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Morphological and quality trait analysis of guava (*Psidium guajava* L.) hybrid progenies

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ABSTRACT

The present investigation was carried out to characterize the pre breeding progenies of 36 guava hybrids (F_1) based on their physical and biochemical characteristics. Observations were recorded under three groups *viz.*, morphological characters of the plant, physical and biochemical characters of the fruit during rainy season. Results revealed that variations were present with reference to various physical and biochemical characteristics amongst the 36 F_1 hybrids. Based on physical and bio-chemical traits, PGH1-A_4-20 was found quite different from the others. Maximum fruit size (192.00 g) and fruit diameter (8.36 cm) was noted in genotype PGH8-B_1-6-20. The highest TSS (12.30 °B), ascorbic acid (189.83 mg/100 g), total sugars (9.18%) and lycopene content (3.53 mg/100 g) was observed in genotype PGH1-A_4-20, whereas maximum pectin content (1.04%) and reducing sugars were determined in genotype PGH20-C_2-18-20. The highest fruit retention (68.00%) and yield (6.97 Kg/Plant) along with lowest seed hardiness (4.31 Kg/cm^2) were recorded in genotype PGH1-A_4-20. Hence after proper testing of the identified hybrid under different agro-climatic conditions, can be used in further breeding programs in future with desired superior trait.

Key words: Guava, lycopene, novel F_1 hybrids, pectin content, seed hardness, variability.

INTRODUCTION

Guava *(Psidium guajava* L.) belongs to the Myrtaceae family, which has nearly 150 species, of which only 20 are edible and the rest are wild that produce low and inferior quality fruits. It is also referred to as “Poor Man’s Fruit” or “Apple of the Tropics” (Pandey *et al.,* 13). It is a popular tropical and subtropical fruit crop that is native to Tropical America, ranging from Mexico to Peru. Guava is now grown in nearly every tropical and subtropical country on the planet. Guava tree is short statured with many branches that bears several little to medium-sized fruits. The genotypes differ in colour, size, flavour (tart to sweet), and unique musky odour. India is the second largest producer of fruit after China with the area and production of 7.17 mha and 114 MT, respectively (Anonymous, 2). The guava fruits also possess immense nutritional and medicinal value. The fruits contain high amount of vitamin C (260mg/100 g). It is high in dietary fibre (5-7%), vitamin-A, pectin (0.1-1.8%), phosphorus (22.5-40.0 mg/100 g) and calcium (10.0-30.0 mg/100 g) (Deshmukh *et al*., 6). Fruits are also rich in pectin which has industrial uses for jelly or juice production. Guava has a lot of genetic diversity, which is shown by the many germplasm it has. As this fruit crop becomes more popular and in demand, it is important to create better varieties by choosing from existing germplasm. The first and most important step in evaluating germplasm is to look at its morphological traits. Morphological characterization is a simple conventional, and extensively utilized method that remains significant in the identification and assessment of genetic variability in germplasm. These morphological features are such as plant height, leaf colour, leaf texture, leaf shape, growth habit, colour of flowers, tree vigour, number of fruits per tree. Although this approach is time-consuming and extensively influenced by environmental and natural variables, it continues to be considered as beneficial for germplasm evaluation and characterization. Moreover, such germplasm should be selected which shows profuse bearing with good sized fruits having high total soluble solids content, high vitamin C content and high sugar content. Soft seeded guava fruits along with coloured flesh have high market acceptance. This study focuses on characterizing F_1 guava hybrids based on their physical and biochemical characteristics for identifying promising hybrids.

