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Morphological and Chemical Characterization of *Psidium* Species

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Abstract

The present study was conducted to estimate the genetic relationship between 20 genotypes of *Psidium guajava* and two species, *P. friedrichsthalianum* Ndz. and *P. catleianum* Sabine, by means of a morphological characterization. Out of 16 morphological characters studied, only inflorescence type did not show any variation, while the remaining traits showed variability to considerable extent. Morphological data on different genotypes were used to calculate similarity matrix which ranged from 0.06 to 0.50 and based on this cluster analysis, it was peformed using UPGMA. The genetic variation among genotypes was high enough to divide them into two major clusters. Cluster I consisted of 'Chakaiya Rehmannagar', 'Gutaniwala', 'Super Max Ruby', and 'Spear Acid', whereas cluster II consisted of the rest of 18 genotypes.

Keywords: guava, morphological characters, polymorphism, biochemical

Introduction

Guava (*Psidium guajava*) is a luscious and important tropical fruit crop belongs to family *Myrtaceae*. It is the hardiest among tropical fruit trees and excels most of the other fruit crops in productivity and adaptability. Moreover, guava scores over other fruits in ascorbic acid, pectin and other mineral contents. Guava cultivars however, display a greater diversity in tree size, bearing habit and yield, as well as in fruit size, shape, quality and ripening season. The existence of a very largenumber of rootstocks, cultivars and clones, maintained by vegetative propagation, reinforces the need of a reliable verification of cultivars identifications for nurserymen and growers. An accurate knowledge of genetic diversity available and the origin of cultivars would assist in the selection of parents in a hybridization programme. A careful study o germplasm would also help to eliminate duplicates in the germplasm collection, thus saving land, space and time.

Assessment of diversity has traditionally been achieved through morphological characters, chemical composition, and cytological characters, however, they have several limitations especially in perennial crops. Despite the fact that morphological characters are often limited in number, they have a complex inheritance pattern and are vulnerable to environmental conditions, it is easy and cheap to carry them out, and can be carried out systematically.

In the light of the above facts, the present study was conducted to study the diversity of guava germplasm at morphological level.

Materials and methods

A total of 20 cultivars of *Psidium guajava* and two other species namely *Psidium cattelianum* and *Psidium friedrichsthalianum* were selected from the experimental orchard of the Department of Horticulture, CCS Haryana Agricultural University, Hisar for morphological studies.

The 16 morphological characteristics used to characterize and discriminate the 22 guava genotypes. Data were recorded on mature leaves for foliage density, phyllotoxy, leaf shape and mature leaf colour. The number of leaves was observed per twenty centimeter length of shoot from the apex. Inflorescence position was the only flower character taken on to account for characterization studies.

All observations on the fruit and its related parts were made at the matured to optimum ripening stage. Fruit-characteristics were observed on five fruits per each tree. Data were documented for fruit shape, fruit surface, fruit diameter, fruit length, fruit weight, fruit colour, and pulp colour.

Physico-chemical analysis

Titrable acidity

Total titrable acidity was determined by methods given by A.O.A.C. (1990). Two grams of fruit pulp were macerated with a small amount of distilled water and the volume was made to 25ml. A few drops of 1% phenolphthalein were added and titrated against N/10 sodium hydroxide taken in burette. The appearance of light pink colour lasting for a minute or longer indicated the end point. Acidity was expressed in percentage i.e. grams of citric acid per 100 g of fruit pulp.

Total Soluble Solids

The fruits out of the composite sample were selected and then pulp was crushed. The juice thus extracted was used for the estimation of total soluble solids. The estima-

tion was made with the help of digital hand refractometer and expressed as total soluble solid in percentage.

*Ascorbic acid (*mg/100 fruit pulp*)*

Method given by A.O.A.C. (1990) was followed. Two grams of fruit pulp was taken and macerated in pestle and mortar with a small amount of 3 per cent metaphosphoric acid solution and filtered through muslin cloth. A final volume was made to 25 ml with 3 per cent meta phosphoric acid.

