arka Amulya	Allahabad Safeda x Seedless (Triploid)
Banarsi Surkha	Seedling selection
B S 6-10	Selection at IIHR, Bangalore
B S 6-12	Selection at IIHR, Bangalore
B S 17-7	Selection at IIHR, Bangalore
CISH G-1	Half sib selection at CISH, Lucknow
CISH G-3 (Lalit)	Half sib selection at CISH, Lucknow
CISH G-4 (Shweta)	Half sib selection at CISH, Lucknow
Hisar Safeda	Allahabad Safeda x Seedless
Hisar Surkha	Apple Color x Banarsi Surkha
H-21	Red Fleshed x Arka Mridula
H S-1	Portugal x L-49= F_1 x Apple Colour
H S-2	Portugal x L-49= F_1 x Apple Colour
L-49 (Sardar guava)	Open-pollinated seedling selection from Allahabad Safeda
Malaysian guava	Purple guava
Pakistan guava	Thailand selection
Portugal	--
Punjab Pink	Portugal x L-49= F_1 x Apple Colour
Red Fleshed	Selection from local red fleshed
Safri	Commercial variety of Assam
One kg	Selection from Giant Thai
6-4	Portugal x L-49= F_1 x Apple Colour
7-8	Portugal x L-49= F_1 x Apple Colour
12-11	Portugal x L-49= F_1 x Apple Colour
14-10	L-49 x Portugal
14-12	L-49 x Portugal
16-11	L-49 x Portugal
17-3	L-49 x Portugal
17-8	L-49 x Portugal
17-16	L-49 x Portugal
19-3	L-49 x Portugal
21-6	Allahabad Safeda x Portugal
30-9	L-49 x Portugal

Correlation coefficient: Phenotypic and genotypic correlation coefficients were worked out by the formulae suggested by Al-Jibouri *et al*. (1958).

Results and discussion

The range of mean values based on phenotypic expression are rough estimates of the variation or magnitude of divergence present among different genotypes. A relative amount of variation in genotypes for different characters can be judged by comparing the coefficients of genotypic and phenotypic variation. The results pertaining to the phenotypic and genotypic coefficients of variation are presented in Table 2.

Phenotypic coefficient of variation (%): Data presented in Table 2 indicates wide range of phenotypic variability in the studied material. Phenotypic coefficients of variation for different traits expressed in percentage ranged from 7.26 to 35.00 per cent. The maximum expression of phenotypic coefficient of variation was for number of seeds per fruit (35.00 %), followed by vitamin C content (32.20 %), seed weight per 100g fruit (30.69 %), pedicel length (30.51 %), seed weight per fruit (29.07 %), fruit weight (28.21 %), petiole length (20.61 %), 100-seed weight (19.42 %), number of petals (18.24 %), thickness of the outer flesh in relation to core ratio (17.49 %) and diameter of calyx cavity (16.67 %). Phenotypic coefficient of variation was moderate for thickness of outer flesh (14.99 %), fruit length (14.36 %), young twig diameter (13.29 %), fruit length to width ratio (12.95 %), flower size (12.94 %), leaf length to width ratio (12.77 %), inter node length (12.75 %), total soluble solids (12.65 %), leaf length (11.55 %) and leaf width (11.02 %). Lower values for phenotypic coefficient of variation was observed for acidity (10.35 %), core diameter (9.06 %) and fruit width (8.17 %) with minimum expression of phenotypic coefficient of variation for fruit width index (8.17 %). While studying various seed related characters in relation to fruit weight, Rajan *et al.* (2005) found high PCV for pulp:seed weight ratio, number of seeds $fruit^{-1}$, 100-seed weight and number of seeds $100g^{-1}$ fruit. Similarly, Raghava and Tiwari (2008) observed high phenotypic coefficient of variance for number of seeds per fruit, 100-seed weight, fruit weight and fruit volume while lower values for phenotypic coefficient of variation were observed for fruit diameter, total soluble solids and total sugars. Dinesh and Vasugi (2010b) also reported phenotypic coefficient of variance to the tune of 20.93 % for fruit weight and moderate values were found for total soluble solids and seed hardness in guava. In another study conducted on some promising guava selections under Indo-Gangetic region of Uttar Pradesh, Bihari and Suryanarayan (2011) observed phenotypic covariance ranging from 12.20 percent for pollen grain size to 71.78 percent for fruit weight.