MATERIALS AND METHODS

The present study was carried out during 2023 at Horticulture Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and

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Technology, Pantnagar, Uttarakhand on 3 years old plants of 36 different F_1 guava hybrids planted at a spacing of 5 × 2 m^2. The experimental site is situated at the foothills of the Himalayas between 29.5° North latitude and 79.3° East longitude and at an altitude of 243.84 m above mean sea level. All experimental plants were maintained under uniform cultural practices during the entire period of investigation. The morphological characteristics of guava hybrids were documented following the guidelines outlined in the 'Guava Descriptor,' published in 2011 by the All India Coordinated Research Project on Subtropical Fruits (AICRP-STF) at CISH, Lucknow. The observations included various plant traits such as plant height, plant girth, shape of mature leaf, shape of leaf apex, shape of leaf base, colour of young twig, young leaf anthocyanin colouration, internodal length, number of fruits per plant, fruit retention and yield per plant. The different physical characteristics of the fruits such as fruit length, fruit diameter, fruit volume, fruit weight and seed cavity size if mature fruits were measured. The seed hardness of the mature fruits was estimated with the help of a grain seed hardness tester and expressed in Kg/cm^2. The different biochemical characteristics *viz.*, total soluble solids (°Brix), pectin content (%), total sugar (%), reducing sugar (%), non-reducing sugar, ascorbic acid (mg/100 g), acidity (%) and lycopene (mg/100 g) were estimated in mature guava fruits. The total soluble solids content was measured with a hand refractometer (ERMA ehb-32) and was expressed as °Brix. Total and reducing sugars were analysed by the method given by Rangana (15) using Fehling Solution A and Fehling Solution B. Pectin content was calculated as per cent calcium pectate by the method given by Rangana (15) and expressed in percentage. The ascorbic acid content was estimated by titration of sample against 2,6-dichlorophenol-indophenol dye (Lane and Eylon, 9) and expressed as mg/100 g of pulp. The titratable acidity of guava pulp extract was assessed according to the procedure outlined by Rangana (15). Lycopene content was estimated by using the method given by Rangana (15) and expressed as mg/100 g of pulp.

The experiment employed in a randomized block design with three replications for the analysis of biochemical characters of both parents and hybrids. Quantitative data was statistically analysed using the analysis of variance method with SPSS software, version 19. Qualitative morphological data was analysed using DARwin5 software, version 5.0.158, developed by CIRAD's genetic improvement of vegetatively propagated crops research unit.

RESULTS AND DISCUSSION

Variation was observed amongst the hybrids based on different physical and biochemical characteristics of the plant. Data presented in figure 2 indicates that maximum plant height (2.30 m) and plant girth (6.01 cm) were recorded in hybrid PGH5-A_2-24-20 while minimum plant height (1.06 m) and plant girth (1.33 cm) were recorded in hybrids PGH17-C_1-3-20 and PGH13-B_3-35-20. Similar results were reported Deshmukh *et al*. (6) and Mehta *et al.* (11) who observed variation in plant height and girth among various guava genotypes. The variations in these characters may be attributed to the genetic diversity of the hybrids and local agro-climatic conditions. Among the 36 hybrids studied, internodal length ranged from 3.01 cm in hybrid PGH2-A_1-6-20 to 7.00 cm in hybrid PGH25-D_1-11-20. The results align with the findings of Jain (7) who reported that the influence of genotypes was non-significant on internodal length among the 25 guava genotypes taken under study. Maximum (60) number of flower buds/plant were recorded in hybrid PGH1-A_1-4-20 while the minimum (13.00) value was recorded in hybrid PGH23-C_3-34-20. Maximum (68 %) fruit retention was observed in hybrid PGH1-A_1-4-20 while minimum (42.30 %) value was recorded in hybrid PGH15-B_3-38-20 during rainy season. The results align with the findings of Sahoo and Tarai (16) who recorded maximum (67%) fruit retention in Pant Prabhat while minimum (51.67 %) value was recorded in Allahabad Safeda. The highest (41.00) number of fruits per plant was recorded in hybrid PGH1-A_1-4-20 while the minimum (8.00) number of fruits were recorded in hybrid PGH23-C_3-34-20. According to Vishwakarma *et al*. (20) the maximum (2573.33) number of fruits per plant were recorded in *P. cattleianum* var. *cattleianum* while minimum (80.00) value was recorded in *P. molle*. The variations in the bearing of fruits might be due to inherent genetic makeup of the hybrids. The highest (6.97 kg) yield/ plant was recorded in hybrid PGH1-A_1-4-20. On the other hand, the lowest (0.79 kg) value was recorded in hybrid PGH23-C_3-34-20. Similar results were reported by Aulakh (4). The differences in yield may be due to the interactions between the phenotypic and genotypic traits of the hybrids taken under study. Shape of mature leaf, leaf apex and leaf base varied among different hybrids (Fig. 3). Similar results were reported by prior researchers Aslam *et al.* (3) and Biswas *et al*. (5). Variation was noted in the remaining qualitative characters *viz.,* growth habit of plant, colour of young twig and young leaf anthocyanin colouration amongst the various hybrids taken under study.