Results and discussion

Morphological characters of the genotypes

A summary of the characters observed in the cultivars studied in this study is provided in Tab. 1. 'Chakaiya Rehmannagar', 'Hybrid Red Supreme', 'Supreme', 'Barafkhana', 'White Flesh Sour', 'Dharwar', 'Gutaniwala', 'Tehsildar' and 'Strawberry' had a drooping growth habit, whereas well known cultivars like 'Allahabad Safeda', 'Hisar Safeda', 'Apple Colour', 'Banarasi Surkha', 'SP 6550', 'Spear Acid', 'Nasik', 'Hafsi', and 'Chinese guava' have upright growth. The remaining genotypes 'Patillo', 'Super Max Ruby', 'Smooth Green' and 'Lucknow-49' showed spreading nature of growth. Spreading growth habit of 'Lucknow-49' has been also reported by Daulta *et al*. (1998) and Sehgal and Singh (1965). In all the genotypes, the leaves were oppositely arranged, however, a further study of phylloaxy revealed that genotypes viz., 'Patillo', 'Spear Acid', 'Barafkhana', 'White Flesh Sour', 'Lucknow-49', 'Allahabad Safeda', 'Hisar Safeda', 'Banarasi Surkha', 'Strawberry' have superimposed leaves, while the rest of the thirteen genotypes showed decussate pattern of arrangement. Genotypes showed considerable variation in foliage colour. 'Chakaiya Rehmannagar', 'Super Max Ruby', 'Supreme', 'Smooth Green' and 'Allahabad Safeda' showed green shade of foliage colour while genotypes 'Patillo', 'Hybrid Red Supreme', 'SP 6550', 'Nasik', 'Hafsi', 'Gutaniwala', 'Hisar Safeda', 'Apple Colour' and 'Chinese guava' showed a pale green shade of foliage colour. In the remaining eight genotypes typical dark green foliage was observed. The variation between the genotypes for different morphological characters may be attributed to the differences in the genetic make up of these genotypes.

Foliage density was highest in the case of 'Chinese guava' (35.3) followed by 'Smooth Green' (25.3) and least foliage density was observed in the case of 'Strawberry guava' (11.3). 'Chakaiya Rehmannagar', 'Spear Acid', 'Hafsi', 'Lucknow-49' and 'Apple Colour' had oblong lanceolate leaves, whereas 'Nasik' and 'Chinese guava' had lanceolate leaves. Oblong leaves was a characters of 'Super Max Ruby', 'Tehsildar', 'Allahabad Safeda' and 'Hisar Safeda' and ovate of 'Smooth Green', 'Dharwar' and 'Strawberry guava', while the rest of the genotypes possessed elliptical leaves. The data pertaining to the inflorescence depicted that all the genotypes of guava produced solitary, as well as

Tab. 1. Vegetative and floral characteristics of *Psidium* genotypes during winter season