Genotypic coefficient of variation (%): The GCV helps in comparison and measurement of genetic variability among different characters. In the experimental material under study, the genotypic coefficient of variation for all the characters ranged from 6.95 to 33.11 % (Table 2). Maximum expression of genotypic coefficient of variation was observed for number of seeds per fruit (33.11 %), followed by seed weight per 100 g of fruit (30.25 %), seed weight per fruit (34.32 %), vitamin C content (31.07 %), fruit weight (28.15 %), pedicel length (26.24 %), petiole length (20.53 %) and 100-seed weight (19.38

%), whereas lower values for the parameter were recorded for sweetness (TSS) (9.45 %), core diameter (8.96 %), fruit width (8.03 %) and least for acidity (7.64 %). Raghava and Tiwari (2008) also observed high genotypic coefficient of variation for number of seeds per fruit (60.88 %), fruit weight (45.78 %) and 100-seed weight (45.59 %). Genotypic coefficient of variation was moderate for fruit length (27.64 %), fruit diameter (22.31 %) and sweetness (12.14 %).

The estimates of phenotypic coefficient of variation (PCV) were higher than the genotypic coefficient of variation (GCV) for pedicel length, total soluble solids, acidity and number of seeds per fruit indicating more influence of the environment in the expression of these traits. Rajan *et al.* (2005) also proposed variation in genotypes not only due to genetic makeup but also due to the environmental influence as they observed higher PCV as compared to GCV for some traits under study. However, there were narrow differences between phenotypic and genotypic coefficient of variation in all other characters, indicating low environmental influence in expression of these characters, which implies that phenotypic variability is a reliable measure of genotypic variability. So, selection for improvement of the trait is possible and effective on the phenotypic basis.

Heritability (%): Heritability is a measure of genetic relationship between parent and progeny and has been widely used in determining the degree to which a character may be transmitted from parents to off-springs (Raghava and Tiwari, 2008). Heritability in broad sense was estimated for all the traits. The results pertaining to heritability and per cent genetic advance are given in Table 2.

In the present study heritability expressed as percentage, ranged from 73.97 to 99.77 percent. Very high heritability estimates were obtained for fruit length to width ratio (99.77 %), leaf length to width ratio (99.73 %), 100-seed weight (99.59 %), vitamin C content (99.23 %), petiole length (99.15 %), seed weight per fruit (99.02 %) and fruit weight (98.86 %). Moderate heritability estimates were obtained for number of seeds per fruit (89.50 %), acidity (75.24 %), sweetness (74.63 %) and pedicel length (73.97 %) which is understandable as PCV was also higher in magnitude than GCV for these traits. The above findings are in close association with those of Raghava and Tiwari (2008) and Rajan *et al.* (2005) who also reported higher values for heritability ranging from 90.27 to 99.77 percent and 55.8 to 84.3 percent, respectively for various traits. Rajan *et al.* (2005) and Burton and Devane (1953) also suggested that characters having high heritability associated with high GCV provide greater scope for further selection. Dinesh and Vasugi (2010b) reported the heritability estimates in broad sense to be low for fruit weight, sweetness and seed hardiness. This implies that going in for hybridization by raising large number of progenies is feasible and practical for exploiting the heterosis. Bihari and Suryanarayan (2011) also reported highest heritability (99.00 %) associated with reducing sugar content, followed by pollen grain size (98.95 %) and lowest heritability (75.18 %) for size of flower. While studying genotypic and phenotypic variation among 50 guava accessions under subtropical conditions, Rajan *et al.* (2012) estimated high heritability ranging from 0.499 for fruit firmness to 0.988 for fruit seed weight ratio.

