

Characterization of Yield and Quality of Guava (*Psidium guajava L.*) Genotypes Under Kymore Plateau & Satpura Hills

THESIS

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**Jawaharlal Nehru Krishi Vishwa Vidyalaya,
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**In partial fulfilment of the requirements for
the Degree of**

MASTER OF SCIENCE

In

**AGRICULTURE
Horticulture (Fruit Science)**

by

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2019

CERTIFICATE - I

This is to certify that the thesis entitled “**Characterization of field and quality of Guava (*Psidium guajava* L.) Genotypes Under Kymore Plateau & Satpura Hills**” submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE in Agriculture, Horticulture (Fruit Science)** of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur is a record of the bonafide research work carried out by **Mr. PAWANDEEP SINGH** under my guidance and supervision. The subject of the thesis has been approved by the Student’s Advisory Committee and the Director of Instruction, J.N.K.V.V., Jabalpur (M.P.).

All the assistance and help received during the course of the investigation have been acknowledged by him.

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The matter embodied in the thesis has not been submitted for the award of any other degree/diploma. Due credit has been made to all the assistance and help.

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Place: Jabalpur

Date:

(PAWANDEEP SINGH)

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INTRODUCTION

Guava (*Psidium guajava* L.) is the most valuable cultivated species of the Myrtaceae family, popularly known as 'poor man's fruit' or 'apple of tropics' (Nakasone and Paull 1998). It is a native to tropical America and distributed in many tropical and subtropical countries (Morton 1987). Guava is commercially grown in India and outside India. It is popular due to its year-round availability, rich nutritional and medicinal value, and affordable price, suitability for transportation, handling and consumer preference. It is the fifth most important fruit crop of India, occupying 3.38 per cent of the total area under fruit cultivation. It is widely grown all over the tropical and subtropical conditions. In India, wide range of variability in guava is reported. Guava represents an excellent source of vitamins-C, as well as calcium, zinc, phosphorus and iron (Singh 2005). Furthermore, fruits, leaves, flowers, roots, bark and stems are used in medicinal applications (Gutierrez *et al.* 2008, Kamath *et al.* 2008). Keeping in view of the above facts, as well as the low cultivation costs, the guava crop is economically important in various tropical and subtropical countries (Rodriguez *et al.* 2010). It is the hardiest crops among tropical fruit trees and excels most of the other fruit crops in productivity and adaptability. Majority of the variability of guava populations is due to the seedling origin, they are variable in fruit colour (both pulp and peel), pulp thickness, numbers of seed and other morphological and quality characters are also reported from different regions. Hence, there is a great potential for the application of characterization of tropical fruit crops like guava. It would further help in identification of potential parent genotypes for effective utilization in future breeding programme. Studies focus on characterization of wild species and local cultivars is still lacking in Indian breeding programme which plays a significant role for further crop improvement.

Guava requires an annual rainfall of 1,000 to 2,000 mm with optimum temperature of 23°C to 26°C, though it can withstand up to 46 °C

(Radha and Mathew, 2007). In the areas having distinct winter, the yield tends to increase as well as quality also improves.

Guava is a perennial, evergreen shrub or small tree, the tree can reach (10 m) in height, with a spreading branches. The guava tree can easily be recognizable for its smooth, thin, brown bark that flakes off, exposing a greenish layer underneath. Guava tree has perfect flowers with male and female parts in each flower; flowers are white, fragrant, 4 cm wide, borne singly or a few together at leaf axils. Fruit is round, oval and pear-shaped berry, growing up to 5.0-12.5 cm length. The thin skin varies in colour from pale-green to light-yellow, blushed with pink for certain cultivars. Underneath the skin is a layer of flavorful sweet and tangy flesh with colour varying from white, yellowish, light pink, dark pink or red. When immature, the fruit is green, hard, and very astringent. When ripe, some varieties have custard like consistency while others are crispy like apple. Pulp is juicy and normally filled with very hard and yellowish seeds (Mortan, 1987).

Keeping in view, the work has been done for “Characterization of yield and quality of guava (*Pisidium guajava* L.)genotypes under KymorePlateau and SatpuraHills” with the following objectives:

Objectives:

1. To study the growth, flowering and fruiting behaviour of guava genotypes
2. To estimate the quality traits and maturity index of existing guava genotypes
3. To categorize the early, medium and late types

REVIEW OF LITERATURE

Guava is grown throughout the country in the tropical and sub-tropical climate on different type of soils. The performance of the cultivars from the different part of country differs under different agro-climatic conditions. The brief reviews of work done in India and abroad have been presented in this chapter.

2.1 Varietal evaluation:

Das *et al.* (1995) found the largest and heaviest fruits of Sardar guava with the highest pulp per centage and lowest number of seeds per fruit. Banarasi, Baruipur and Pear-Shaped fruits had poor physico-chemical characters.

Singh and Mandal (1996) observed the effect of season (rainy and winter) on the growth and yield of two guava cultivars Lucknow-49 and Allahabad Safeda. Lucknow-49 was superior in both the season with regard to the size, weight, length, TSS, acidity and ascorbic acid contents of fruits. Lucknow-49 produced heavier fruits than Allahabad Safeda which contained fewer seeds.

Singh and Sharma (1996) observed that highest fruit weight (109 gm) was recorded for Lucknow-49 followed by Allahabad Safeda (106.8 gm). Wild guava had the lowest fruits (4.23 gm).

Ghosh and Chattopadhyay (1996) evaluated twelve guava cultivars and reported that Chittidar gave the highest yields (38.0 kg) followed by Lucknow-49 (35.9 kg) per plant and Seedless, Supreme and Allahabad Safeda gave the lowest yield 6.4, 19.4 and 20.8 kg per plant, respectively. Fruit weight and size were highest in Lucknow-49 and Allahabad Safeda and lowest in Seedless. Fruit quality was excellent in Lucknow-49 and Allahabad Safeda.

Bulk *et al.* (1997) analysed chemical contents of guava fruit and found that the ascorbic acid increased significantly with fruit maturity in all cultivars. The highest content varied between 88.2 and 113.3

mg100g⁻¹. TSS gradually increased with fruit development in all cultivars, which differed in their final value (11.2-13.0⁰ Brix.).

Gerhard *et al.* (1997) investigated four varieties and reported that the fruit of IAC4 had the thickest flesh, highest flesh/core ratio and TSS content. Fruits of Patillo showed good physical characteristics, the highest ascorbic acid contents but its white flesh had unpleasant flavor. Riverside Vermelha had highest mean fruit weight (79.7gm).

Mattiuzet *et al.* (1997) reported that fruit growth based on diameter and length on 4-yearold guava cultivars Paluma. Red selection of Florida and Patillo plants was rapid from 0 to 20 days, after which it slowed until day 80, when a new growth burst was observed. Red selection had the greatest mean daily fruit length, while Patillo could grow only 0.027 cm day⁻¹ diameter and 0.033 cm day⁻¹ in length.

Pandey *et al.* (1997) evaluated nine guava cultivars and reported maximum height of Seedless guava with lowest yield. Whereas, Chittidar was found to have maximum volume and yield, Gwalior-27 and Apple Colour were dwarf cultivars and had the best quality fruits, Seedless had no seeds. Apple Colour and Sardar contained seeds.

Sharma *et al.* (1998) evaluated nine varieties of guava viz., Allahabad Safeda, Sardar, Chittidar, Red Fleshed, Seedless, Apple Coloured, Dharidar, Gwalior-27 and Rewa-72 for four years. Among the varieties Chittidar, Seedless and Sardar were significantly superior to other cultivars in respect of growth and vigour whereas Gwalior-27, Allahabad Safeda and Dharidar were significantly inferior. On a four-year bearing mean yield basis, it was observed that Allahabad Safeda gave the highest yield followed by Chittidar, Sardar and Dharidar. Seedless, Rewa-72 and Red Fleshed gave the lower yield per plant. The fruits of Allahabad Safeda, Seedless and Sardar were of better quality as compared to other varieties.

Kundu *et al.* (1998) studied growth and maturity of fruit of five guava cultivars of 11- year-old tree Allahabad Safeda, Apple Colour,

Chittidar, L-49 and Seedless. He started growth study from 30 days after fruits set in 10-day-intervals until fruits harvest. Three distinct stages of fruit growth were observed in all the cultivars, differing in the rate of growth. The ratio of T.S.S to acids increased markedly towards the last growth.

Selvaraj *et al.* (1999) assessed and analysed the guava fruits of Allahabad Safeda and Sardar harvested at different developmental stages for their physico-chemical characters, Total pectin content in Allahabad Safeda was observed to be higher at early stages, which gradually decreased up to the ripening stage. However, in the case of Sardar, a decreasing trend was observed at early stages followed by slight increasing order at mid stage which again showed decreasing order at later stage up to the ripe stage.

Reddy *et al.* (1999) reported that the overall performance of the cultivars Lucknow-49, Allahabad Safeda was best suited for commercial cultivation in the region. However, Allahabad Safeda was the second highest yielder with quality fruits and hence may also be considered for plantation in Chhotanagpur plateau, ArkaMridula containing soft seeds with fine texture and sweet pulp, can also be recommended for cultivation in this region.

Biswas (1999) studied the physico-chemical characteristics of six guava cultivars viz., Swaroop Kathi, Deshi, Seedless, Kashi, Kazi and Rachi collected in June in Rajshani, Bangladesh were determined. Kazi recorded the highest moisture content (83.90 per cent); fruit weight (310 gm), diameter (23.22 cm) and fruit length (8.40 cm); pulp weight (280.10 gm) and per centage (90.35 per cent); total soluble solids (12.20 per cent); acidity (0.38 per cent); total sugars (7.40 per cent), and reducing (3.50 per cent) and nonreducing sugars (3.90 per cent), whereas Swaroop Kathi recorded the highest ascorbic acid content (188.50 mg100 g⁻¹).

Khattaket *al.* (1999) tested on fruit and juice characteristics of guava cultivars Waikea, Holumberg, Selection No.8 (SN-8),Kahuakola

and Beaumont grown at Islamabad, Pakistan were compared. Physical characteristics such as growth habit of plant, leaf length and width, maturity tests, fruit size and shape, cross and longitudinal section of fruit, skin surface and colour, pulp colour, and the seed core were studied. In juice the following parameters were quantified: total acidity, TSS, pH, total and reducing sugars, pectin and vitamin C.

Gonzaga Neto *et al.* (1999) tested the agronomic performance of 4 Indian varieties of guava (Allahabad Safeda, Chittidar, Banarasi and Lucknow 49) in Petrolina, Brazil, during 1993-98. Average yield varied between 125.43 and 170.41 kg for the varieties Chittidar and Allahabad Safeda, respectively. Large variations in yield were observed within varieties. The average of number of fruits per plant per harvest was 135 and 187 for Banarasi and Lucknow 49, respectively. With the exception of Chittidar, the varieties produced fruits with white pulp.

Jain *et al.* (2000) reported that considerable variation among genotypes of guava for various traits. On the basis of physical parameters, the genotype G-135 was found superior out of forty-eight genotypes, followed by G-90 and G-110.

Singh (2000) reported that maximum extension growth of guava (*Psidium guajava* L.) was recorded in spring season followed by rainy and winter season. Highest yield per plant was obtained in rainy season followed by winter and spring season, while maximum TSS, acidity and vitamin "C" content were found in winter season followed by spring and rainy season.

Singh *et al.* (2002) obtained maximum fruit weight in Allahabad Safeda followed by 'Safed Jam' during both seasons and least fruit weight was found in KohirSafeda, rainy-season fruits had less fruit weight than of winter season in all germplasm. The rainy-season crop recorded more fruit yield than winter season crop. Maximum T.S.S. and vitamin C was recorded in Allahabad Safeda.

Babuet *et al.* (2002) investigated the performance of 10 guava cultivars evaluated in a field experiment conducted in Meghalaya, India

during the rainy season of 2000. Significant differences were recorded for crop yield, number of fruits per tree and fruit weight and length, with Lucknow-49, Selection-1, Selection-11 and Allahabad Safeda recording the highest values for the parameters measured, respectively. Skin colour varied from light to greenish yellow. Seed content was least in Selection-11. Both Selection-11 and Allahabad Safeda were soft-seeded. Selection-11 recorded the highest total soluble solids and ascorbic acid content, whereas Selection-1 recorded the highest titratable acidity. Lucknow-49, Allahabad Safeda, Selection-1 and Selection-7 gave high yields, whereas Selection-11, Selection-7, Lucknow-49 and Allahabad Safeda gave high quality fruits.

Shrivastava (2005) tested on guava germplasm grown under agro-climatic region of Kymore plateau and Satpura hills region. The extent of variation in the different morphological, physical, chemical and yield parameters of different types have been found.

Thaipong and Boonprakob (2005) evaluated the proportion of genetic and environmental variances for fruit weight (FW), total soluble solids (TSS) and ascorbic acid (AA) in guava were estimated with eight genotypes, four trees per genotype and five fruits per tree for two seasons. A high proportion of genotypic variance was found with FW and AA indicating that genetic improvement for these traits through breeding and selection was achievable. Seasonal variance in among fruits within tree variance was greatest for TSS.

Tomaret *et al.* (2005) assessed the yield attributes and yields of two guava cultivars (Gwalior-27 and Lucknow-49) for two years at the Horticulture Research Station, Agriculture College in Gwalior, Madhya Pradesh, India. The average fruit diameter, fruit length and fruit weight of Gwalior-27 were higher compared to those of Lucknow-49. On the other hand, the total acidity, TSS per centage and total sugar and ascorbic acid were higher in Lucknow-49 than in Gwalior-27.