Name of Genotypes	Tree habit	Foliage density	Phyllotaxy	Leaf shape	Mature leaf colour	Inflorescence position
'Chakaiya Rehmannagar'	Drooping	23.6	Decussate	Oblong lanceolate	Green	Cymose/Solitary
'Patillo'	Spreading	14.6	Superimposed	Elliptical	Pale Green	Cymose/Solitary
'Hybrid Red Supreme'	Drooping	16.6	Decussate	Elliptical	Pale Green	Cymose/Solitary
'Super Max Ruby'	Spreading	22.0	Decussate	Oblong	Green	Cymose/Solitary
'SP 6550'	Upright	24.6	Decussate	Elliptical	Pale Green	Cymose/Solitary
'Supreme'	Drooping	18.0	Decussate	Elliptical	Green	Cymose/Solitary
'Spear Acid'	Upright	12.6	Superimposed	Oblong lanceolate	Dark Green	Cymose/Solitary
'Nasik'	Upright	15.3	Decussate	Lanceolate	Pale Green	Cymose/Solitary
'Hafsi'	Upright	19.3	Decussate	Oblong lanceolate	Pale Green	Cymose/Solitary
'Barafkhana'	Drooping	20.6	Superimposed	Elliptical	Dark Green	Cymose/Solitary
'Smooth Green'	Spreading	25.3	Decussate	Ovate	Green	Cymose/Solitary
'White Flesh Sour'	Drooping	21.3	Superimposed	Elliptical	Dark Green	Cymose/Solitary
'Dharwar'	Drooping	24.6	Decussate	Ovate	Dark Green	Cymose/Solitary
'Gutaniwala'	Drooping	13.3	Decussate	Elliptical	Pale Green	Cymose/Solitary
'Tehsildar'	Drooping	21.3	Decussate	Oblong	Dark Green	Cymose/Solitary
'Lucknow-49'	Spreading	24.6	Superimposed	Oblong lanceolate	Dark Green	Cymose/Solitary
'Allahabad Safeda'	Upright	20.6	Superimposed	Oblong	Green	Cymose/Solitary
'Hisar Safeda'	Upright	20.0	Superimposed	Oblong	Pale Green	Cymose/Solitary
'Apple Colour'	Upright	19.3	Decussate	Oblong lanceolate	Pale Green	Cymose/Solitary
'Banarsi Surkha'	Upright	19.3	Superimposed	Elliptical	Pale Green	Cymose/Solitary
'Chinese'	Upright	35.3	Decussate	Lanceolate	Pale Green	Cymose/Solitary
'Strawberry'	Drooping	11.3	Superimposed	Ovate	Dark Green	Cymose/Solitary
CD at 5%		5.43				

flowers in cymes of two or three in the leaf excel on current season growth.

Flowers are borne singly or in cymes of two or three in the leaf axils of the current season growth both on terminal and lateral shoots. A similar inflorescence character has also been reported by Ray (2002) and Shukla and Vashishtha (2004).

Fruit characters

The genotype 'Chakaiya Rehmannagar' had an ovate fruit shape. While 'Patillo', 'Gutaniwala', 'Tehsildar' and 'Chinese guava' had obovate fruits. Oblate fruits was a character of 'Super Max Ruby' and 'Apple Colour', whereas oval fruits were found in 'Hafsi' and 'Dharwar'. 'Spear Acid' had pear shaped fruits, whereas in the remaining 10 genotypes, a round fruit shape was observed. A rough surface of fruits was noted in 'Chakaiya Rehmannagar', 'Super Max Ruby', 'Spear Acid', 'Gutaniwala' and 'Chinese guava', whereas rough fruit surface along the ridges was a character of 'SP 6550', 'Barafkhana', 'White Flesh Sour', 'Dharwar', 'Tehsildar', 'Lucknow-49' and 'Banarsi Surkha'. 'Patillo' and 'Supreme' have a smooth and ridged fruit surface, while the rest of the genotypes had a smooth surface (Tab. 2). Fruit length ranged from 2.63 to 7.62 cm. Maximum fruit length was observed in 'Lucknow-49' (7.62 cm) that was at par with 'Tehsildar' (7.29 cm). 'Barafkhana' (7.07 cm), 'Dharwar' (6.76 cm), 'Gutaniwala' (6.66 cm), 'Super Max Ruby' (6.49 cm.) and 'Smooth Green' (6.36). The minimum fruit length was observed in genotype 'Strawberry guava' (2.63 cm) which was at par with that of the 'Chinese guava' (3.14 cm).

The fruit diameter ranged from 2.47 to 7.07 cm. The highest fruit diameter was observed in the case of 'Lucknow-49' (7.07 cm), followed by 'Barafkhana' (6.63 cm) and 'Dharwar' (6.47 cm). The minimum fruit width was recorded in 'Strawberry guava' (2.47 cm), which was at par with 'Chinese guava' (2.54 cm). The fruit weight ranged from 11.93 to 213.80 g. The fruit weight was maximum m 'Barafkhana' (213.80 g), which was at par with 'Lucknow-49' (211.26 g). The minimum fruit weight was recorded in 'Strawberry guava' (11. 93 g) which was at par with the 'Chinese guava' (12.92 g).