Variations were found in the qualitative characters of the fruits *viz*., fruit skin colour, fruit shape and

fruit pulp colour (Table 1). The fruit skin colour varied significantly among the different hybrids. Cream white skin-coloured fruits were noted in hybrids PGH22-C_3-33-20, PGH23-C_3-34-20 and PGH24-C_3-35-20 while green yellowish skin-coloured fruits were reported in the remaining hybrids. Similar

Table 1: Shape of mature leaf, leaf apex, leaf base, growth habit, colour of twig and anthocyanin colouration of different F_1 guava hybrids.

Sr. No.	Hybrids	Shape of mature leaf	Shape of leaf apex	Shape of leaf base	Growth habit of plant	Colour of young twig	Young leaf anthocyanin colouration
1.	PGH1-A_1-4-20	Oblong	Apiculate	Round	Upright	Green	Present
2.	PGH2-A_1-6-20	Oblong	Apiculate	Round	Upright	Green	Present
3.	PGH3-A_1-9-20	Oblong	Apiculate	Round	Upright	Green	Present
4.	PGH4-A_2-23-20	Oblanceolate	Obtuse	Round	Spreading	Dark red	Present
5.	PGH5-A_2-24-20	Oblanceolate	Obtuse	Round	Spreading	Dark red	Present
6.	PGH6-A_2-25-20	Oblanceolate	Obtuse	Round	Spreading	Dark red	Present
7.	PGH7-B_1-3-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Present
8.	PGH8-B_1-6-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Present
9.	PGH9-B_1-11-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Present
10.	PGH10-B_2-21-20	Oblong	Apiculate	Round	Upright	Green	Present
11.	PGH11-B_2-24-20	Oblong	Apiculate	Round	Upright	Green	Present
12.	PGH12-B_2-27-20	Oblong	Apiculate	Round	Upright	Green	Present
13.	PGH13-B_3-35-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Present
14.	PGH14-B_3-36-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Present
15.	PGH15-B_3-38-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Present
16.	PGH16-C_1-2-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Absent
17.	PGH17-C_1-3-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Absent
18.	PGH18-C_1-4-20	Oblong	Obtuse	Round	Spreading	Green with red streaks	Absent
19.	PGH19-C_2-17-20	Oblanceolate	Obtuse	Obtuse	Spreading	Dark red	Present
20.	PGH20-C_2-18-20	Oblanceolate	Obtuse	Obtuse	Spreading	Dark red	Present
21.	PGH21-C_2-19-20	Oblanceolate	Obtuse	Obtuse	Spreading	Dark red	Present
22.	PGH22-C_3-33-20	Oblong	Apiculate	Obtuse	Spreading	Green with red streaks	Absent
23.	PGH23-C_3-34-20	Oblong	Apiculate	Obtuse	Spreading	Green with red streaks	Absent
24.	PGH24-C_3-35-20	Oblong	Apiculate	Obtuse	Spreading	Green with red streaks	Absent
25.	PGH25-D_1-11-20	Oblanceolate	Obtuse	Obtuse	Upright	Dark red	Present
26.	PGH26-D_1-12-20	Oblanceolate	Obtuse	Obtuse	Upright	Dark red	Present
27.	PGH27-D_1-13-20	Oblanceolate	Obtuse	Obtuse	Upright	Dark red	Present
28.	PGH28-D_3-26-20	Oblanceolate	Acute	Obtuse	Upright	Green with red streaks	Present
29.	PGH29-D_3-28-20	Oblanceolate	Acute	Obtuse	Upright	Green with red streaks	Present
30.	PGH30-D_3-29-20	Oblanceolate	Acute	Obtuse	Upright	Green with red streaks	Present
31.	PGH31-E_1-2-20	Oblanceolate	Apiculate	Obtuse	Spreading	Green with red streaks	Absent
32.	PGH32-E_1-3-20	Oblanceolate	Apiculate	Obtuse	Spreading	Green with red streaks	Absent
33.	PGH33-E_1-4-20	Oblanceolate	Apiculate	Obtuse	Spreading	Green with red streaks	Absent
34.	PGH34-E_3-11-20	Oblanceolate	Obtuse	Round	Upright	Dark red	Present
35.	PGH35-E_3-12-20	Oblanceolate	Obtuse	Round	Upright	Dark red	Present
36.	PGH36-E_3-13-20	Oblanceolate	Obtuse	Round	Upright	Dark red	Present