Genetic Advance: Improvement in the mean genotypic value of the selected families over base population is known as genetic advance. Genetic advance depends upon the heritability of the character under selection, genetic variability of the genotypes and intensity of selection. A high heritability coupled with high genetic advance gives effective criteria for selection.

In the present investigation, the genetic advance as per cent of mean was highest for number of seeds per fruit (64.52 %), followed by seed weight per 100 g fruit (61.43 %), vitamin C content (60.81 %), seed weight per fruit (59.29 %), fruit weight (57.51 %) and pedicel length (46.50 %) (Table 2). Moderate genetic advance estimates were obtained for petiole length (42.10 %), 100-seed weight (39.85 %), thickness of the outer flesh in relation to core ratio (35.15 %), number of petals (34.95 %), diameter of calyx cavity (31.65 %) and thickness of outer flesh (30.03 %). Least genetic advance was observed for fruit width (16.25 %) followed by core diameter (18.25 %). Raghava and Tiwari (2008) observed highest values of genetic advance as percent mean for number of seeds per fruit, fruit weight, fruit volume, 100-seed weight, fruit length, fruit diameter and moderate for rest of the traits indicating influence of environment on expression of these characters to a certain extent and rigid selection might bring about improvement in these characters. As found in present investigation, Rajan *et al.* (2012) also observed high genetic advance for fruit weight, seed number per fruit and fruit seed weight ratio.

From the present investigation, it is clear that characters like seed weight per 100 g fruit, seed weight per fruit, 100-seed weight, thickness of outer flesh and fruit weight have high heritability and higher genetic advance which indicate that the expression of these characters is governed by additive gene action. So these characters can be easily improved by selection methods. Higher heritability coupled with moderate genetic advance was expressed in fruit length to width ratio, fruit length, leaf length to width ratio. Similarly, Raghava and Tiwari (2008) reported D/L index with moderately high value of GCV and GA but high value of heritability revealing the relatively low influence of environment on this trait, suggesting that fairly rapid genetic gain could be expected for the fruit shape. Higher heritability estimates and low genetic advance were obtained for fruit width, core diameter, leaf width and leaf length which implied that this trait is most probably governed by non-additive gene action.

Correlation studies: The correlation studies between characters play an important role in determining the efficient breeding strategy. From genotypic and phenotypic correlation matrix of different characters under study, presented in Table 3 and 4, respectively, it is evident that genotypic correlation coefficients, in general, are higher in magnitude than the corresponding phenotypic correlation coefficients. This indicated that there is an inherent association among various characters under study, which is negatively influenced due to environmental influence and ultimately result in low phenotypic expression of the correlation. Rajan *et al.* (2008) also observed higher genotypic correlation coefficient as compared to phenotypic correlation coefficient in guava.

Estimation of phenotypic correlation coefficients indicated that fruit weight expressed highly significant and positive correlation

Table 2. Heritability (h^2), genetic advance as percent mean (GA%), phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for 35 guava genotypes for various characters