The observations recorded in the present investigation suggested that the different genotypes varied markedly with respect to fruit length, weight and shape, obviously due to their differential genetic behavior.

Considerable variability was observed in skin colour. The skin colour was yellowish green in 'Chakaiya Rehmannagar', 'Hafsi', 'Gutaniwala', 'Lucknow-49' and 'Banarsi Surkha', whereas it was greenish yellow in 'Hybrid Red Supreme', 'Supreme', 'Nasik', 'Barafkhana', 'White Flesh Sour' and 'Allahabad Safeda'. The remaining geno-

Tab. 2. Fruit characteristics of *Psidium* genotypes during winter season

Name of Genotypes	Fruit shape	Fruit surface	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit skin colour	Pulp colour
'Chakaiya Rehmannagar'	Ovate	Rough	5.83	5.61	151.79	Yellowish green	Creamy
'Patillo'	Obovate	Smooth and ridged	6.27	3.39	64.90	Green	Pink
'Hybrid Red Supreme'	Round	Smooth	5.53	4.83	81.66	Greenish yellow	Pink
'Super Max Ruby'	Oblate	Rough	6.49	5.17	86.65	Green	Creamy white
'SP 6550'	Round	Rough and ridged	5.42	5.74	104.29	Green	White
'Supreme'	Round	Smooth and ridged	6.18	5.70	158.57	Greenish yellow	White
'Spear Acid'	Pear shaped	Rough	6.24	5.45	131.16	Green	Creamy white
'Nasik'	Oblong	Smooth	5.36	5.01	91.07	Greenish yellow	White
'Hafsi'	Oval	Smooth	5.66	5.05	105.07	Yellowish green	White
'Barafkhana'	Round	Rough and ridged	7.07	6.63	213.80	Greenish yellow	Creamy white
'Smooth Green'	Round	Smooth	6.36	5.88	151.78	Green	White
'White Flesh Sour'	Round	Rough and ridged	5.96	5.44	114.59	Greenish yellow	White
'Dharwar'	Oval	Rough and ridged rough	6.76	6.47	114.88	Green	White
'Gutaniwala'	Obovate	Rough	6.66	5.36	155.99	Yellowish green	Creamy white
'Tehsildar'	Obovate	Rough and ridged	7.29	5.39	106.65	Green	Creamy white
'Lucknow-49'	Round	Rough and ridged	7.62	7.07	211.26	Yellowish green	White
'Allahabad Safeda'	Round	Smooth	5.84	5.41	116.28	Greenish yellow	White
'Hisar Safeda'	Round	Smooth	5.32	5.20	95.33	Yellowish green	Creamy white
'Apple Colour'	Oblate	Smooth	5.81	5.07	102.31	Green with reddish blush	White
'Banarasi Surkha'	Oblong	Rough and ridged	5.58	5.07	131.52	Yellowish green	Pink
'Chinese'	Obovate	Rough	3.14	2. 54	12.92	Green	Yellowish pink
'Strawberry'	Round	Smooth	2.63	2.47	11.93	Green	Yellowish pink
CD at 5%			0.99	0.69	12.69		

types in the study had typical green coloured fruit skin, while green skin colour with reddish blush was recorded in 'Apple Colour'. Variability with respect to pulp colour was also recorded. 'Chakaiya Rehmannagar', 'Super Max Ruby', 'Spear Acid', 'Barafkhana', 'Gutaniwala', 'Tehsildar' and 'Hisar Safeda' had creamy white pulp. Pink pulp colour was served in 'Patillo', 'Hybrid Red Supreme' and 'Banarsi Surkha', whereas the rest of the cultivars of *Psidium guajava* L. under study had white pulp. The two other species in the study viz., *P. cattleianum* and *P. firiedrichsthalianum* have yellowish white and yellowish pulp colour, respectively. Mortan (1984) also observed variation in the pulp colour of two different species viz., *P. cattleianum* and *P. friedrichsthalianum*.