Patel *et al.* (2005) reported the fruit quality in 8 guava cultivars (Allahabad Safeda, Lucknow-49, Apple guava, Dharidar, Hafsi,

Seedless, Chittidar and Rewa-72) grown in Rewa, Madhya Pradesh, India, during 2000-01. Dharidar recorded the greatest fruit weight (192.50 gm), fruit length (7.31 cm), flesh weight (127.68 gm), seed ball weight (64.85 gm) and seed ball diameter (4.67 cm). The specific gravity did not significantly vary among the cultivars. Flesh thickness was greatest in Seedless (1.66 cm). The greatest breadth/length ratio per fruit (1:261) was registered for Apple guava. The number of seeds per fruit varied from 4.66 (Seedless) to 583.83 (Rewa-72). Allahabad Safeda fruits had the highest TSS (total soluble solids) and total sugar (11.80 per cent) and ascorbic acid (250.80 mg100 g⁻¹ of pulp) contents, as well the lowest level of acidity (0.25 per cent). Thus, this cultivar was superior among the cultivars in fruit quality.

Kumar *et al.* (2006) found that the highest length of the fruit in cv. Allahabad Safeda (7.7 cm) while, breadth and weight were highest in cv. L-49 (7.8 cm and 235.50 gm respectively) followed by Allahabad Safeda (7.2 cm and 210 gm respectively). Cv. Chittidar had highest TSS (10⁰ Brix) followed by Apple Colour (9.8⁰ Brix). Acidity ranged between 0.38 (L-49) to 1.53 (Apple Colour) and maximum sugar was found in cv. L-49 (7.06 per cent) followed by Chittidar (6.97 per cent).

Rajanet *et al.* (2007) observed that the efficiency of guava breeding programme for low seed content can be enhanced by choosing superior cross combination made by divergent clones.

Sahay and Kumar(2007) reported that the maximum fruit length was found in Kasba (3.96 cm) followed by Purvi (3.86 cm). In respect of fruit breadth, it was maximum in Lal Bombai (3.75 cm) whereas, minimum was in Bedana (2.20 cm).

Nema (2007) tested on guava genotypes under climatic region of Kymore plateau and Satpura hills region and the extent of variation in the different morphological, physical, chemical and yield parameters of different types have been found.

Singh and Singh (2007) conducted an experiment in which, Allahabad Safeda and Sardar were subjected to uniformity trial

analysis. Data on tree height, canopy spread, fruit number and fruit weight for 100 trees each in Allahabad Safeda and Sardar were compiled for four consecutive years. In the present investigation, it was found that yield could be predicted with the help of fruit number and fruit weight by selecting an optimum sample size of 35 for each character for cultivar Allahabad Safeda and 39,38 in Sardar at 95 per cent confidence probability, respectively for the above characters, with condition that the sample mean falls within 5 per cent of the actual value.

Pandey *et al.* (2007) evaluated eleven newly developed guava hybrids/selections. The tree height, stem circumference and canopy spread were maximum in Hybrid-21, individual fruit weight was highest in cultivar Shweta (CISH-G-4), while fruit yield was maximum in Lalit. Maximum TSS ($^{\circ}$ Brix), total sugar and reducing sugar contents and minimum acidity were recorded in Hisar Surkha and ascorbic acid content was highest in cultivar Shweta (CISH-G-4).

Patel *et al.* (2007) evaluated five year old six guava hybrids/cultivars viz. Hybrid-1, Hybrid-2, Hybrid-11, Allahabad Safeda, L-49 and EC-12 and reported that Hybrid-11 was found superior in stem diameter (8.51 cm), mean tree spread (2.68 m) and yield (18.50 kg tree⁻¹), while cultivar L-49 was found better in fruit weight (152.50 g), fruit length (6.56 cm) and fruit diameter (6.91 cm). However, Hybrid-1 was found better in quality traits like T.S.S. (10.40⁰ Brix), vitamin 'C' (296 mg 100 g⁻¹), reducing sugar (2.67 per cent), non-reducing sugar (5.37 per cent) and total sugar (8.04 per cent).

Marak and Mukunda (2007) tested on crop improvement in guava (*Psidium guajava* L.) by selection of open pollinated seedlings progenies of Apple Colour cultivar was initiated in 272 six-year-old seedlings grown in farmer's field at Ramanagara taluk of Bangalore Rural District, Karnataka. These 272 seedlings were short-listed to ten seedlings based on attractive and bright red colour of skin along with superior fruit quality. Studies on these ten open pollinated progenies of guava revealed that A.C. Seln. 6/10 was an outstanding one with dwarf

stature (1.98 m), moderate yield with medium to large sized fruit (143.43 gm), attractive shape, good volume (165.28 ml), high TSS (13.80°Brix), moderate acidity (0.37 per cent citric acidity) and high ascorbic acid (194.85 mg100 g⁻¹) content. The total sugars (8.27 per cent), reducing sugar (4.46 per cent) and non-reducing sugar (3.80 per cent) were also high in this selection with moderate to good sugar/acid blend (22:10). The fruits are very attractive, uniformly bright red in colour with lycopene pigment of 3.61 mg100 g⁻¹ of fruit. The fruits fetch the highest score in characteristics such as peel colour (13.45 out of 15), pulp colour (12.20 out of 15) and the organoleptic taste of pulp (22.30 score out of 30). Further, the overall acceptance of the fruit for organoleptic qualities was also highest (79.03 score out of 100). Hence this selection could be utilized for commercial cultivation.

Choudhary *et al.* (2007) reported that the eighteen genotypes of guava grown in West Bengal, India which were evaluated for yield and yield components (tree characters, leaf and shoot characters, flowering and fruiting characters). Highest yield was obtained from Kabri (98.3 kg), Bhagalpur (90.6 kg), Mohammad Khaja (88.5 kg), Dudh Khaja (88.2 kg) and Teli (84.1 kg). Considering the characters, the genotypes Dudh Khaja, Kafri Khaja, Bhagalpur, L-49, Allahabad Safeda, Kabri and Teli can be recommended for cultivation in West Bengal.

Babuet *al.* (2007) evaluated the yield and quality traits of seven-year-old guava hybrids, both Red and White Flesh types, during the rainy season of 2002 and 2003, in Meghalaya, India. Hybrid-3 topped the list of all hybrids with respect to productivity (22.50 kgtree⁻¹). Fruit weight was maximum in Hybrid-7 (151.50 gm), which was followed by Hybrid-11 (128.25 gm). Hybrid-7 (8.5/cut surface) and Hybrid-8 (10.0/cut surface) were found to contain less seed. Vitamin-C content was highest in Hybrid-3 (258.50 mg100 g⁻¹) followed by Hybrid-1 (240.00 mg100 g⁻¹). Total soluble solids content was highest in Hybrid-7 (11.5 per cent) followed by Hybrid-1 (11.2 per cent). The White Flesh types, Hybrid-7 and Hybrid-1, with high TSS, vitamin-C and less

pronouncement towards seediness are best suitable for growing under mid hill altitude of Meghalaya.

Singh and Jain (2007) reported that Allahabad Safeda is a well-known guava cultivar and is recommended for cultivation in throughout India. In agroclimatic conditions of Chhattisgarh, the fruit growth of Allahabad Safeda in terms of length and width was maximum during 30-60 days, while in terms of weight and volume the highest growth period was 60-90 days from fruit set. The TSS (total soluble solids) showed increasing trend during whole growth period and maximum (14.93 per cent) at 150 days. The ratio of TSS and acidity initially increased up to 90 days and then decreased up to 120 days. This ratio again increased during the period of 120-150 days of fruit growth. Ascorbic acid content was recorded very low (15.4 mg100 g⁻¹) at initial stage of fruit growth and highest (270.80 mg100 g⁻¹) on 150 days.

Singh *et al.* (2008) assessed on ten important cultivars of guava to evaluate the physico-chemical attributes in rainy and winter season during 2006-07. The maximum fruit length, diameter, weight, T.S.S., ascorbic acid, total sugar and pectin were recorded in the cv. L-49 during both the season followed by cv. Allahabad Safeda except TSS and pectin. Highest seed weight was found in cv. Apple Colour and BanarasiSurkha during rainy and winter season, respectively. Maximum seed/pulp ratio, palatability rating and lowest level of acidity were noted in cv. Allahabad Safeda followed by L-49.

Dubey *et al.* (2009) found that Allahabad Safeda had less acidity (0.26 per cent) giving rise to maximum TSS: acid ratio closely followed by Safed jam. Ascorbic acid content of fruit was also maximum in Allahabad Safeda (298.00 mg100 g⁻¹). Allahabad Safeda showed superiority over others due to varietal characters.

Jana *et al.* (2010) assessed about the evaluation of guava (*Psidium guajava*L.) genotypes based on fruit morphology, physico-chemical properties and yield under Eastern Plateau Condition. He reported that the characteristics of Mild Flesh cultivar was accounted

for the maximum fruit weight (179.4 gm) and ascorbic acid content (265.83 mg100 gm pulp⁻¹) whereas the cultivar CHG-5 had higher T.S.S. content of 10.26^o Brix during rainy season. As winter crop, the cultivar Mild Flesh recorded the maximum fruit weight of 199.1 gm whereas the cultivars Seed Drop and Kairnla Seedling exhibited highest T.S.S. content of 12.86^o Brix but later had the maximum ascorbic acid content of 358.33 mg100 gm⁻¹ pulp.

Sharma *et al.* (2010) reported that out of sixteen morphological characters only the inflorescence type did not show any variations, while the remaining trends showed variability to a considerable extent. Morphological data on different genotypes exhibited similarity in matrix which ranged from 0.06 to 0.50 and based on this clusters analysis was performed using UPGMA. The genetic variation among genotypes was high enough to divide them into two major clusters.

Nag *et al.* (2011) evaluated that chemical changes of different guava varieties during different ripening stages. Fruit was harvested at three different ripening stages such as 1) green mature 2) colour break down from green 3) yellow or yellowish green. Vit. C, reducing sugar, non-reducing sugar, total sugar and TSS content (fresh weight basis) increased significantly during ripening.

Sharma *et al.* (2011) reported that maximum fruit set (65 per cent) was observed in Lucknow-49 which was significantly higher as compared to other cultivars. The minimum fruit set (53 per cent) and maximum fruit drop (47 per cent) was observed in cv. Hisar Surkha that was significantly lower than the other cultivars. Maximum fruit set was recorded during spring flowering season.

Choudhary *et al.* (2012) found that the cultivar Rewa-72 had maximum weight of seed and non-edible waste followed by L-49, Allahabad Safeda and Apple colour. The highest acidity was observed in the cv. Rewa-72, while minimum content in Allahabad Safeda. The cultivar Allahabad Safeda recorded high pH followed by L-49, Apple Colour and Rewa-72.

Haji *et al.* (2012) reported that the fruits during winter season showed significantly higher fruit size and weight as compared to the rainy season fruits. The chemical constituents also varied significantly under the influence of season. Fruits from winter season crops were having higher TSS, reducing sugar, total sugars, titrable acidity and ascorbic acid content; however non-reducing sugars were found higher in rainy season crop. Thus, winter season crop should be preferred.

Mahouret *et al.* (2012) studied that the ripe fruits of 20 selected varieties of guava for their physico-chemical characters under malwa plateau of Madhya Pradesh. Significant variation in fruit characters i.e. size, weight, pulp, seed, TSS, acidity, reducing sugar, non-reducing sugar, total sugar and ascorbic acid content were recorded among various varieties. In general, Allahabad safeda and Lucknow-49 was superior as compared to other varieties/germplasm in relation to different physicochemical parameters of fruit. The other varieties/germplasm i.e. Rewa-72, Dharidar, Apple colour and Gwalior-27 was also superior in some of the characters as compared to the other varieties/germplasm.

Deshmukh *et al.* (2013) reported that the fruit yield was significantly highest in RCGH 1 (39.05 kgplant⁻¹) followed by Allahabad Safeda (31.37 kgplant⁻¹), however lowest in L-49 (21.26 kgplant⁻¹) and had significantly less than RCGH 7 (24.26 kgplant⁻¹). The highest fruit weight was recorded in RCGH 4 (183.52 gm). While less number of seeds100 g⁻¹ fruit weight was recorded in RCGH 7 (111.18). In fruit quality hybrid RCGH 1 recorded highest TSS (10.83⁰ Brix), ascorbic acid (231.86 mg100g⁻¹) and total sugar (8.07 per cent) with lowest acidity (0.50 per cent) followed by RCGH 7 (10.39⁰ Brix, 205.26 mg100g⁻¹, 8.05 per cent and 0.51 per cent), respectively, and found superior over Allahabad Safeda and L 49 under mid-hills situations.

Ghosh *et al.* (2013) investigated about performance of twenty one guava cultivars in red and laterite soil of West Bengal under irrigated condition and after four years of study reported that Banarasi cultivar produced higher average yield (73.7kg plant⁻¹ year⁻¹) followed

by Allahabad Safeda, (71.6kg plant⁻¹ year⁻¹) and Apple colour (69.5kg plant⁻¹year⁻¹). Fruit weight was maximum in Almond Iskbala followed by Red Fleshed and Apple Colour. Maximum ascorbic acid content was in Supreme followed by Seedless. Considering the overall performance, 'Banarasi' and 'Apple Colour' cultivars of guava are recommended for cultivation in red and laterite zone of West Bengal.