Parameter	h^2 (%) (b s)	GA%	PCV	GCV
Inter nodal length	92.70	24.35	12.75	12.28
Twig diameter	95.45	26.14	13.29	12.99
Leaf length	98.05	23.34	11.55	11.44
Leaf width	97.73	22.19	11.02	10.89
Leaf length to width ratio	99.73	26.24	12.77	12.76
Petiole length	99.15	42.10	20.61	20.53
Flower size	96.18	25.64	12.94	12.69
Number of petals	93.00	34.95	18.24	17.59
Fruit length	98.77	29.21	14.36	14.27
Fruit width	96.58	16.25	8.17	8.03
Fruit length to width ratio	99.77	26.61	12.95	12.93
Peduncle length	73.97	46.50	30.51	26.24
Diameter of calyx cavity	92.18	31.65	16.67	16.00
Thickness of outer flesh	97.25	30.03	14.99	14.78
Core diameter	97.83	18.25	9.06	8.96
Thickness of the outer flesh in relation to core	97.56	35.15	17.49	17.28
Sweetness (TSS)	74.63	24.33	12.65	9.45
Acidity	75.24	21.54	10.35	7.65
Vitamin C content	99.23	60.81	32.20	31.07
Number of seeds per fruit	89.50	64.52	35.00	33.11
Seed weight per fruit	99.02	59.29	29.07	28.92
Seed weight per 100 g fruit	97.15	61.43	30.69	30.25
100 seed weight	99.59	39.85	19.42	19.38
Fruit weight	98.86	57.51	28.21	28.06

with fruit width (0.862), fruit length (0.851), flesh thickness (0.749) and core diameter (0.491). While it showed negative and significant correlation with leaf length to width ratio (-0.528), seed weight per 100g of fruit (-0.484), flesh colour (-0.409), vitamin C content (-0.363), sweetness (-0.212) and acidity (-0.204) and showed non-significant correlation with other seed parameters. This indicates that plants having wider leaves will bear larger fruits with thick white flesh, more seed weight having low sweetness and other quality parameters. Raghava and Tiwari (2008) also found significant positive correlation of fruit weight with fruit diameter. Bihari and Suryanarayn (2011) reported positive correlation of fruit weight with diameter of fruit (0.862) and number of seeds per fruit (0.176). In the present investigation, among the other traits, fruit length to width ratio had significant and positive correlation with leaf width (0.317), followed by flesh colour (0.298) and fruit weight (0.233) while, it showed significantly negative correlation with diameter of calyx cavity (-0.519), number of petals (-0.451), core diameter (-0.453), sweetness (-0.414) and flower size (-0.326). This means that smaller flowers with less number of petals develop into a longer or pyriformed fruit with pink flesh and smaller core diameter with low number of seeds per fruit. This is also evident that fruit having pink flesh can be identified with longer fruit shape and smaller diameter of calyx cavity as flesh colour also showed considerable negative correlation with diameter of calyx cavity. Diameter of calyx cavity showed positive significant correlation with core diameter (0.493), fruit diameter (0.424) and number of seeds per fruit (0.290) but high negative correlation with 100-seed weight (-0.359). This lead to the fact that fruits having wider calyx cavity are round in shape with white flesh and larger seed core. Further, fruit contain more but smaller seeds. Flesh thickness of fruit showed more positive correlation with fruit weight and diameter as compared to fruit length and significant negative correlation with flesh colour and seed parameters except 100-seed weight where it showed significant positive correlation. On the basis of above statement, it can be said that fruits with thick flesh have white coloured flesh and round shape with low seed weight per fruit.

Among quality parameters, total soluble solids showed positive and significant correlation with vitamin C (0.305), number of seeds per fruit (0.278) and acidity (0.245), whereas it showed significant negative correlation with fruit length (-0.418) and fruit weight (-0.202). Flesh vitamin C content showed negative significant correlation with fruit size and weight but highly positive correlation with flesh colour. Vitamin C content of fruit showed high positive correlation with other fruit quality parameters but negative with seed traits.

Table 3. Genotypic correlation coefficients for all possible pairs of characters in 35 guava genotypes