results were quoted in the work done by Ahir *et al*., (1) who reported yellow green colour of peel in Hisar Safeda, Hisar Surkha, Allahabad Safeda, L-49, H-1, H-2, CISH-G-1 and CISH-G-4 respectively. Subglobose shaped fruits were recorded in majority of the hybrids while pyriform shaped fruits were noted in hybrids PGH4-A_2-23-20, PGH5-A_2-24-20, PGH6-A_2-25-20, PGH31-E_1-2-20, PGH32-E_1-3-20, PGH33-E_1-4-20, PGH34-E_3-11-20, PGH35-E_3-12-20 and PGH36-E_3-13-20. The fruit flesh colour was categorized into three groups white, creamy white and pinkish. The results also align with the findings of Meena *et al*. (12), and who reported variation in fruit flesh colour among different guava genotypes. While flesh colour is primarily a varietal trait, minor variations in its intensity can be attributed to climatic factors and soil type. The maximum fruit length (7.98 cm) and fruit diameter (8.36 cm) were recorded in hybrid PGH8-B_1-6-20 while minimum fruit length (3.90 cm) and fruit diameter (4.30 cm) were recorded in hybrids PGH17-C_1-3-20 and PGH16-C_1-2-20, respectively. Similar findings were reported by Deshmukh *et al*. (6) which showed variation in fruit length and fruit diameter among different guava genotypes. Maximum fruit length was recorded in hybrid H6 (CISH G-1× Allahabad Safeda) while minimum (66.72 mm) value was recorded in hybrid H3 (Shweta × 1716). According to Aulakh, (4) the fruit diameter ranged from 4.60 cm in cv. Strawberry to 5.80 cm in cv. Seedless. The maximum (192.00 g) fruit weight was recorded in hybrid PGH8-B_1-6-20. On the other hand, the minimum (90.14 g) value was recorded in hybrid PGH24-C_3-35-20. According to Tandon *et al*. (18) fruit weight ranged from 118g (White Flesh) to 220.9 g (Guness). The seed hardness ranged from 4.32 kg/cm^2 in hybrid PGH17-C_1-3-20 to 11.01 kg/cm^2 in hybrid PGH9-B_1-11-20 (Table 2). Similar results regarding variation in seed hardness were reported by Pandey *et al*. (13). According to Vishwakarma *et al*. (20), seed hardness ranges from 4.82 kg/cm^2 in cv. Arka Poorna to 13.04 kg/cm^2 in *P. guineense*.