Ahmed Zaki El-Sisy (2013) tested and he was carried out the Total soluble solids (TSS) values increased with fruit ripening, the highest values were in stage 3 (full yellow). There were no significant differences between guava genotypes in fruit weight and fruit diameter, length and width during fruit ripening. Fruit acidity (per cent) significantly decreased with fruit ripening and the lowest values was in stage 3 (full-yellow), it was associated with significant increase in total sugars (per cent), reducing and non-reducing sugars contents, which increased and then declined. For vitamin C content there were no significant differences observed between stages of ripening in 2012, while it increased significantly and then decreased with fruit ripening in 2013.

Dolkaret *al.* (2014) was observed that the L-49 was first to flower, while the duration of flowering was longer in Allahabad Safeda followed by L-49 and shortest in Lalit and Pant Prabhat. L-49 was superior to all other cultivars in terms of yield attributes as it registered highest fruit yield, fruit set with lowest fruit drop. Among the various physical characters, it was found that the fruit weight and fruit volume was highest in L-49, while Allahabad Safeda produced biggest size fruit. Highest numbers of seeds per fruit were observed in ArkaAmulya followed by Pant Prabhat, whereas lowest seed number was observed in Lalit.

Jana *et al.* (2014) observed that fruit weight and fruit size were gradually increased from summer to rainy season and thereby winter season. TSS was low in rainy season, medium in winter season and high in summer season (13.70^o Brix, cv. Seed Drop). However, ascorbic acid content was maximum in winter season (358 mg100g⁻¹

pulp, cv. Kairala Seedling) followed by summer and rainy season. The maximum yield was observed in rainy season ($27.39 \text{ kg tree}^{-1}$, cv. Allahabad Safeda) followed by winter and summer season in this ecosystem.

Kumar *et al.* (2015) reported that the genotype L-49 has highest pulp weight (206.02 gm). The genotype GRS4 had significantly lowest number of seed and weight of seeds per fruit (194.33) and (1.91 gm), respectively. The genotype L-49 was recorded the highest fruit weight (214.03 gm). The highest pulp content (96.55 per cent), number of fruits per tree (406.44) and fruit yield ($52.9 \text{ kg tree}^{-1}$ and 21.15 Mtha^{-1}) was observed in genotype GRS4.

Patel *et al.* (2015) studied the physiological and biochemical changes during fruit growth, development and maturity of eleven genotypes of guava fruit at 30, 60, 90, 105, 120 and 127 days after fruit set (DAFS). Fruit weight, length and diameter of guava fruit increased continuously from the initial stage of fruit development till maturity and ripening in all the genotypes. The increases in fruit weight and diameter were comparatively more between 30 to 60 DAFS and 90 to 127 DAFS than 60 to 90 DAFS where the increase in fruit weight and diameter was slow in most of the genotypes.

Verma and Singh (2015) reported that maximum fruit length, width, weight, volume was recorded in L-49 and GorakhBilashPasand followed by Sweta. The maximum acidity was recorded in L-49 which was comparable to Allahabad Safeda and Sweta. The highest vitamin 'C' was recorded in L-49 followed by Allahabad Safeda and Sweta. The maximum TSS was recorded in Lalit and Sangam.

Gupta *et al.* (2016) reported that Lucknow-49 was the most successful variety with the highest fruit yield (78 and 114 kg tree^{-1}) followed by cv. Allahabad Safeda (61 and 88 kg tree^{-1}) in rainy and winter season, respectively. Apple colour cv. recorded lowest (24 kg tree^{-1}) fruit yield during rainy season however cv. Hybrid-2 observed the lowest fruit yield (43 kg tree^{-1}) in winter season.

Mehta *et al.* (2016) reported that the maximum fruit weight of guava (158.08 gm), fruit length of guava (6.10 cm), diameter of guava fruits (6.45 cm), number of seed/100gm⁻¹ fruit weight (146.51 gm) was found in the T1 (Lucknow-49) cultivar and the minimum fruit weight (108.18 gm) was recorded under T3 (Pant Prabhat) cultivar and total soluble solids (11.82^o Brix), acidity (0.60 per cent), total sugar content (7.38 per cent), vitamin-C (ascorbic acid) in guava fruits (230.44mg/100 gm⁻¹) were found in T2 (Allahabad Safeda) cultivar.

2.2 Correlation studies:

Thimmappaiah and Suman (1986) worked out correlation among the fruit and yield characters in winter season guava crop. They found high correlation of fruit weight with fruit diameter, fruit length and seed weight per fruit. The seed weight per fruit was found as the most important character which not only influence the size and weight but also the quality of fruits. However, the correlation between fruit weight and other characters like acidity, total soluble solids, ascorbic acid content and yield were not significant.

Prasad (1987) carried out correlation studies on growth behaviors, fruit characters and yield component of forty varieties of mango. They noted positive and significant correlation between the number of fruits and their size with T.S.S., ascorbic acid, fruit weight and fruit volume. Plant spread (N-S and E-W) had a positive indirect effect through different aspects of fruit growth and yield.

Kurmi (1992) studied the correlation coefficient between different characters of guava. The study revealed that average weight per fruit showed significant positive association with length per fruit, width per fruit, flesh weight per fruit, seed ball weight per fruit and seed ball diameter per fruit. Length per fruit had significant positive association with width, flesh weight, seed ball diameter and seed weight per fruit. Flesh weight per fruit was positively associated with seed ball weight per fruit. Non-reducing sugar showed significant positive association with total sugars. The association between total sugar and T.S.S. was

also positively significant. Acidity per centage showed significant negative association with total sugars, T.S.S. and non-reducing sugar.

Pandey *et al.* (1997) worked out correlation coefficient between different characters of nine guava varieties and found that all vegetative characters were associated positively or negatively with each other and number of fruits/plant⁻¹, length, width and weight/fruit were positively associated with each other and T.S.S., reducing, non-reducing and total sugars had positive association with each other.

Pandey *et al.* (2002) tested 48 guava genotypes in Jabalpur, Madhya Pradesh, India and found that the correlation among fruit weight, fruit diameter, fruit length, fruit width, pulp thickness, and pulp per centage were positively and significantly correlated.

Mrinalini and Tiwari (2008) conducted field studies in Pantnagar, Uttar Pradesh, India, to determine the genetic variation, heritability and genetic advance (GA) of 13 fruit characters in 15 guava genotypes. Significant differences were observed for almost all traits studied, i.e. fruit weight, fruit length, fruit diameter, acidity and ascorbic acid with high values of genotypic coefficient of variation, phenotypic coefficient of variation which makes them prime traits for direct selection. Total soluble solids, total sugars, reducing and non-reducing sugars are the other important characters which were considered for selection. The fruit yield per tree was positively and significantly correlated with fruit weight and fruit length.

Raghava and Tiwari (2008) evaluated the correlation analysis of fruit characters in guava genotypes and reported that the fruit yield/tree was positively and significantly correlated with fruit weight and fruit length.

Agrawal (2010) assessed the correlation in a characters of guava and found that weight of fruit had significant positive correlation with length of fruit but there was significant negative association with pulp per centage and thickness of pulp. The total soluble-solids

showed positive correlation with reducing, non-reducing and total sugars.

Lakadeet *al.* (2011) revealed that fruit yield per hectare exhibited highly significant and positive correlation with height of tree, tree volume, number of fruits per tree, ascorbic acid and total sugar at genotypic and phenotypic level and pulp content at genotypic level. Fruit yield per hectare also showed significant and positive correlation with TSS and non-reducing sugar at genotypic and phenotypic level and pulp content at phenotypic level. Also, it showed highly significant but negative correlation with number of seeds per fruit, weight of 100 seeds and acidity at genotypic level, whereas, it showed significant but negative association with days to maturity at both the levels. The remaining characters *viz.*, weight of fruit, weight of pulp and reducing sugar showed positive correlation with fruit yield per hectare at both the levels.

MATERIAL AND METHODS

The present investigation entitled “Characterization of yield and quality of guava (*Psidium guajava*L.) genotypes under KymorePlateau&SatpuraHills” was conducted during the year 2018-2019 with the objects to find out promising genotypes of guava for Jabalpur region.

The method employed during the course of investigation and material used and techniques applied in carrying out the investigation are described under the following heads.

3.1 Experimentalsite:

The present investigation was carried out at Fruit Research Station, Imalia, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) and the chemical analysis of fruits was done in the laboratory of the department of Food Science and Technology.

3.2 Climate and weather condition:

The climate of Jabalpur region is semi-arid and subtropical having warm and dry spring summer and cool winter as main characteristics feature, in general the maximum and minimum temperature reaches above 45°C and below 5°C, respectively. The relative humidity varies from 70-80 per cent. The average annual rainfall of about 1375 mm, which is mainly distributed from Mid-June to first week of October from south-west monsoon with occasional rain during winter.

The meteorological data were recorded during the experimental period June to December 2018 from the Department of Physics and Agro-meteorology, College of Agricultural Engineering, JNKVV, Jabalpur (M.P.) and summarized in Table 3.1 and graphically presented in Fig 3.1

Table 3.1 Weekly meteorological data during the period of investigation(June- December 2018)

Standard Meteorological weeks (SMW)	Temperature(°c)		Relative Humidity (%)		Sunshine (Hrs.)	Rainfall (mm.)	Rainy Days
	Max.	Min.	Morn.	Even.			
23	39.6	27.4	67.4	47.1	4.9	7.8	1
24	31.9	24.8	94.0	79.6	1.9	2.4	0
25	29.9	24.5	96.1	86.0	0.4	48.2	4
26	33.6	25.3	84.6	76.3	2.2	60.6	3
27	32.5	24.6	86.0	67.4	3.9	373.3	7
28	32.4	24.8	92.4	78.1	1.8	83.6	5
29	31.4	24.8	95.3	79.9	1.8	63.6	3
30	28.7	23.6	95.0	88.4	0.0	61.8	3
31	29.6	24.3	89.0	72.9	0.5	196.4	5
32	29.4	24.3	93.3	83.7	0.6	132.8	4
33	30.3	24.6	94.0	77.9	2.6	182.9	7
34	28.5	23.3	95.1	93.0	0.9	263.2	6
35	26.8	23.4	95.3	91.4	0.3	35.2	4
36	26.8	22.6	96.4	84.3	0.3	17.6	2
37	31.2	22.7	90.0	69.1	8.1	18	1
38	31.1	22.7	91.0	72.0	6.0	3.8	0
39	32.8	22.1	90.0	61.7	8.0	52.4	3
40	34.2	19.8	88.7	53.9	9.2	24.2	2
41	32.0	18.0	86.4	60.7	8.1	0	0
42	32.7	17.8	85.7	53.3	8.7	0	0
43	31.9	14.7	84.9	52.9	9.2	0	0
44	30.5	15.1	87.7	45.6	8.6	0	0
45	29.0	10.9	84.9	28.6	8.3	0	0
46	30.5	9.0	82.4	35.3	8.8	0	0
47	29.7	9.9	84.3	30.3	8.0	0	0
48	27.0	8.2	84.4	34.1	6.7	0	0
49	25.6	9.0	85.9	33.9	4.4	0	0
50	24.4	7.9	83.3	43.3	5.1	0	0
51	22.3	4.8	77.4	36.6	7.1	0	0
52	22.8	4.8	75.8	31.4	8.2	0	0

3.3 Experimental details:

The large number of guava seedlings were planted in Fruit Research Station, Imalia during the year 2006-07. The large population of genotypes is existed at the center.

3.4 Selection criteria:

During the study only 21 genotypes were selected from the existing genotype population for detailed study on the basis of plant type, growth, leaf size, flowering, fruiting, fruit size and rest were discarded. The selected genotypes were given accession number (G-1..... G-21).

Screening of guava seedlings was undertaken to select out the superior type for further study and multiplication. Genotypes selected from the existing population and plant were tagged to study their morphological and Physico-chemical characteristics.

Table 3.2 Treatment Details:

Sr. No.	Treatment	Sr. No.	Treatment
1.	Jawahar Guava-1	12.	Jawahar Guava-12
2.	Jawahar Guava-2	13.	Jawahar Guava-13
3.	Jawahar Guava-3	14.	Jawahar Guava-14
4.	Jawahar Guava-4	15.	Jawahar Guava-15
5.	Jawahar Guava-5	16.	Jawahar Guava-16
6.	Jawahar Guava-6	17.	Jawahar Guava-17
7.	Jawahar Guava-7	18.	Jawahar Guava-18
8.	Jawahar Guava-8	19.	Jawahar Guava-19
9.	Jawahar Guava-9	20.	Jawahar Guava-20
10.	Jawahar Guava-10	21.	Jawahar Guava-21
11.	Jawahar Guava-11		

3.5 Observation recorded:

The observations were recorded on the following aspects.