	Leaf length	Leaf width	Leaf length to width ratio	Flower size	Number of petals	Fruit weight	Fruit length	Fruit width	Fruit length to width ratio	Diameter of calyx cavity	Flesh colour	Flesh thickness	Core diameter	Sweetness (TSS)	Acidity	Vitamin C	Number of seeds per fruit	Seed weight per fruit	Seed weight per 100g fruit
Leaf width	0.428	1																	
Leaf length to width ratio	0.566	-0.497	1																
Flower size	0.333	-0.082	0.398	1															
Number of petals	0.196	0.117	0.092	0.684	1														
Fruit weight	-0.311	0.358	-0.588	-0.138	0.194	1													
Fruit length	-0.048	0.440	-0.420	-0.314	-0.184	0.759	1												
Fruit width	-0.309	0.284	-0.548	0.020	0.452	0.89	0.453	1											
Fruit length to width ratio	0.174	0.322	-0.102	-0.338	-0.480	0.235	0.802	-0.163	1										
Diameter of calyx cavity	-0.144	-0.178	-0.003	0.334	0.611	0.165	-0.241	0.441	-0.549	1									
Flesh colour	0.291	-0.065	0.313	-0.222	-0.356	-0.421	-0.038	-0.542	0.298	-0.499	1								
Flesh thickness	-0.399	0.172	-0.521	-0.217	-0.007	0.754	0.594	0.722	0.173	0.147	-0.310	1							
Core diameter	-0.093	0.172	-0.255	0.211	0.609	0.493	0.009	0.715	-0.463	0.502	-0.425	0.020	1						
Sweetness (TSS)	-0.076	-0.286	0.189	0.116	-0.070	-0.212	-0.447	-0.101	-0.445	0.074	-0.031	-0.143	0.056	1					
Acidity	0.194	-0.143	0.305	0.247	-0.043	-0.214	-0.263	-0.225	-0.160	-0.160	0.446	-0.315	0.047	0.275	1				
Vitamin C	-0.041	-0.321	0.269	0.126	-0.022	-0.367	-0.361	-0.344	-0.172	-0.133	0.164	-0.098	-0.341	0.334	0.207	1			
Number of seeds per fruit	0.168	0.139	0.016	0.220	0.296	0.078	-0.184	0.142	-0.294	0.293	-0.075	-0.253	0.435	0.304	0.214	-0.406	1		
Seed weight per fruit	0.318	0.316	0.008	0.295	0.407	0.137	0.103	0.201	0.001	0.187	0.112	-0.119	0.347	-0.089	0.216	-0.462	0.802	1	
Seed weight per 100g fruit	0.454	-0.003	0.429	0.303	0.116	-0.501	-0.301	-0.455	-0.022	-0.086	0.398	-0.584	-0.108	0.049	0.351	-0.129	0.631	0.744	1
100-seed weight	0.043	0.069	-0.008	0.048	-0.110	0.092	0.378	-0.045	0.045	-0.381	0.235	0.234	-0.333	-0.445	0.098	0.102	-0.599	-0.056	-0.007

Number of seeds per fruit showed significant positive correlation with seed weight per fruit (0.763), core diameter (0.424), total soluble solids (0.278) and acidity (0.204) but it showed negative correlation with 100-seed weight (-0.555). Hundred seed weight showed significant positive association with fruit length (0.373), flesh colour (0.225) and flesh thickness (0.229). This also confirmed that pink colour of flesh is associated with bold seed size. On the other hand, it was observed that bold seed size is negatively correlated with diameter of calyx cavity, core diameter, total soluble solids and number of seeds per fruit. Rajan *et al.* (2008) also found that number of seeds per fruit was significantly and positively correlated with seed weight per fruit and fruit weight at genotypic as well as phenotypic levels and this finding is in line with the present investigation. The results obtained also corroborated with the earlier studies reported by Bihari and Suryanarayan (2011) and on the basis of correlation studies, it can be said that desirable traits among different genotypes are associated with undesirable traits such as pink flesh with seed weight per fruit and bold seed size, thick flesh and heavier fruits lack pink colour, and thus careful breeding strategy is required to combine all the desirable traits in a single line/cultivar. Cultivars bearing larger fruits, having low number of few soft/ small seed along with thick pink flesh with high organoleptic reading are needed to be evolved through different breeding strategies.