Significant variations in biochemical characteristics of the fruits were observed among different guava hybrids and their parents (Fig. 1). It was observed that the TSS content varied significantly among different hybrids and their parents. The TSS content ranged from 8.46 °Brix in PGH9-B_1-11-20 to 12.30 °Brix in hybrid PGH1-A_1-4-20. In the study conducted by Reddy et al. (14), the highest TSS levels were found in *P. cujavillis*, whereas the lowest levels were recorded in river side. Kaur *et al*. (8) reveal that TSS content was found comparatively higher in Allahabad Safeda (11.00 %) in comparison to the other five cultivars taken under study. The maximum (0.40 %) titratable acidity was recorded in PGH11-B_2-24-20 while minimum (0.23 %) value was observed in PGH7-B_1-3-20. Contrary to these results Singh (17) reported the highest titratable acidity content in Lalit. The maximum (189.83 mg/100 g) ascorbic acid content was recorded in hybrid PGH1-A_1-4-20. On the other hand, minimum (104.99 mg/100 g) value was recorded in hybrid PGH19-C_2-17-20 (Table 2). Similar results were reported by Deshmukh *et al.* (6) who observed variation in ascorbic acid content among various guava genotypes. The maximum (1.06 %) pectin content was recorded in hybrid PGH21-C_2-19-20. The minimum (0.75 %) pectin content was recorded in hybrid PGH11-B_2-24-20. Similar variations regarding pectin content among different guava hybrids were also reported by

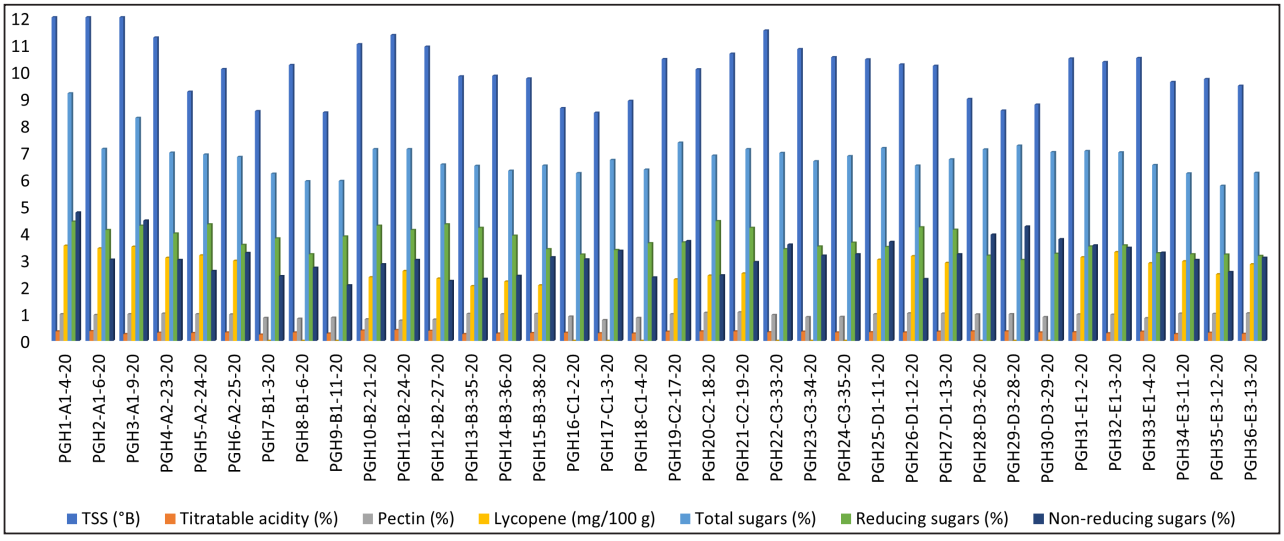

Fig. 1. Biochemical characters of fruits of different F_1 guava hybrids and their parents.