3.5.1 Morphological parameters:

1. Tree height (m)- Tall /medium/small
2. Canopy spread (m)- East-West, North-South
3. Shape of canopy- Erect/ spread/ semi spread
4. Bark colour- Whitish/light brown/dark brown
5. Date of bud emergence
6. Date of bud burst
7. Date of first flowering
8. Date of 50% flowering
9. Date of first fruit set
10. Date of 50% fruit set
11. Leaf characteristics-
 - (a) Number of leaves per 30cm length of shoot
 - (b) Leaf length
 - (c) Leaf breadth
 - (d) Leaf colour

3.5.2 Physico-chemical parameters:

1. Fruit length (cm) and width (cm) at maturity
2. Number of seeds fruit⁻¹
3. Pulp percentage
4. Pulp thickness
5. Pulp colour
6. Fruit colour
7. Seed size
8. Seed hardness
9. Average fruit weight

3.5.3 Qualitative parameters:

1. TSS (%)
2. Reducing sugar (%)
3. Total sugar (%)
4. Non- Reducing sugar (%)
5. Vitamin C (mg100gm⁻¹ pulp)
6. Acidity (%)

3.5.4 Yield attributes:

1. Days to harvest after fruit set
2. No. of fruitsplant⁻¹
3. Crop duration
4. Yieldplant⁻¹ (kg)

3.5.1 Morphological parameters:

The growth observations of each plant of the experiment were recorded on the following heads.

3.5.1.1 Tree height (m):The height of the genotype was measured from ground level to the tip of the terminal shoot in meters with the help of measuring device at flowering time.

3.5.1.2Canopy spread:The canopy height of the genotypes was recorded from North-South and East-West direction in meters.

3.5.1.3Shape of canopy:Shape of canopy (Erect/Spread/Semi-spread) was observed by visual observation.

3.5.1.4Bark colour:Bark colour(Whitish/Light brown/Dark brown) was also observed on the basis of visual observation.

3.5.1.5 Date of bud emergence:The date of flower bud emergence was Noted when small swollen buds appear on the tagged twig of the plants.

3.5.1.6 Date of bud burst:After the emergence of bud, the next stage is bud burst. In this stage there is formation of petal and sepal take palace.

3.5.1.7 Date of firstflowering:When the tagged buds start to opening, the date of start flowering was noted.

3.5.1.8Date of 50% flowering:The date of taken for 50 percent flowering was counted from the opening of first flower in a plant.

3.5.1.9Date of first fruit set:The date of fruit setting was noted. When the small structure appeared after the shedding of petals.

3.5.1.10 Date of 50% fruit set:The date of taken for 50 percent fruit setting was counted from the setting of first fruit in a plant.

3.5.1.11Leaf characters:The leaf samples were collected at randomly from shoots of current season growth. The leaves at the 5th position from the apex were collected for recording the observation. Observation on the following leaf characters were recorded for comparison.

3.5.1.11.1 Number of leaves30cm⁻¹length of shoot:30cm size of shoot is measured bymeter scale from top of shoot and counted number of leaves was noted.

The average leaf length, width for genotypes was worked out for comparison.

3.5.1.11.2 Leaf length (cm):Length of selected samples was recorded from base to tip in centimeters with the help of measuring scale.

3.5.1.11.3 Leaf breadth (cm):The width of leaves was recorded at the maximum point of the blade.

3.5.1.11.4 Leaf colour:Leaf colour (light green/dark green) was also observed on the basis of visual observation and took the help of “Colour Dictionary”.

3.5.2 Physico-chemical parameters:

3.5.2.1 Fruit length (cm): The length of the fruits was measured from stem end to calyx end in centimeters, after cutting the fruits in two equal pieces with the help of vernier calipers at maturity.

3.5.2.2 Fruit width (cm): The width of the fruits was measured from the centre of cut pieces of the fruits in centimeters with the help of vernier calipers.

3.5.2.3 Number of seeds fruit⁻¹: Fully matured yellow coloured fruits were taken from every tagged plant and number of seeds per fruit was counted manually to get number of seeds per fruit.

3.5.2.4 Pulp percentage: The weight of pulp was calculated by deducting the weight of seed from the total weight of fruit. Pulp percentage was calculated by using the following formula.

$$\text{Pulp percentage} = \frac{\text{Total weight of pulp}}{\text{Total weight of fruits}} \times 100$$

3.5.2.5 Pulp thickness (cm): To measure the thickness of pulp, the fruits were equally divided into two pieces by cutting and length between skin and seedball was measured with the help of scale in centimeter.

3.5.2.6 Pulp colour: Pulp colour (creamy, dusty creamy, pink, whitish) was observed by visual observation.

3.5.2.7 Fruit colour: Fruit colour (dark-green, light-green, yellowish-green, white with red blush, yellow with red blush, pinkish-red) was observed by visual observation.

3.5.2.8 Seed size: The size of seeds was determined and was categorized as small and bold size.

3.5.2.9 Seed hardness: The hardness of seeds was also determined and was categorized as hard, semi hard and soft.

3.5.2.10 Average fruit weight (g): The average weight of fruit was calculated after the final picking as per the formula given below:

$$\text{Average Fruit Weight (g)} = \frac{\text{Total weight of fruits (g)}}{\text{Number of fruits}}$$

3.5.3 Qualitative parameters:

For determination of fruit quality, three healthy fruits were selected randomly from each genotype at full maturity stage. The fruits were washed thoroughly before analysis the following contents.

3.5.3.1 Total soluble solids (%): All the fruits of each plant were crushed to form the homogenized sample and then the juice was extracted through muslin cloth. The extract was used for determination of T.S.S. in percent by hand refractometer. Few drops of juice were placed on the surface of prism. The hinged part was placed back. The refractometer was then placed against the sun and the reading was noted by revolving the eye piece at room temperature (A.O.A.C.,1970).

3.5.3.2 Sugars (%)

Methods for estimation of sugars in fruit juice:

(a) Preparation of fruit juicesolution: A homogenous sample of pulp juice was prepared after crushing the fruits for chemical analysis. 20 ml juice sample was diluted to 100 ml and this solution was used for estimation of sugars.

(b) Preparation of Fehling's solution:

- I. **Fehling solution "A":** Weighed 34.63 g of copper sulphate (A.R.) crystals on an analytical balance. Transferred it to a clean and dry 500 ml volumetric flask. Added 0.5 ml of concentrated sulphuric acid and small quantity of distilled water. Shaked well to dissolve and added distilled water to make the volume up to mark 500 ml.

II. Fehling solution “B”: Dissolved 173.0 g of pure sodium potassium tartrate (Rochelle salt) and 50g of sodium hydroxide in distilled water and made the volume (500 ml) in volumetric flask by adding distilled water.

(c) Glucose solution (0.5%): Dissolved 2.5 g of glucose (A.R. anhydrous) in distilled water and made the volume to 500 ml by adding distilled water.

3.5.3.2.1 Reducing sugar (%): Reducing sugar in fruit juice were estimated by the method as suggested by Nelson (1944). 5 ml each of Fehling’s ‘A’ and ‘B’ solution were taken in a 300 ml conical flask and diluted with 40 ml of distilled water. The juice solution taken in a burette was added slowly in hot (boiling) Fehling solution till the appearance of slight red colour. Now three drops of methylene blue indicator was added and titration was continued till a brick red precipitate appeared by destroying the blue colouration. The reducing sugar in percentage was calculated with the help following formula.

$$\text{Reducing sugar \%} = \frac{0.25}{\text{Burette reading}} \times 100$$

3.5.3.2.2 Total sugar (%): For the estimation of total sugars, 20 ml of guava juice solution was taken in a beaker and 5 ml of concentrated HCl was added and then the solution was boiled on water bath for five minutes for the hydrolysis to convert the non-reducing sugar into reducing sugar. After cooling, the excess of acid was neutralized by sodium carbonate solution. The solution was transferred in a 100 ml volumetric flask and volume was made up to mark by adding distilled water. This solution was taken in a burette and titrated with the Fehling’s solution ‘A’ and ‘B’ similar as was done in reducing sugar. The total sugars in percentage was calculated with the help of following formula.

$$\text{Total sugar \%} = \frac{1.25}{\text{Burette reading}} \times 100$$

3.5.3.2.3 Non-reducing sugar (%): The difference in percentage between total sugar and reducing sugar was taken as the estimate of non-reducing sugar.

$$\text{Non reducing sugar \%} = \text{Total sugar \%} - \text{Reducingsugar \%}$$

3.5.3.3 Vitamin C (mg100g⁻¹ pulp): Assay method was given by Ranganna (1977).

(a) Preparation of 3% meta phosphoric acid (HPO₃): For preparing the 3 per cent meta phosphoric acid (HPO₃) solution dissolve the 3 gm sticks or pellets of HPO₃ in distilled water.

(b) Preparation of standard ascorbic acid solution: 100 mg of 1-ascorbic acid was weighted and made up to 100 ml with 3 per cent HPO₃. One ml of this solution was diluted to 10 ml by adding 3 per cent HPO₃.

(1 ml = 0.1 mg ascorbic acid).

(c) Preparation of dye solution: 52 mg of sodium salt of 2,6-dichlorophenol indophenols was dissolved in approximately 150 ml of hot distilled water containing 42 mg sodium bicarbonate. After cooling it was diluted with distilled water to 200 ml and stored in refrigerator and standardized every day.

(d) Standardization of dye: In 5ml of standard ascorbic acid solution 5 ml HPO₃ was added. Micro burette was filled with the dye solution. Standard ascorbic acid was titrated against dye solution to a pink colour which persisted for 15 seconds. Milligram of ascorbic acid was used per ml of dye to determine the dye of factor as follows:

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

(e) **Preparation of sample:**Ten grams of sample was blended with 100ml of 3 per cent HPO_3 then it was filtered.

(f) **Assay of ascorbic acid:**An aliquot (10 ml) of the sample was taken and titrated against the standard dye to a pink colour end point which persisted for 15 seconds. Calculated the ascorbic acid content of the sample by using the following formula.

Ascorbic acid (mg/100 gm pulp)

$$= \frac{\text{Titre} \times \text{dye factor} \times \text{volume made up}}{\text{Aliquot extract taken for estimation} \times \text{weight of sample taken for estimation}} \times 100$$

3.5.3.4 Acidity (%): Acidity was estimated by simple acid-alkaline titration method as described in A.O.A.C. in 1970. 20 ml of fruit juice solution by pipette and transferred into a 100 ml flask and then added distilled water to make up the volume up to 100 ml and shaken well to dissolve. 25 ml of diluted fruit juice was taken by pipette and transferred into a 250 ml beaker. Added 3 drops of phenolphthaleine indicator to the solution. Filled the burette with N/10 NaOH solution and titrated the juice with alkali solution, drop by drop with constant stirring till the pink end point was reached. End point readings were recorded and the percentage acidity was calculated by the formula and expressed in terms of citric acid.

$$\text{Total acidity \%} = 0.128 \times \text{titer value}$$

3.5.4 Yield attributes:

The yield and yield contributing characters of fruit were recorded after the picking of mature fruits of each plant at harvesting.

3.5.4.1 Days to harvest after fruit set: Days to harvest after fruit set was noted during harvest.

3.5.4.2 Number of fruits/plant⁻¹: The number of fruits per plant was recorded separately for each plant at each picking.

3.5.4.3 Crop duration: The total number of days taken from bud emergence to final harvesting.

3.5.4.4 Yieldplant⁻¹ (kg): The fruit of each plant were weighed separately in kg by top pan balanced and recorded at each picking.

3.6 Statistical analysis:

Correlation studies: Correlation coefficient between different characters were calculated as per formula described by Panse and Sukhatme (1963) mentioned below.

$$r = \frac{\Sigma xy - (\Sigma x \Sigma y) / n}{\sqrt{[\Sigma x^2 - \frac{(\Sigma x)^2}{n}][\Sigma y^2 - \frac{(\Sigma y)^2}{n}]}}$$

Where,

r = Correlation coefficient between to characters

n = Number of observations

x and y = Characters under study

The 't' test was used for judging the significance of correlation coefficient the formula was given below as.

$$|t| = \frac{\sqrt{r(n-2)}}{\sqrt{1-r^2}}$$

Where,

t = Students 't' test statistics with (n-2) d.f.

d.f. = n-2 = 23

t_{5%} tab. (23 d.f.) = 2.07

t_{1%} tab. (23 d.f.) = 2.81

RESULT

The chapter deals with the results of investigation on various morphological, physico-chemical and yield parameters of 21 genotypes of guava (*Psidium guajava*L.) and the results are described under appropriate headings. The observations recorded during study are summarized in the form of tables (Table- 4.1 to 4.9) and illustrated through Figures (Fig. 4.1 to 4.9) wherever, found necessary.

(A) Morphological parameters:

The various morphological parameters of different genotypes of guava are presented in Table-4.1, 4.2 and 4.3 described as below. Fig. 4.1 respectively.