Present investigation indicate that among guava genotypes studied, morphological and physico-chemical traits possess significant genetic variability, along with high genotypic as well as phenotypic coefficient of variation, heritability and genetic advance and provide great opportunity in breeding programme to get desired guava variety. Findings from correlation studies indicated positive and negative association between vegetative, fruit and seed traits and suggest a careful breeding programme to combine traits like larger fruit size, better fruit quality, few soft seeds, resistance/tolerance to abiotic as well as abiotic stresses and long shelf life into a single line/cultivar.

Table 4. Phenotypic correlation coefficients for all possible pairs of characters in 35 guava genotypes

	Leaf length	Leaf width	Leaf length to width ratio	Flower size	Number of petals	Fruit weight	Fruit length	Fruit width	Fruit length to width ratio	Diameter of calyx cavity	Flesh colour	Flesh thickness	Core diameter	Sweetness (TSS)	Acidity	Vitamin C	Number of seeds per fruit	Seed weight per fruit	Seed weight per 100g fruit
Leaf width	0.447**	1																	
Leaf length to width ratio	0.557**	-0.487	1																
Flower size	0.319**	-0.068	-0.487	1															
Number of petals	0.178	0.107	0.085	0.638**	1														
Fruit weight	-0.293	0.347**	-0.582	-0.137	0.179	1													
Fruit length	-0.044	0.431**	-0.415	-0.306	-0.178	0.751**	1												
Fruit width	-0.291	0.273**	-0.528	0.008	0.399**	0.862**	0.466**	1											
Fruit length to width ratio	0.172	0.317**	-0.102	-0.326	-0.451	0.233*	0.794**	-0.161	1										
Diameter of calyx cavity	-0.140	-0.172	-0.003	0.290**	0.541**	0.173	-0.214	0.424**	-0.519	1									
Flesh colour	0.284**	-0.052	0.304**	-0.215	-0.352	-0.409	-0.035	-0.501	0.298**	-0.491	1								
Flesh thickness	-0.389	0.164	-0.512	-0.220	-0.016	0.749**	0.589**	0.706**	0.170	0.158	-0.305	1							
Core diameter	-0.092	0.162	-0.248	0.180	0.554**	0.491**	0.020	0.698**	-0.453	0.493**	-0.416	0.052	1						
Sweetness (TSS)	-0.086	-0.276	0.173	0.081	-0.081	-0.212	-0.418	-0.098	-0.414	0.066	-0.014	-0.141	0.047	1					
Acidity	0.191*	-0.132	0.297**	0.227*	-0.029	-0.204	-0.252	-0.209	-0.155	-0.128	0.445**	-0.305	0.048	0.245*	1				
Vitamin C	-0.038	-0.312	0.267**	0.123	-0.019	-0.363	-0.357	-0.331	-0.173	-0.125	0.142	-0.097	-0.332	0.305**	0.199*	1			
Number of seeds per fruit	0.138	0.110	0.013	0.181	0.259**	0.023	-0.173	0.126	-0.276	0.290**	-0.059	-0.222	0.424**	0.278**	0.204*	-0.381	1		
Seed weight per fruit	0.308**	0.306**	0.007	0.283**	0.378**	0.151	0.109	0.203*	0.001	0.191*	0.095	-0.105	0.350**	-0.095	0.212*	-0.457	0.763**	1	
Seed weight per 100g fruit	0.433**	-0.008	0.419**	0.287**	0.118	-0.484	-0.308	-0.460	-0.024	-0.080	0.387**	-0.563	-0.103	0.048	0.336**	-0.123	0.587**	0.721**	1
100-seed weight	0.044	0.069	-0.007	0.045	-0.106	0.091	0.373**	-0.049	0.045	-0.359	0.225*	0.229*	-0.324	-0.413	0.093	0.098	-0.555	-0.055	-0.011

Critical value of ‘r’ at 5%= 0.141 and that at 1%= 0.184. * and ** at 5% and 1% level of significance, respectively

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