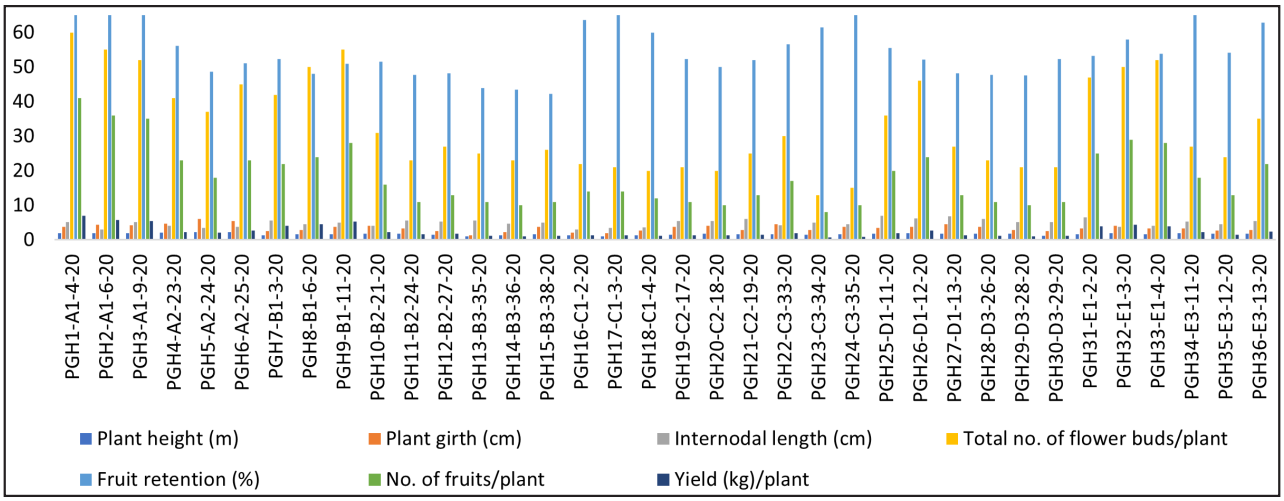

Fig. 2. Biochemical characters of fruits of different F_1 guava hybrids and their parents.

Table 2: Fruit skin colour, fruit shape, length, diameter, weight, flesh colour, seed hardiness and ascorbic acid content of different F_1 guava hybrids.

S. No.	Hybrids	Fruit skin colour	Fruit shape	Flesh colour	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Seed hardness (kg/cm^2)	Ascorbic acid (mg/100 g)
1.	PGH1-A_1-4-20	Green-yellowish	Sub-globose	Pinkish	7.01	7.60	170.00	5.56	189.83
2.	PGH2-A_1-6-20	Green-yellowish	Sub-globose	Pinkish	5.40	5.46	160.24	5.00	187.91
3.	PGH3-A_1-9-20	Green-yellowish	Sub-globose	Pinkish	6.11	6.83	154.32	5.61	188.86
4.	PGH4-A_2-23-20	Green-yellowish	Pyriform	Pinkish	4.70	4.78	100.00	6.84	155.37
5.	PGH5-A_2-24-20	Green-yellowish	Pyriform	Pinkish	4.23	4.50	113.85	6.20	154.34
6.	PGH6-A_2-25-20	Green-yellowish	Pyriform	Pinkish	4.72	5.00	115.40	6.41	150.58
7.	PGH7-B_1-3-20	Green-yellowish	Sub-globose	White	6.00	6.30	189.00	8.15	143.50
8.	PGH8-B_1-6-20	Green-yellowish	Sub-globose	White	7.98	8.36	192.00	9.80	140.34
9.	PGH9-B_1-11-20	Green-yellowish	Sub-globose	White	6.29	6.43	190.10	11.01	145.52
10.	PGH10-B_2-21-20	Green-yellowish	Sub-globose	Pinkish	6.16	6.50	140.00	5.14	162.29
11.	PGH11-B_2-24-20	Green-yellowish	Sub-globose	Pinkish	6.50	7.11	143.36	5.05	155.25
12.	PGH12-B_2-27-20	Green-yellowish	Sub-globose	Pinkish	5.83	6.20	138.30	4.87	159.30
13.	PGH13-B_3-35-20	Green-yellowish	Sub-globose	Pinkish	4.34	5.00	100.00	6.31	179.35
14.	PGH14-B_3-36-20	Green-yellowish	Sub-globose	Pinkish	4.70	4.55	99.84	6.11	183.02
15.	PGH15-B_3-38-20	Green-yellowish	Sub-globose	Pinkish	4.56	4.94	105.30	5.87	178.42
16.	PGH16-C_1-2-20	Green-yellowish	Sub-globose	White	4.18	4.30	97.50	5.64	142.87
17.	PGH17-C_1-3-20	Green-yellowish	Sub-globose	White	3.90	4.33	94.34	4.32	139.50
18.	PGH18-C_1-4-20	Green-yellowish	Sub-globose	White	4.27	5.00	100.02	4.50	140.64
19.	PGH19-C_2-17-20	Green-yellowish	Sub-globose	Pinkish	4.91	5.30	122.00	4.93	104.99
20.	PGH20-C_2-18-20	Green-yellowish	Sub-globose	Pinkish	6.50	6.84	128.85	4.85	108.90
21.	PGH21-C_2-19-20	Green-yellowish	Sub-globose	Pinkish	6.00	6.90	114.70	4.72	114.48
22.	PGH22-C_3-33-20	Cream white	Sub-globose	White	5.90	5.55	115.00	6.80	114.75
23.	PGH23-C_3-34-20	Cream white	Sub-globose	White	5.26	5.60	99.42	7.34	117.68