Table 4.1: Morphological parameters of genotypes (Tree height, Canopy spread – North-South and East-West, Shape of canopy and Bark colour)

Genotypes (m)N-SE-W	Tree height (m)	Canopy spread (m)		Shape of canopy	Bark colour
		North-South canopy	East-West canopy		
G1	3.10	3.20	4.55	Spreading	Light brown
G2	6.20	6.50	6.15	Semi Spreading	Light brown
G3	7.00	5.45	4.50	Semi Spreading	Light brown
G4	5.70	4.25	4.95	Spreading	Light brown
G5	4.40	3.80	4.30	Semi Spreading	Light brown
G6	6.00	5.25	4.75	Semi Spreading	Light brown
G7	6.30	8.30	5.25	Semi Spreading	Light brown
G8	5.85	5.70	5.30	Erect	Light brown
G9	6.25	5.00	5.65	Spreading	Light brown
G10	7.10	7.50	6.10	Erect	Light brown

G11	6.90	6.25	5.95	Semi Spreading	Light brown
G12	8.55	6.80	5.60	Spreading	Light brown
G13	4.65	5.00	4.00	Spreading	Light brown
G14	5.30	4.40	4.15	Semi Spreading	Light brown
G15	2.50	3.00	3.50	Spreading	Light brown
G16	3.70	2.55	3.85	Spreading	Light brown
G17	5.90	4.80	4.65	Spreading	Light brown
G18	3.50	3.15	3.80	Spreading	Light brown
G19	4.10	3.40	3.95	Spreading	Light brown
G20	3.45	3.20	3.80	Spreading	Light brown
G21	3.60	3.35	3.45	Spreading	Light brown

N-S =Canopy spread, North-South, E-W = Canopy spread, East-West

1. **Tree height (m):** The maximum tree height was recorded in genotype G-12 (8.55 m) followed by G-10 (7.10 m) whereas, the minimum height was recorded in G-15 (2.50 m) as given in table-4.1.
2. **Canopy spread:**
 - (a) **North-South (m):** From table-4.1 it is clear that the maximum North-South spread was recorded in genotype G-7 (8.30 m) followed by G-10 (7.50 m) and G-12 (6.80 m) respectively whereas, the minimum spread of North-South was recorded in G-16 (2.55 m).
 - (b) **East-West (m):** From table-4.1 it is clear that the maximum East-West spread was recorded in genotype G-2 (6.15 m) followed by G-11 (5.95 m) and G-9 (5.65 m) respectively whereas, the minimum spread of East-West was recorded in G-21 (3.45 m).
3. **Shape of canopy:** In visual observation, it was seen that out of the 21 genotypes, 2 genotypes were found erect type, 7 genotypes

were semi spreading and 12 genotypes were spreading type as shown the data of the table-4.1.

4. **Bark colour:** The data given in table-4.1 indicate that bark colour of all genotypes were light brown. This shows that there was no more variation was observed in all genotypes regarding bark colour.

Table 4.2: Morphological parameters of guava genotypes (Date of bud emergence, Bud brust, First flowering, 50per cent flowering, Fruit set, 50 per cent fruit set)

Genotypes	Date of bud emergence	Date of bud brust	Date of first flowering	Date of 50% flowering	Date of first fruit set	Date of 50% Fruit set
G1	12/7/18	18/7/18	22/7/18	07/8/18	31/7/18	15/8/18
G2	01/8/18	07/8/18	10/8/18	02/9/18	24/8/18	09/9/18
G3	19/8/18	23/8/18	26/8/18	22/9/18	09/9/18	30/9/18
G4	20/8/18	25/8/18	30/8/18	25/9/18	13/9/18	04/10/18
G5	06/8/18	12/8/18	17/8/18	07/9/18	29/8/18	16/9/18
G6	30/8/18	04/9/18	09/9/18	08/10/18	25/9/18	18/10/18
G7	09/8/18	14/8/18	19/8/18	13/9/18	01/9/18	22/9/18
G8	12/7/18	19/7/18	23/7/18	07/8/18	01/8/18	16/8/18
G9	25/7/18	31/7/18	05/8/18	31/8/18	19/8/18	10/9/18
G10	30/8/18	04/9/18	09/9/18	08/10/18	25/9/18	18/10/18
G11	12/7/18	18/7/18	22/7/18	07/8/18	31/7/18	15/8/18
G12	08/8/18	14/8/18	19/8/18	12/9/18	31/8/18	21/9/18

G13	03/8/18	08/8/18	14/8/18	04/9/18	27/8/18	13/9/18
G14	16/7/18	21/7/18	25/7/18	12/8/18	09/8/18	21/8/18
G15	12/7/18	18/7/18	22/7/18	07/8/18	31/7/18	16/8/18
G16	22/7/18	27/7/18	31/7/18	22/8/18	14/8/18	30/8/18
G17	16/8/18	20/8/18	24/8/18	19/9/18	07/9/18	29/9/18
G18	24/7/18	29/7/18	02/8/18	23/8/18	13/8/18	01/9/18
G19	24/7/18	30/7/18	03/8/18	22/8/18	14/8/18	01/9/18
G20	01/8/18	05/8/18	09/8/18	29/8/18	20/8/18	08/9/18
G21	31/7/18	05/8/18	09/8/18	30/8/18	22/8/18	09/9/18

Table 4.2: Morphological parameters of guava genotypes (Date of bud emergence, Bud burst, First flowering, 50 per cent flowering, Fruit set, 50 per cent fruit set)

- 1. Date of bud emergence:** The data given in the table-4.2 showed that bud emergence was observed in 12 July to 30 August in all the genotypes of guava but the earlier bud emergence was observed in G-1, G-8, G-11, G-15 (12 July) whereas, later bud emergence was observed in G-6 and G-10 (30 August).
- 2. Date of bud burst:** The value of table-4.2 showed that bud burst was observed in 18 July to 04 September in all the genotypes of guava but the earlier bud burst was observed in G-1, G-11, G-15 (18 July) whereas, later bud burst was observed in G-6 and G-10 (04 September).
- 3. Date of first flowering:** Table-4.2 showed that first flowering was observed in 22 July to 9 September in all the genotypes of guava but the earlier flowering was observed in G-1, G-11, G-15 (22 July) whereas, later flowering was observed in G-6 and G-10 (9 September).

4. **Date of 50% flowering:** From the table-4.2 it is clear that 50 per cent flowering was observed in 07 August to 08 October in all the genotypes of guava but the earlier 50 per cent flowering was observed in G-1, G-8, G-11, G-15 (07 August) whereas, later 50 per cent flowering was observed in G-6 and G-10 (08 October).
5. **Date of first fruit set:** The value of table-4.2 showed that first fruit set was observed in 31 August to 25 September in all the genotypes of guava but the earlier fruit set was observed in G-1, G-11, G-15 (31 August) whereas, later fruit set was observed in G-6 and G-10 (25 September).
6. **Date of 50% fruit set:** Table-4.2 showed that 50 per cent fruit set was observed in 15 August to 18 October in all the genotypes of guava but the earlier 50 per cent fruit set was observed in G-1, G-11 (15 August) whereas, later 50 per cent fruit set was observed in G-6 and G-10 (18 October).

Table 4.3: Morphological parameters of guava genotypes (Leaf Characters-Number of leaves per 30 cm length of shoot, Leaf length, Leaf breadth and Leaf colour)

Genotypes	Leaf Characters			
	No. of leaves per 30cm length of shoot	Leaf length	Leaf breadth	Leaf colour
G1	24	9.33	4.86	Light green
G2	22	8.63	4.20	Light green
G3	16	7.83	4.00	Light green
G4	15	7.73	4.73	Light green
G5	26	9.76	4.23	Light green
G6	19	9.86	4.53	Light green
G7	23	5.70	3.43	Light green

G8	25	8.30	4.73	Light green
G9	23	8.66	4.20	Light green
G10	17	8.46	4.16	Light green
G11	27	8.63	4.50	Light green
G12	24	11.63	5.03	Light green
G13	26	9.16	4.23	Light green
G14	17	8.73	4.36	Light green
G15	25	9.26	4.40	Light green
G16	23	7.86	4.26	Light green
G17	24	10.13	5.16	Light green
G18	22	11.80	5.13	Light green
G19	20	11.83	5.13	Light green
G20	26	11.26	4.40	Light green
G21	24	11.73	4.80	Light green

1. Leaf characters:

(a) Number of leaves per 30 cm length of shoot: The value of table-4.3 showed that the maximum number of leaves in per 30cm shoot length of tagged branch was found in genotype G-11 (27) followed by G-5, G-13 and G-20 (26) respectively whereas, minimum was observed in G-4 (15).

(b) Leaf length (cm):The values of table-4.3 showed that the maximum leaf length of tagged branch in all genotypes was found in G-19 (11.83 cm) followed by G-18 (11.80 cm) whereas, minimum leaf length was found in G-7 (5.70 cm).

(c) Leaf breadth (cm): As the data depicted in the table-4.3 indicated that the maximum leaf breadth in genotype G-17 (5.16 cm) followed

by G-18 and G-19 (5.13 cm) whereas, minimum leaf breadth was found in G-7 (3.43 cm).

(d) Leaf colour: Table-4.3 showed that in this investigation the leaves colour of all genotypes were light green which shows that there was no more variation observed in all genotypes regarding leaf colour.

(B) Physico-chemical parameters:

The observation on the physical parameters of the fruits were recorded and the data is given in Table 4.4 and 4.5. Fig. 4.2 and 4.3 respectively.

Table 4.4: Fruit length, fruit width, number of seeds fruit⁻¹, seed size and seed hardness (at harvest) of fruits

Genotypes	Fruit length (cm)	Fruit width (cm)	Number of seedsfruit ⁻¹	Seed size	Seed hardness
G1	5.56	5.78	87	Small	Semi-hard
G2	5.44	5.56	168	Bold	Hard
G3	4.87	5.15	149	Bold	Hard
G4	5.51	5.57	125	Bold	Hard
G5	5.94	5.41	96	Small	Semi-hard
G6	5.51	5.57	179	Small	Semi-hard
G7	5.11	5.28	140	Bold	Soft
G8	5.91	6.15	185	Small	Semi-hard
G9	5.87	5.82	182	Small	Semi-hard
G10	5.06	5.35	163	Small	Soft
G11	7.30	6.74	61	Bold	Hard
G12	5.71	5.88	117	Bold	Hard
G13	9.00	8.04	321	Bold	Hard

G14	7.00	7.54	221	Small	Semi-hard
G15	6.81	6.90	188	Bold	Hard
G16	6.31	5.84	148	Small	Soft
G17	6.23	6.65	199	Bold	Hard
G18	8.70	7.64	186	Bold	Semi-hard
G19	5.93	6.15	132	Bold	Semi-hard
G20	6.35	6.37	104	Small	Soft
G21	6.50	5.74	151	Small	Soft

- 1. Fruit length (cm):** The data given in table-4.4 indicate that the fruit length ranged from 4.87 to 9.00 cm and the maximum fruit length was recorded in G-13 (9.00 cm) followed by G-18 (8.7 cm) and G-11 (7.3 cm) respectively while minimum fruit length was recorded in G-3 (4.87 cm).
- 2. Fruit width (cm):** The fruit width ranged from 5.15 to 8.04 cm but the maximum fruit width was noted in G-13 (8.04 cm) followed by G-18 (7.64 cm) and G-14 (7.54 cm) respectively while the minimum fruit width was recorded in G-3 (5.15 cm) as given in table-4.4.
- 3. Number of seeds fruit⁻¹:** Table-4.4 shows that in this investigation maximum number of seeds per fruit was found in genotype G-13 (321) followed by G-14 (221) and G-17 (199) respectively while the minimum number of seeds per fruit was found in G-11 (61).

4. Seed size: In all genotypes under this investigation, it was observed that out of 21 genotypes, 11 genotypes had bold seed and 10 genotypes had small seeds as shown table-4.4.

5. Seed hardness: Under this investigation, it was found that out of 21 genotypes, 8 genotypes had hard seeds, 8 genotypes had semi hard seeds and 5 genotypes had soft seeds as data given in the table-4.4.

1. Average fruit weight (gm): From table-4.5 it is clear that the average fruit weight ranged from 79.33 to 232.25 gm. The maximum average fruit weight was found under G-13 (232.25 gm) followed by G-20 (226.38 gm) and G-14 (203.38 gm) respectively whereas, the minimum fruit weight found in genotype G-4 (79.33 gm).

2. Pulp percentage (%): The pulp percentage of different genotypes ranged from 96.90 to 98.35 per cent but genotype G-13 (98.35 per cent) had higher pulp percentage followed by G-11 (98.20 per cent) whereas, lower pulp percentage was recorded in G-14 (96.90 per cent) as shown table-4.5.

Table 4.5: Average fruit weight (gm), pulp percentage (%), pulp thickness (cm), pulp colour and Fruit colour

Genotypes	Average fruit weight (gm)	Pulp percentage (%)	Pulp thickness (cm)	Pulp colour	Fruitcolour
G1	134.75	97.99	1.3	White	L.G.
G2	88.35	97.54	1.4	C.W.	L.G.
G3	110.61	97.59	0.9	White	Y.G.
G4	79.33	98.00	0.7	White	L.G.

G5	95.28	97.53	1	C.W.	Y.G.
G6	85.90	97.10	1.1	C.W.	L.G.
G7	130.75	97.88	1.2	White	L.G.
G8	113.04	97.81	0.7	White	L.G.
G9	121.15	97.47	1	C.W.	Y.G.
G10	109.20	97.98	1.1	C.W.	Y.G.
G11	194.42	98.20	1.5	C.W.	Y.G.
G12	148.07	97.21	0.9	White	L.G.
G13	232.25	98.35	1.8	C.W.	Y.G.
G14	203.38	96.90	1	C.W.	L.G.
G15	195.28	97.05	1	C.W.	Y.G.
G16	197.66	97.46	1.5	C.W.	Y.G.
G17	199.34	96.94	1.3	White	Y.G.
G18	201.00	97.71	1.8	C.W.	Green
G19	200.34	98.07	1.1	C.W.	Green
G20	226.38	98.04	0.7	C.W.	L.G.
G21	200.20	97.48	1.3	C.W.	L.G.

C.W.- Creamish white, L.G.- Light green, Y.G.- Yellowish green

3. Pulp thickness (cm):The pulp thickness of different genotypes ranged from 0.7 to 1.8 cm and the maximum pulp thickness was recorded with G-13,G-18 (1.8 cm) followed by G-11,G-16 (1.5 cm) whereas, minimum pulp thickness was recorded in G-4,G-8,G-20 (0.7 cm) as given in the table-4.5.