Similarity in the fruit characters of 'Hisar Safeda' with 'Allahabad Safeda' may be due to 'Allahabad Safeda' is one of the parents of 'Hisar Safeda'. The similar variations in the fruit characters were also observed by Dinesh and Reddy (2001) and Singh (1988).

Physico-chemical characters

The total soluble solids, acidity and ascorbic acid constitute the important chemical constituents for assessing fruit quality of different guava genotypes. The total soluble solids ranged from 9.4 brix to 13.5 brix. The maximum total soluble solids was recorded in 'Hybrid Red Supreme' (13.5) followed by 'Hisar Safeda' (13.2) and 'Patillo' (13. 1), while minimum total soluble solids was recorded in 'Chakaiya Rehmannagar' (9.4) which was at par with 'Chinese' (9.6), 'Super Max Ruby' (10.1). The acidity ranged between 0.37% to 0.96% for the different genotypes. Maximum acidity was recorded in 'Chinese guava' (0.96%), which was at par with 'Spear Acid' (0.95%). The minimum acidity was noted in 'Hisar Safeda' (0.37%), followed by 'Lucknow-49' and 'Patillo' (0.42%). Ascorbic acid, the major constituent of guava ranged from 51.90 to 189.73 mg/100 g of fruit pulp. Maximum amount of ascorbic acid was recorded in the 'Gutaniwala' (189.73 mg/100 g fruit pulp) which was at par with 'Lucknow-49' (187.13 mg/100 fruit pulp) and 'Hisar Safeda' (184.20 mg/100 g fruit pulp), whereas the minimum amount of ascorbic acid was observed in 'Nasik' (51.90 mg/100 g fruit pulp), which was at par with that in 'White Flesh Sour' (58.70 mg/100 fruit pulp). Chemical composition of fruits showed remarkable variation TSS, acidity and ascorbic acid which may be due to environmental factors and cultural practices adopted. High acid content in 'Chinese guava' has been reported by Morton (1984), Shukla and Vashishtha (2004) and Subramanyam and Iyer (1993).

Tab. 3. Physico-chemical characteristics of *Psidium* genotypes during winter season

Name of Genotypes	TSS (0Brix)	Acidity (%)	Ascorbic acid (mg/100 g pulp)
'Chakaiya Rehmannagar'	9.4	0.41	127.20
'Patillo'	13.1	0.42	94.40
'Hybrid Red Supreme'	13.5	0.58	141.40
'Super Max Ruby'	10.1	0.62	169.53
'SP 6550'	12.4	0.79	71.37
'Supreme'	11.8	0.61	114.60
'Spear Acid'	10.6	0.95	67.27
'Nasik'	11.8	0.64	51.90
'Hafsi'	11.8	0.72	97.70
'Barafkhana'	11.2	0.45	93.30
'Smooth Green'	11.3	0.58	86.40
'White Flesh Sour'	12.1	0.55	58.70
'Dharwar'	11.6	0.73	65.00
'Gutaniwala'	10.6	0.46	189.73
'Tehsildar'	11.8	0.53	171.73
'Lucknow-49'	12.0	0.42	187.13
'Allahabad Safeda'	10.7	0.54	165.10
'Hisar Safeda'	13.2	0.37	184.20
'Apple Colour'	12.8	0.79	165.63
'Banarasi Surkha'	11.6	0.52	156.96
'Chinese'	9.6	0.96	72.80
'Strawberry'	10.5	0.89	77.13
CD at 5%	1.06	0.06	7.24