Contd...

Table 2 contd...

S. No.	Hybrids	Fruit skin colour	Fruit shape	Flesh colour	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Seed hardness (kg/cm^2)	Ascorbic acid (mg/100 g)
24.	PGH24-C_3-35-20	Cream white	Sub-globose	White	5.70	5.49	90.14	7.28	115.20
25.	PGH25-D_1-11-20	Green-yellowish	Sub-globose	Pinkish	5.73	5.56	97.00	5.95	157.14
26.	PGH26-D_1-12-20	Green-yellowish	Sub-globose	Pinkish	6.11	6.40	113.76	5.76	156.12
27.	PGH27-D_1-13-20	Green-yellowish	Sub-globose	Pinkish	5.73	6.10	107.40	5.30	152.26
28.	PGH28-D_3-26-20	Green-yellowish	Sub-globose	White	4.82	5.19	103.40	4.83	128.55
29.	PGH29-D_3-28-20	Green-yellowish	Sub-globose	White	5.36	5.80	97.76	6.22	124.05
30.	PGH30-D_3-29-20	Green-yellowish	Sub-globose	White	5.80	5.52	102.80	5.39	127.31
31.	PGH31-E_1-2-20	Green-yellowish	Pyriform	Pinkish	5.69	6.20	154.00	5.21	145.49
32.	PGH32-E_1-3-20	Green-yellowish	Pyriform	Pinkish	6.58	6.24	151.91	4.84	139.28
33.	PGH33-E_1-4-20	Green-yellowish	Pyriform	Pinkish	6.37	6.00	142.63	5.30	137.60
34.	PGH34-E_3-11-20	Green-yellowish	Pyriform	Pinkish	6.12	5.80	121.00	5.54	182.06
35.	PGH35-E_3-12-20	Green-yellowish	Pyriform	Pinkish	5.70	5.25	113.00	5.92	184.59
36.	PGH36-E_3-13-20	Green-yellowish	Pyriform	Pinkish	6.03	5.70	110.00	5.78	175.57