4. Pulp colour: Out of 21 genotypes, it was observed that 7 genotypes had white pulp colour and 14 genotypes had creamish white pulp colour as shown table-4.5.

5. Fruit colour: Out of 21 genotypes, it was observed that 10 genotypes had light green fruit colour, 2 genotypes had green fruit colour and 9 genotypes had yellowish green fruit colour as shown table-4.5.

(C) Qualitative parameters:

The data pertaining to quality parameters to fruits of various selected genotypes are presented in Table-4.6. Fig.4.4, 4.5, 4.6 and 4.7 respectively. The results on various parameters are given under different heads.

Table 4.6:Quality parameters of guava genotypes(TSS, Total sugar, Reducing sugar, Non-reducing sugar, vitamin C and acidity) of fruits

Genotypes	TSS (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Vitamin C (mg100g ⁻¹ pulp)	Acidity (%)
G1	09.70	10.00	4.45	5.55	141.31	0.38
G2	11.30	08.68	5.75	2.93	172.18	0.54
G3	12.30	11.70	5.40	6.30	161.54	0.34
G4	12.90	11.59	5.24	6.35	184.43	0.32
G5	12.00	11.36	5.22	6.14	176.14	0.36
G6	09.80	09.90	4.60	5.30	156.21	0.40
G7	09.80	09.49	4.21	5.28	167.69	0.35
G8	12.50	11.69	5.31	6.38	193.28	0.33
G9	11.30	11.74	5.80	5.94	141.31	0.46

G10	12.10	11.15	5.05	6.10	167.76	0.35
G11	10.70	10.95	5.08	5.87	161.11	0.35
G12	12.50	11.50	5.20	6.30	181.85	0.34
G13	10.80	11.23	5.12	6.11	183.86	0.28
G14	10.90	09.17	5.69	3.48	241.96	0.57
G15	14.30	12.32	5.90	6.42	265.63	0.18
G16	10.10	11.20	5.12	6.08	181.71	0.35
G17	12.40	11.71	5.26	6.45	186.34	0.33
G18	12.60	11.45	5.22	6.23	196.69	0.34
G19	12.40	11.31	5.07	6.24	189.19	0.34
G20	10.30	10.63	4.73	5.90	172.61	0.36
G21	12.60	11.83	5.18	6.65	215.32	0.38

- 1. Total soluble solids (T.S.S.):** The data given in the table-4.6 shown that the T.S.S. of different genotypes of guava ranged from 9.7 to 14.3 percent. The maximum T.S.S. was found in G-15 (14.3 per cent) followed by G-4 (12.9 per cent) and G-18,G-21 (12.6 per cent) respectively whereas, the minimum T.S.S. was found in G-1 (9.7per cent).
- 2. Total sugar:** The total sugar of different genotypes ranged from 8.68 to 12.32 percent but the maximum total sugar was found in G-15 (12.32 per cent) followed by G-21 (11.83 per cent) and G-9 (11.74 per cent) respectively whereas, the minimum total sugar was found in G-2 (8.68 per cent) as shown in table-4.6.

- 3. Reducing sugar:** It is clear from Table-4.6 that the reducing sugar percentage of different genotypes varied from 4.21 to 5.75 per cent but the maximum reducing sugar was found in G-15 (5.90 per cent) followed by G-9 (5.80 per cent) and G-2 (5.75 per cent) respectively whereas, the minimum reducing sugar was recorded in G-7 (4.21 per cent).
- 4. Non-reducing sugar:** The non-reducing sugar of different genotypes ranged from 2.93 to 6.65 percent but the maximum percentage of non reducing sugar was found in G-21 (6.65 per cent) followed by G-17 (6.45 per cent) and G-15 (6.42 per cent) whereas, the minimum percentage of non reducing sugar was found in G-2 (2.93 per cent) as shown the data of the table-4.6
- 5. Vitamin C:** The data given in the table-4.6 indicate that the vitamin C content of different genotypes ranged from 141.31 to 265.63 mg 100 g⁻¹ of pulp but the maximum vitamin C was found in G-15 (265.63 mg 100 g⁻¹ pulp) followed by G-14 (241.96 mg 100 g⁻¹ pulp) and G-21 (215.32 mg 100 g⁻¹ pulp) respectively whereas, the minimum vitamin C was found in G-1 and G-9 (141.31 mg 100 g⁻¹ pulp).
- 6. Acidity:** The acidity percentage of different genotypes ranged from 0.18 to 0.57 per cent but the maximum acidity was found in G-14 (0.57 per cent) followed by G-2 (0.54 per cent) and G-9 (0.46 per cent) respectively while the minimum acidity was recorded in G-15 (0.18 per cent) as given in the table-4.6.

(D) Yield attributes:

The observation on the total number of fruits per genotype and yield per genotype were recorded at the time of each picking. The results are given in Table-4.7 and Fig. 4.8.

Table 4.7: Yield attributes of guava genotypes

Genotypes	Days to harvest after fruit set	No. of fruitsplant ⁻¹	Yieldplant ⁻¹ (Kg)	Crop duration
G1	67	152	10.18	112
G2	76	128	16.78	123
G3	81	96	11.78	132
G4	84	91	13.24	134
G5	71	224	28.78	119
G6	78	116	39.15	129
G7	74	202	22.63	121
G8	69	198	29.93	116
G9	70	183	28.72	119
G10	78	137	42.05	130
G11	63	219	26.30	112
G12	79	109	13.95	119
G13	68	177	21.24	122
G14	75	104	17.85	128
G15	63	176	19.78	114
G16	69	207	18.84	120
G17	77	168	19.50	127
G18	70	196	47.45	124
G19	73	182	47.72	126
G20	76	135	30.68	129
G21	80	148	34.68	131

- 1. Days to harvest after fruit set:** Under this investigation the data from table-4.7 indicate that earliest harvesting after fruit set was recorded in genotypes G-11,G-15 (63 days) while later harvesting was recorded in genotype G-4 (84 days).

2. **Number of fruits plant⁻¹:** It was observed from the data presented in Table-4.7 that the variation in total number of fruits in different genotypes were ranged from 91 to 224. The maximum number of fruits per genotype was recorded in G-5 (224) followed by G-11 (219) and G-16 (207) respectively while the minimum total number of fruits was recorded in G-4 (91).
3. **Yield plant⁻¹:** Data presented in Table-4.7 clearly shows that the yield of different genotypes ranged from 10.18 to 47.72 kg but the maximum yield was obtained with G-19 (47.72 kg) followed by G-18 (47.45 kg) and G-10 (42.05 kg) respectively while the minimum yield was obtained in G-1 (10.18 kg).
4. **Crop duration:** It was observed from the data presented in Table-4.7 that the variation in crop duration in different genotypes were ranged from 112 to 134 days. The maximum days of crop duration was recorded in G-4 (134 days) followed by G-3 (132 days) G-21 (131 days) respectively while the minimum days of crop duration was recorded in G-1 and G-11 (112 days)

Table 4.8:Zero order simple correlation among physical parameters offruits

Characters	Fruit length	Fruit width	Number of seeds fruit ⁻¹	Average fruit weight	Pulp percentage	Pulp thickness
Fruit length	1.000					
Fruit width	0.918**	1.000				
Number of seeds fruit ⁻¹	0.486*	0.567**	1.000			
Average fruit weight	0.725**	0.745**	0.237	1.000		
Pulp percentage	0.145	0.003	-0.183	0.051	1.000	
Pulp thickness	0.636**	0.466*	0.323	0.430	0.178	1.000

* Significant at 5% level of probability

** Significant at 1% level of probability

Table 4.9:Zero order simple correlation coefficient among quality parameters of fruits

Characters	TSS	Total Sugar	Reducing Sugar	Non reducing Sugar	Vitamin C	Acidity
TSS	1.000					
Total sugar	0.686**	1.000				
Reducing sugar	0.619**	0.296	1.000			
Non reducing sugar	0.430	0.902**	-0.146	1.000		
Vitamin C	0.577**	0.207	0.490*	-0.008	1.000	
Acidity	-0.432	-0.708**	0.159	-0.805**	-0.203	1.000

* Significant at 5% level

** Significant at 1% level

Correlation studies:

Correlation coefficient between physical parameters of fruit: It is clear from (Table-4.8) that the physical parameters of fruit i.e. fruit length (0.725), fruit width (0.745), number of seeds per fruit (0.237), pulp percentage (0.795) and pulp thickness (0.721) were significant positively correlated with fruit weight. However, the highest correlation coefficient was noted by fruit width followed by fruit length, pulp percentage and pulp thickness. Thus, association study in the present investigation reveal that fruit width, fruit length, pulp percentage and pulp thickness played an important role in improvement of fruit weight.

Length of fruits had positive association with fruit width (0.918), number of seeds per fruit (0.486), pulp percentage (0.145) and pulp thickness (0.636). Fruit width positively correlated with number of seeds

per fruit (0.567), pulp percentage (0.003) and pulp thickness (0.466). Number of seeds per fruit positively correlated with pulp thickness (0.323) whereas, negative association was recorded with pulp percentage (-0.183). Pulp percentage had positive correlation with pulp thickness (0.178) under this investigation.

Correlation coefficient between chemical (quality) parameters of fruit:

Data presenting in (Table-4.9) indicate that the T.S.S. had significant positive correlation with total sugar (0.686), reducing sugar (0.619), non-reducing sugar (0.430) and vitamin C (0.577) whereas, negative association was observed with acidity (-0.432). Total sugar show positive correlation with reducing sugar (0.296), non-reducing sugar (0.902) and vitamin C (0.207) whereas, negative correlation was observed with acidity (-0.708).

Reducing sugar has significant positive association with vitamin C (0.490) and acidity (0.159) whereas, negative association was seen with non-reducing sugar (-0.146). Non-reducing sugar show negative association with both vitamin C (-0.008) and acidity (-0.805). Vitamin C had negative association with acidity (-0.203) under this investigation.

DISCUSSION

The experiment entitled “**Characterization of yield and quality of guava (*Psidium guajava*L.) genotypes under Kymore Plateau & Satpura Hills**” was conducted during the year 2018-19. The detail study of selected genotypes was carried out in relation to morphological, physico-chemical parameters, qualitative characteristics, yield attributes and correlation studies. The results are discussed in the light of research work done in India and abroad.

One of the most essential prerequisites of crop improvement programme is an intensive scanning regarding existing seedling population and phenotypic variation in the vast population. The greater diversity in the material, the more is the genetic potential and greater chances of producing a desirable type with this view keeping in mind, 21 genotypes were selected for the study of various parameters.

5.1 Morphological parameters:

The morphological parameters of the selected genotypes were studied for tree height, canopy spread (North-South, East-West), shape of canopy, bark colour, date of bud emergence, date of bud burst, date of first flowering, date of 50 per cent flowering, date of first fruit set, date of 50 per cent fruit set, number of leaves per 30 cm length of shoot, leaf length, leaf breadth and leaf colour. Table-4.1,4.2 and 4.3.

The height of the tree varied from 2.50 m (G-15) to 8.55 m (G-12) in different selected genotypes. The tree height was maximum under G-12 (8.55 m) and minimum in G-15 (2.50 m). The variability in growth due to genetic makeup of genotypes which developed through open pollinated seed. On the other hand, soil and micro-climate of the region also contributed in expressing the inherent characters of different genotypes. The habit of tree growth and their use for vegetative growth

are important diagnostic characters for selection of genotypes as reported by Singh *et al.* (1976) and Singh and Khan (1989).

Comprehensive results revealed that the North-South spread of plant varied from 2.55 m (G-16) to 8.30 m (G-7) while, East-West spread of plant also varied from 3.45 m (G-21) to 6.15 m (G-2). It showed more variation amongst the existing genotypes in plant spread. The growth habit is governed by genetic characters as well as the effect of agro-climatic conditions of the region. Subramanyam and Dinesh (1993) also recognized variation in growth habit in different cultivars of guava. They reported that the maximum East-West plant spread in Banarasi Whereas, North-South spread was more in Baumount. The Apple coloured had minimum spread in both the directions. The selected 2 genotypes were erect, 7 genotypes were semi-spreading and remaining 11 genotypes are spreading type. As a consequence of genetic makeup of genotypes showed variability under different locations. The results are in agreement with Pandey *et al.* (1997) and Sharma *et al.*(1998). No variation was noticed amongst the genotypes in terms of bark colour and leaf colour. The reason may be due to close relation of the same species.Variation was noticed in the number of leaves per 30 cm length of shoot, leaf length and leaf width in different selected genotypes. It seems that the variability might be due to genetic makeup of genotypes.

A markeble variation in all genotypes was recorded in bud emergence, bud burst, first flowering, 50 per cent flowering, first fruit set and 50 per cent fruit set. The bud emergence varied from 12 July to 30 August. Bud burst varied from 18 July to 4 September. The first flowering varied from 22 July to 9 September. 50 per cent flowering varied from 7 August to 8 October. The first fruit set varied from 21 August to 25 September. 50 per cent fruit set varied from 15 August to 18 October.