Similarity matrix and dendrogram

The morphological and physico-chemical characters of 22 guava genotypes were used to generate similarity matrices. The morphological diversity data was further used to produce a dendrogram by using distance matrix by UPGMA revealing the morphological relationship between all guava genotypes. Similarity matrices of 22 guava genotypes revealed the relationship between them. A maximum similarity value of 0.50 was observed between 'Hafsi' and 'Apple Colour' and 'Barafkhana' and 'White Flesh Sour', whereas 'Chakaiya Rehmannagar' and 'Patillo', 'Spear Acid' and 'Hybrid Red Supreme', 'Spear Acid' and 'Supreme', 'Barafkhana' and 'Hafsi', 'White Flesh Sour' and 'Super Max Ruby', 'Allahabad Safeda' and 'Gutaniwala', 'Dharwar' and 'Hisar Safeda', 'Barafkhana' and 'Apple Colour', 'Banarsi Surkha' and 'Super Max Ruby', 'Banarsi Surkha' and 'Smooth Green', 'Chinese guava' and 'Barafkhana', 'Chinese guava' and 'White Flesh Sour', 'Chinese guava' and 'Lucknow-49' were quite diverse as indicated by the low value of the similarity coefficient (0.06). The two species 'Chinese guava' (*P. friedrichsthalianum*) and 'Strawberry guava' (*P. cattleianum*) were found to be quite diverse (0. 12).

The similarity coefficient values ranged from 0.06-0.50 clearly indicating a low to moderate genetic diversity among the guava genotypes. This may be so almost all the commercial varieties are natural seedling selections from 'Allahabad Safeda', besides the breeding of new cultivars through hybridization, 'Allahabad Safeda' has been extensively used as one of the parents. Apart from this, related *Psidium* species viz. *P. cattleianum* and *P.*

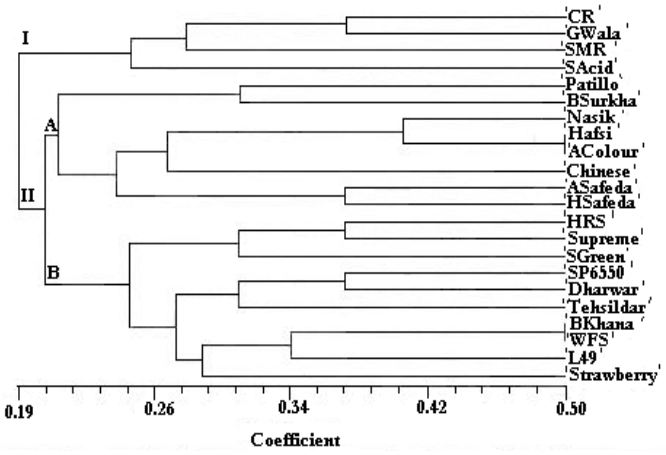

Fig. 1. Dendrogram showing morphological diversity between 22 *Psidium* genotypes based on morphological characterization

friedrichsthalianum have not been used for hybridization programmes (Prakash *et al*., 2002).

The cluster tree analysis based on morphological characterization divided the guava genotypes into two major clusters at a similarity coefficient of 0.19-0.50 (Fig. 1). Cluster I comprised of 'Spear Acid' which merged with 'Super Max Ruby' at a similarity coefficient 0.25 and these two further joined with 'Chakaiya Rehmannagar' and 'Gutaniwala' at a similarity coefficient value of 0.37. Cluster II consisted of the remaining 18 genotypes. This cluster was further branched into two sub-clusters, A and B at a similarity coefficient of 0.20. Sub-cluster A had 8 genotypes that included one of the species i.e. *P. friedrichsthalianum* which clubbed together with 'Nasik', 'Hafsi' and 'Apple Colour'. A high similarity coefficient (0.50) between 'Hafsi' and 'Apple Colour' was noted. 'Allahabad Safeda' and 'Hisar Safeda' were also present in this sub-cluster at a similarity coefficient of 0.37. The remaining 10 genotypes were part sub-cluster B. *P. catlleianum* being a separate species, was present solely at one of the extremes of dendrogram. The rest of the 9 cultivars of *P. guajava* were placed in this sub-cluster. 'Barafkhana' and 'White Flesh Sour' were highly similar as illustrated by a high similarity coefficient of 0.50.

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