Deshmukh *et al*. (6). The maximum (9.18 %) value of total sugar content was recorded in hybrid PGH1-A_1-4-20. The minimum (5.75 %) value was observed in hybrid PGH35-E_3-12-20. The maximum (4.44 %) value of reducing sugar content was recorded in hybrid PGH20-C_2-18-20 while the minimum (3.00 %) value of reducing sugars was observed in hybrid PGH29-D_3-28-20. The non-reducing sugar content ranged from 2.06 % in hybrid PGH9-B_1-11-20 to 4.76 % in hybrid PGH1-A_1-4-20. Mahour *et al.* (10) reported maximum non-reducing sugar content in Surkhi while minimum value was found in Chittidar. Maximum (3.53 mg/100 g) lycopene content was found in PGH1-A_1-4-20. On the other hand, lycopene was found absent in hybrids PGH7-B_1-3-20, PGH8-B_1-6-20, PGH9-B_1-11-20, PGH16-C_1-2-20, PGH17-C_1-3-20, PGH18-C_1-4-20, PGH22-C_3-33-20, PGH23-C_3-34-20, PGH24-C_3-35-20, PGH28-D_3-26-20, PGH29-D_3-28-20 and PGH30-D_3-29-20. The results obtained by Thakre *et al.* (19) reveal that out of the 17 guava genotypes taken under evaluation maximum (6.18 mg/100 g) lycopene content was recorded in RFJ followed by GR-1 (4.43 mg/100 g) and LYLLP (3.53 mg/100 g). The rich diversity in these characters may be due to highly heterozygous and diverse genetic background of the hybrids.

Based on the physical and biochemical characterization hybrid PGH1-A_4-20 was found

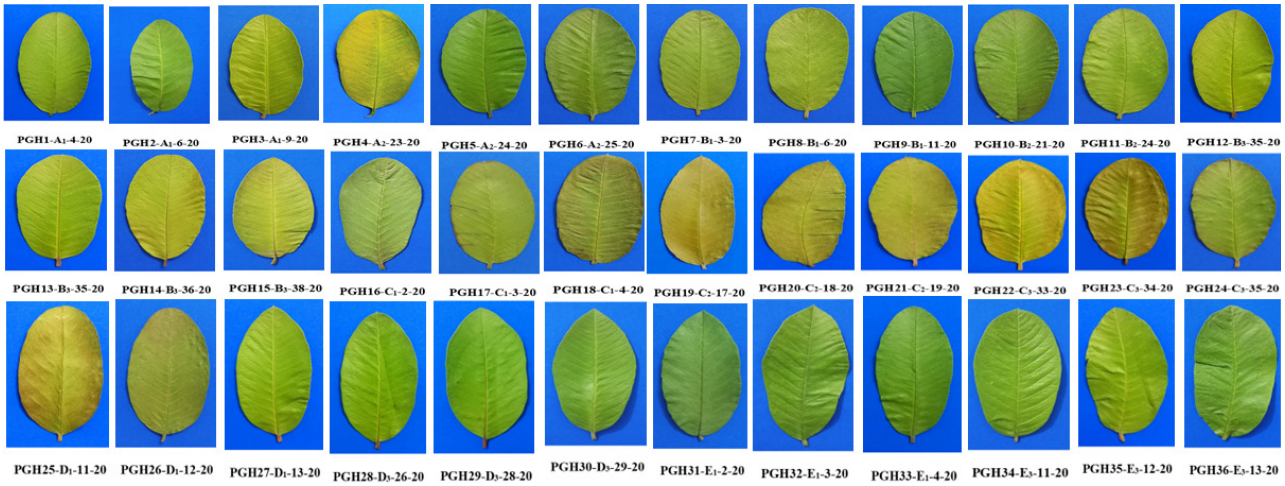

Fig. 3. Variability in foliage characters of different guava hybrids.

different from other hybrids. The identified hybrid showed better yield with good sized fruits. Moreover, the fruits showed better TSS, ascorbic acid content, lycopene content, total and reducing sugar content than the other hybrids and their parents. Hence the identified hybrid can be used in further breeding programs or can be used for commercial cultivation. Since the performance of the identified hybrid is tested under Tarai conditions only it is advised to test the performance under different agro-climatic conditions.

AUTHOR'S CONTRIBUTION

Field experiments and laboratory analysis (MT), Preparation of the manuscript (MT, MK), Conceptualization of the experiments (RK, VPS, NKS, SC), Analysis of data (MT, MK), Editing of the manuscript (MK, VPS, RK).

DECLARATION

Authors of this manuscript declare that they do not have any conflict of interest.

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