Thus, flowering and fruit set of different genotypes under the study showed marked variation which confirms the variability amongst genotypes. Variations in flowering and fruit set may be due to genetic characters and climatic influence on selected genotype. Dwivedi *et al.* (1991) reported maximum flowers and fruits per tree in rainy season but the highest fruit set per centage was found in spring cropping season in guava. Sharma *et al.* (2011) also worked on the improvement of guava and reported that maximum fruit set (65 per cent) was in Lucknow-49 which was significantly higher as compared to other cultivars and the minimum fruit set (53 per cent) was observed in cv. Hisar surkha that was significantly lower than the other cultivars. Maximum fruit set was recorded during spring flowering season as reported by Dwivedi *et al.* (1991). Thus, from the above findings it was noticed that prevailing agro-climate coupled with genetic makeup of individual cultivars persuade the responses to particular agro-climatic condition.

5.2 Physico-chemical parameters of fruits:

As shown in Table-4.4 and 4.5 the considerable variation was noticed in fruit length and width at the harvest stage. Within the various genotypes, the genetic variability related to fruit length ranged from 4.87 to 9.00 cm. The variation in the fruit width ranged from 5.15 to 8.04 cm presenting remarkable differences in the diverse selected genotypes. The other factor controlling the fruit growth is the availability and supply of auxins that is translocated from pollen grains to developing ovules. Although the size of the fruit is a varietal character it may be to some extent influenced by the total number of fruits born on the tree, soil moisture, source sink relation and other factors. Varietal variations for physical characters have also been reported by Ratanpalet *et al.* (2002), Kumar *et al.* (2006), Sahay and Kumar (2007), Singh *et al.* (2008), Haji *et al.* (2012), Dolkaret *et al.* (2014), Jana *et al.* (2014), Verma and Singh (2015) and Mehta *et al.* (2016). The number of seeds per fruit ranged from 61 to 321 seeds per fruit whereas, the maximum seeds per fruit was recorded

in G-13 (321) and minimum seeds per fruit in G-11 (61). Dolkaret *et al.*(2014) reported that highest numbers of seeds per fruit was in Arkaamulya and lowest seed number was observed in Lalit. 10 genotypes were had small seeds and remaining 11 genotypes had bold seeds out of 21 genotypes. Soft (5 varieties), semi hard (8 varieties) and hard (8 varieties) be the range depicted for seed hardness within the genotypes.

The variation amongst the genotypes as regard average fruit weight ranged from 79.33 gm (G-4) to 232.25 gm (G-13) might be due to inherent characters and climatic adoptability in a particular region which may prove an important diagnostic character for selection of genotypes. The highest fruit weight was observed in cv. L-49 (235.50 gm) followed by Allahabad Safeda (210 gm) as reported by Kumar *et al.* (2006). Haji *et al.* (2012) also reported that the fruits during winter season showed significantly higher fruit weight as compared to the rainy season fruits. The fruit size and fruit weight were gradually increased from summer to rainy season and thereby winter season as reported by Jana *et al.* (2014) Which is close to the conformity of the findings. The pulp per centage varied in different genotypes of guava and it ranged from 96.90 per cent (G-14) to 98.35 per cent (G-13). Kumar *et al.* (2015) reported that the highest pulp per cent (96.55 per cent) in genotype GRS-4. The pulp thickness ranged from 0.7 to 1.8 cm in selected genotypes. Maximum thickness of pulp was recorded in G-13 and G-18 (1.8 cm) whereas, minimum thickness of pulp was recorded in G-4, G-8 and G-20 (0.7 cm). 7 genotypes were had white pulp and 14 genotypes were had creamish white pulp colour. 2 genotypes were had green, 9 genotypes were had yellowish green and 10 genotypes were had light green fruit colour. Variability in visual characteristics of fruits may be due to their genetic makeup and phenotypic expressions that are in-fluenced by local climatic conditions as well as micro climatic conditions.

The above findings are also supported by the results of Mahouret *et al.* (2012) and he reported that Allahabad Safeda and lucknow-

49 was superior as compared to other varieties in relation to different physico-chemical parameters of fruit. The other varieties i.e. Rewa-72, Dharidar, Apple colour and Gwalior-27 was also superior in some of the characters as compared to the other varieties.

The result showed that the values of physical parameters viz. fruit length (9.0 cm), fruit width (8.04 cm), pulp per centage (98.35 per cent) and thickness of pulp (1.8 cm) were maximum in genotype G-13. Thus, genotype G-13 was found superior over other genotypes which may be selected for further evaluation and recommendation. There were variations as regards the fruit length, fruit width, pulp per centage and pulp thickness of fruits. The higher content of pulp was due to the more pulp area or larger size of fruits, similar findings are reported by Thonte and Chakrawar (1982). The variability in these selected genotypes may be due to genetic makeup and agro-climatic conditions of the locality. Mitra *et al.* (1983) recognized the relation of large size of fruit of Allahabad Safeda with the number of seeds, this relation is confirmed in seedless variety which has less number of seed and smaller size of fruit.

5.3 Qualitative characteristics of fruits:

Results of chemical composition in different genotypes of guava showed significant variations. The maximum total soluble solids (14.3 per cent) was recorded in G-15 while, minimum (9.7 per cent) was found in G-1 genotype. The total sugar per centage varied from 8.68 per cent (G-2) to 12.32 per cent (G-15). The reducing sugar per centage varied from 4.21 per cent (G-7) to 5.90 per cent (G-15) amongst selected genotypes whereas, non-reducing sugar percentage varied from 2.93 per cent (G-2) to 6.65 per cent (G-21) showed marked variation amongst genotypes. On the other hand, the ascorbic acid varied from 141.31 mg 100 g⁻¹ (G-1 and G-9) to 265.63 mg 100 g⁻¹ (G-15) of pulp which showed very distinct variation for selection of better genotypes. The acidity per centage varied from 0.18 per cent (G-15) to 0.57 per cent (G-14) in different selected

genotypes. The variation in T.S.S., total sugar, reducing sugar, non reducing sugar, vitamin C and acidity may be due to existing variability in genotypes, inheritance and influence of agro-climatic conditions.

Sugars are the important constituents of fruit for determining the sweetness. The maximum TSS was found in cv. Apple Colour (11.2° Brix), reducing sugar in cv. L-49 (6 per cent), non-reducing sugar in cv. SevilalGudia (1.9 per cent) and lowest acidity in cv. L-49 and Behat Coconut (0.42 per cent) as reported by Singh (2000). Thaipong and Boonprakob (2005) studied the genetic and environmental variance components in guava fruit qualities and reported that high proportion of genotypic variance was found with fruit weight and ascorbic acid indicating that genetic improvement for these traits through breeding and selection was achievable. Seasonal variance among fruits within tree variance was greatest for TSS. Nag *et al.* (2011) reported that vitamin C, total sugar, reducing sugar, non reducing sugar and TSS content (fresh weight basis) increased significantly during ripening. Haji *et al.* (2012) recognized that fruits from winter season crops were having higher TSS, reducing sugar, total sugar, titrable acidity and ascorbic acid content; however non reducing sugar were found higher in rainy season crop.

On the basis of chemical analysis, it may be concluded that genotype G-15 contained higher per cent of T.S.S., total sugar, reducing sugar and vitamin C. The overall superiority of this G-15 genotype may be due to genetic makeup which has got favorable micro-climate at Jabalpur for expressing these characteristics. Findings confirmed the fact that G-15 genotype possess good quality characters and superior over all genotypes under study.

5.4 Yield attributes:

The maximum number of the fruits per plant varied in different selected genotypes with the range from 91 (G-4) to 224 (G-5) fruits. It shows marked variation amongst selected genotypes. The yield of each

genotypes also varied from 10.18 kg (G-1) to 47.72 kg (G-19). Days to harvest also showed marked variation which ranged from 63 to 84 days after fruit set. Crop duration also showed variation which ranged from 112 days (G-1 and G-11) to 134 days (G-4). The variation amongst the genotypes as regards number of fruit and yield might be due to inherent characters and climatic adaptability in a particular region which may prove an important diagnostic character for selection of genotypes. In many of the genotypes number of fruit increased but fruit weight decreased. This may be due to distribution and diversion of available food material in more number of fruits. Thimmappaih and Suman (1986) noticed that climatic conditions influenced the fruit size and quality of fruits in guava cultivar Allahabad Safeda. He reported that fruits of winter season were superior in quality and yield also while rainy season adversely affected the yield and quality of fruits. Kumar *et al.* (2015) worked on the performance of guava genotypes to qualitative and yield attributes. The variations recorded during the course of investigation needs confirmation through further testing before making any recommendation for a particular genotype. The variability for yield per plant have also been reported by Mitra *et al.* (1983), Singh and Khan (1989), Pandey *et al.* (1997), Sharma *et al.* (1998) and Singh *et al.* (2008).

Correlation studies:

Correlation studies in the present investigation revealed that increase in one variable cause either increase or decrease in other variable. Thus, the positive associations in the study exhibit that fruit length, width, number of seeds per fruit, pulp thickness and pulp percentage had positive association with fruit weight. This indicates that if the fruit length, width, number of seeds per fruit, pulp thickness and pulp percentage is increase the fruit weight is also increase.

Length of fruit had positive association with fruit width, number of seeds per fruit, fruit weight, pulp percentage and pulp thickness. This

indicate that fruit width, number of seeds per fruit, fruit weight, pulp percentage and pulp thickness played an important role for increasing the length of fruits. Pulp thickness of fruit is the most important parameter which played an important role for enhancing the width of fruits. Thumburajet *al.* (1980) reported positive correlation between fruit weight and length of the fruit.

In case of chemical constituents of fruit, the total sugars had positive association with reducing and non reducing sugar as well as vitamin C. This shows that if the reducing sugar, non reducing sugar and vitamin C are increase, the total sugar is also increase. T.S.S. had significant positive association with reducing and non reducing sugar as well as vitamin C. This shows that all these parameters are responsible for enhancing the T.S.S. in fruit. These are in accordance with the findings of Sheikh and Hulamani (1993), Pandey *et al.* (1997), Pandey *et al.*(2002) and Agrawal (2010).

SUMMARY, CONCLUSIONS AND SUGGESTION FOR FURTHER WORK

The experiment entitled “Characterization of yield and quality of guava (*Psidium guajava*L.) genotypes under Kymore Plateau & Satpura Hills” was carried out at Department of Horticulture, J.N.K.V.V., Jabalpur during July to December 2018 with the object to select the suitable genotypes on the basis of various morphological, physico-chemical, yield parameters and qualitative characters of fruits. The study was undertaken with 21 genotypes. The salient findings recorded on different parameters of genotypes are as below.

The variation in growth habit of trees was noted. Where 12 genotypes were of spreading habit, 7 were semi spreading and 2 genotypes were of erect habit of growth. There was no variation in bark colour and leaves colour in selected genotypes. Genotype G-12 gave the maximum tree height whereas, maximum North-South spread was recorded in genotype G-7 and maximum East-West spread was found in genotype G-2.

The bud emergence was observed in 12 July to 30 August, bud burst was observed in 18 July to 04 September. The first flowering was observed in 22 July to 09 September in G-1, G-11, G-15 (22 July) date of 50 per cent flowering first observed in genotypes G-1, G-8, G-11, G-15 (7 August), date of first fruit set was observed in G-1, G-11, G-15 (31 August) and date of 50 per cent fruit set was observed in G-1, G-11 (15 August).

Maximum number of leaves per 30 cm length of shoot was found in G-11, maximum leaf length was found in genotype G-19 and maximum leaf breadth was recorded in genotypes G-17.

The selected genotypes showed variation in fruit length and width. The length of fruits varied from 4.87 to 9.00 cm. The genotype G-13 had

maximum length of fruit whereas, width varied from 4.15 to 8.04 cm and maximum width was recorded in genotype G-13. Maximum number of seeds per fruit was in G-13. Under this investigation, it was observed that out of 21 genotypes, 11 genotypes had bold seeds and 10 genotypes had small seeds while 8 genotypes had hard seeds, 8 genotypes had semi hard seeds whereas, 5 genotypes had soft seeds.

Thickness of pulp was maximum in genotype G-13 and G-18 while variation amongst genotypes ranged from 0.7 to 1.8 cm. The percentage of pulp was ranged from 96.90 to 98.35 whereas, it was maximum in G-13 (98.35 per cent). Out of 21 genotypes, it was found that 7 genotypes had white pulp colour while 14 genotypes had creamish white pulp. Out of 21 genotypes, it was found that 10 genotypes had light green fruit colour, 2 genotypes had green fruit colour and 9 genotypes had yellowish green fruit colour.

The average fruit weight was maximum in genotype G-13 (232.25 gm) and minimum fruit weight in genotype G-4 (79.33 gm).

The maximum T.S.S., total sugar, reducing sugar and vitamin C were found in genotype G-15 while maximum non reducing sugar was found in G-21 and maximum acidity was found in G-14. Minimum T.S.S. and vitamin C was found in G-1 and minimum total sugar and non-reducing sugar was found in G-2. Minimum reducing sugar was found in G-7 and minimum acidity was found in G-15. The T.S.S. varied from 9.7 to 14.3 per cent. Total sugar ranged from 8.68 to 12.32 per cent. Reducing sugar varied from 4.21 to 5.90 per cent, non-reducing sugar varied from 2.93 to 6.65 per cent, vitamin C varied from 141.31 to 265.63 mg 100 g⁻¹ pulp and acidity varied from 0.18 to 0.57 per cent.

Variation may be due to the genetic makeup of genotypes as well as their performance under the prevailing soil and climatic condition.

These are the important characters which directly influence the quality and hence priority be given in selection methods.

There was variation in days to harvest after fruit set, earliest harvesting after fruit set was recorded in genotypes G-11 and G-15 (63 days) while, late harvesting is recorded in genotype G-4 (84 days). There was marked variation in number of fruits per plant which was ranged from 91 to 224. Maximum number of fruits were recorded in genotype G-5 (224) while the minimum was recorded in genotype G-4 (91). The maximum yield per plant was recorded in genotype G-19 (47.72 kg) whereas, the minimum was recorded in genotype G-1 (10.18 kg). The yield varied from 10.18 kg to 47.72 kg.

Fruit length, fruit width, pulp thickness and average fruit weight showed significant positive correlation with each other while pulp percentage showed significant negative correlation with number of seeds per fruit. T.S.S. and total sugar were significant and had positive correlation with each other while non-reducing sugar showed significant negative correlation with reducing sugar, vitamin C and acidity. Acidity showed negative correlation with T.S.S., total sugar and vitamin C while, positive correlation with reducing sugar.

The variation in morphological and chemical characteristics confirm that the variation in various characters were due to variability in the genetic makeup of selected genotypes. This may be due to seedlings raised by the seeds collected from open pollinated fruits.

Conclusions:

The markable evaluation study on guava genotypes revealed that the variability exists with regard to different morphological, physico-chemical parameters and yield attributes. In order to select out the promising type, the important diagnostic characters like growth habit, fruit yield, pulp per centage and quality parameters viz. T.S.S., Sugar content

and vitamin C were found out in the investigation. It is clear from the investigation that G-15 is found superior to other genotypes. In respect of the other genotypes i.e. G-10, G-13, G-18 and G-19 were also better in some physico-chemical and yield characters as compared to the rest of the genotypes. Finally, on the basis of results the promising genotypes were identified i.e. G-10, G-13, G-15, G-18 and G-19.

Suggestions for further work:

- 1) The experiment should be repeated to confirm the findings of the present investigation which will be helpful for release and recommendation of the genotype/genotypes.
- 2) Floral biology of these genotypes should also be studied in further investigation.
- 3) Some more qualitative and quantitative parameters may also be studied further.

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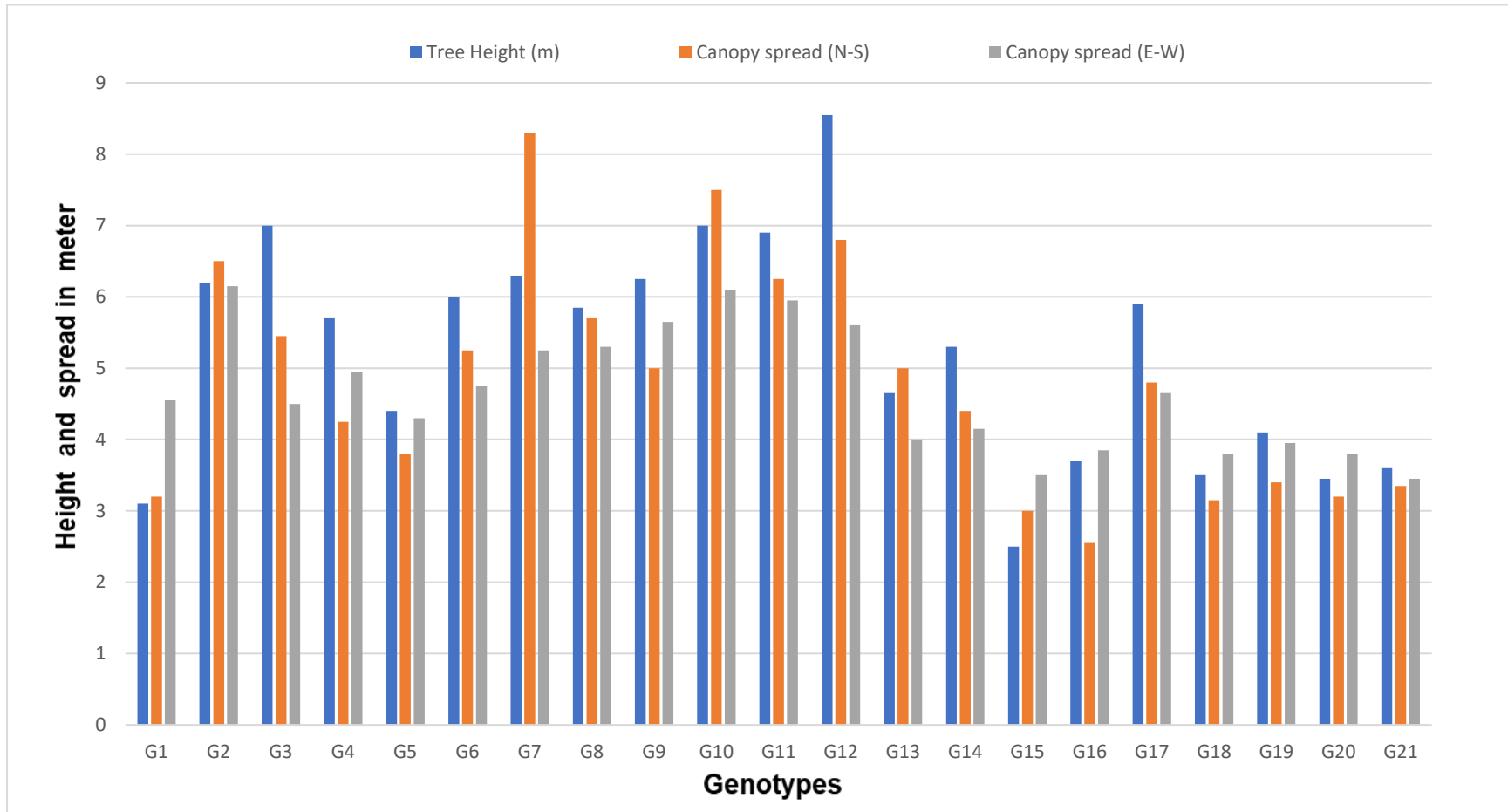


Fig. 4.1: Morphological parameters (Tree height and canopy spread)

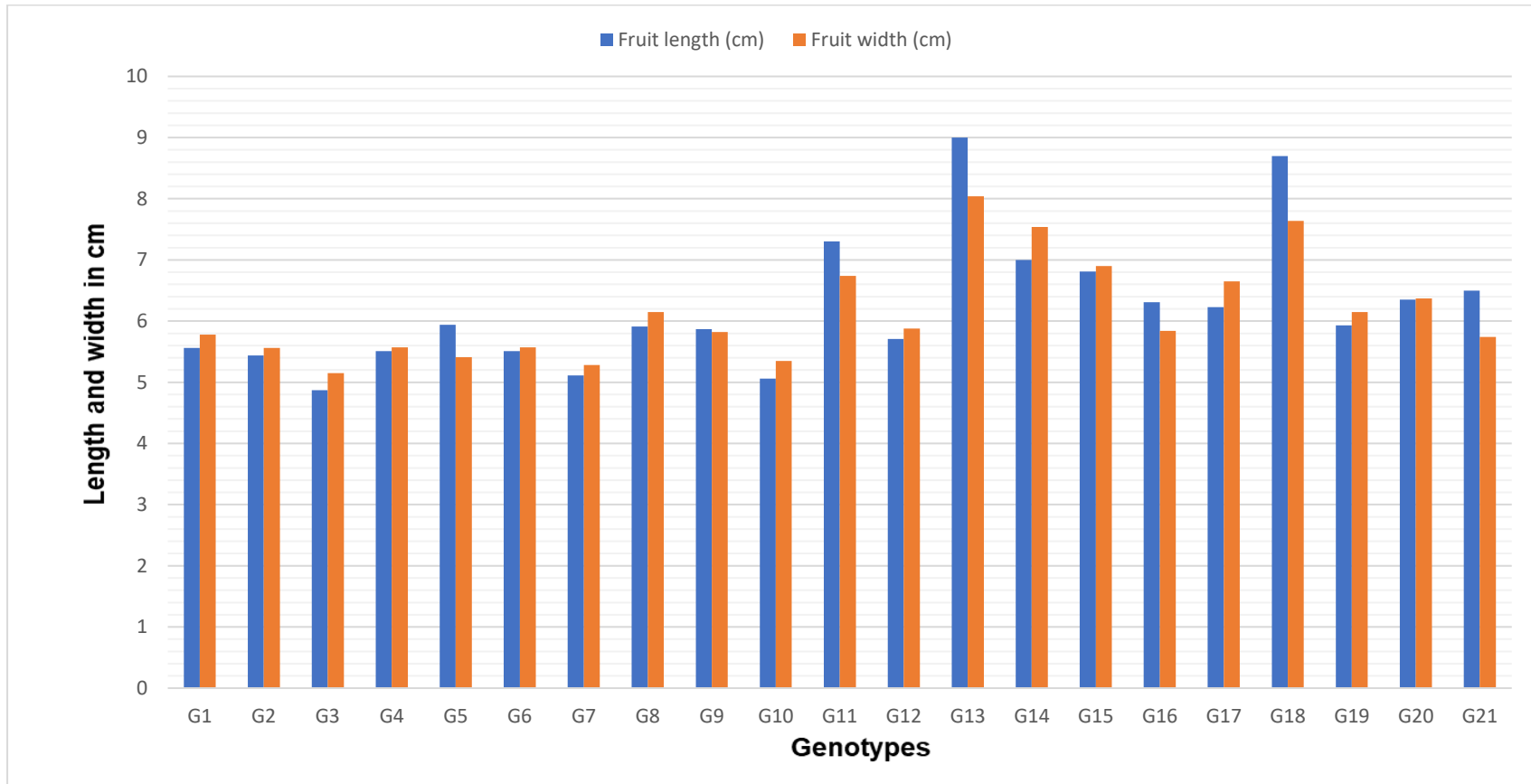


Fig. 4.2: Physico-chemical parameters (Fruit length and width)

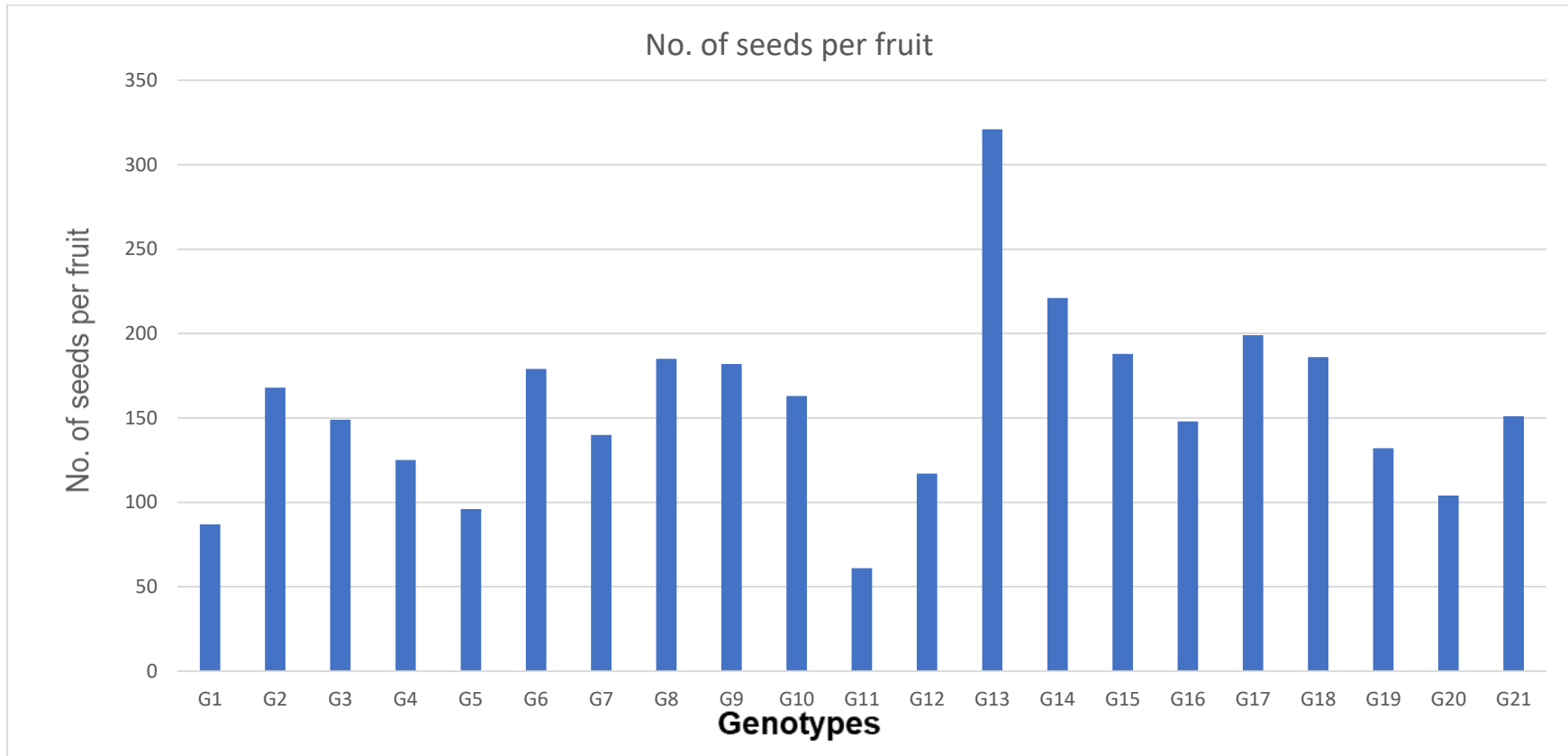


Fig. 4.3: Physico-chemical parameters (Number of seeds per fruit)

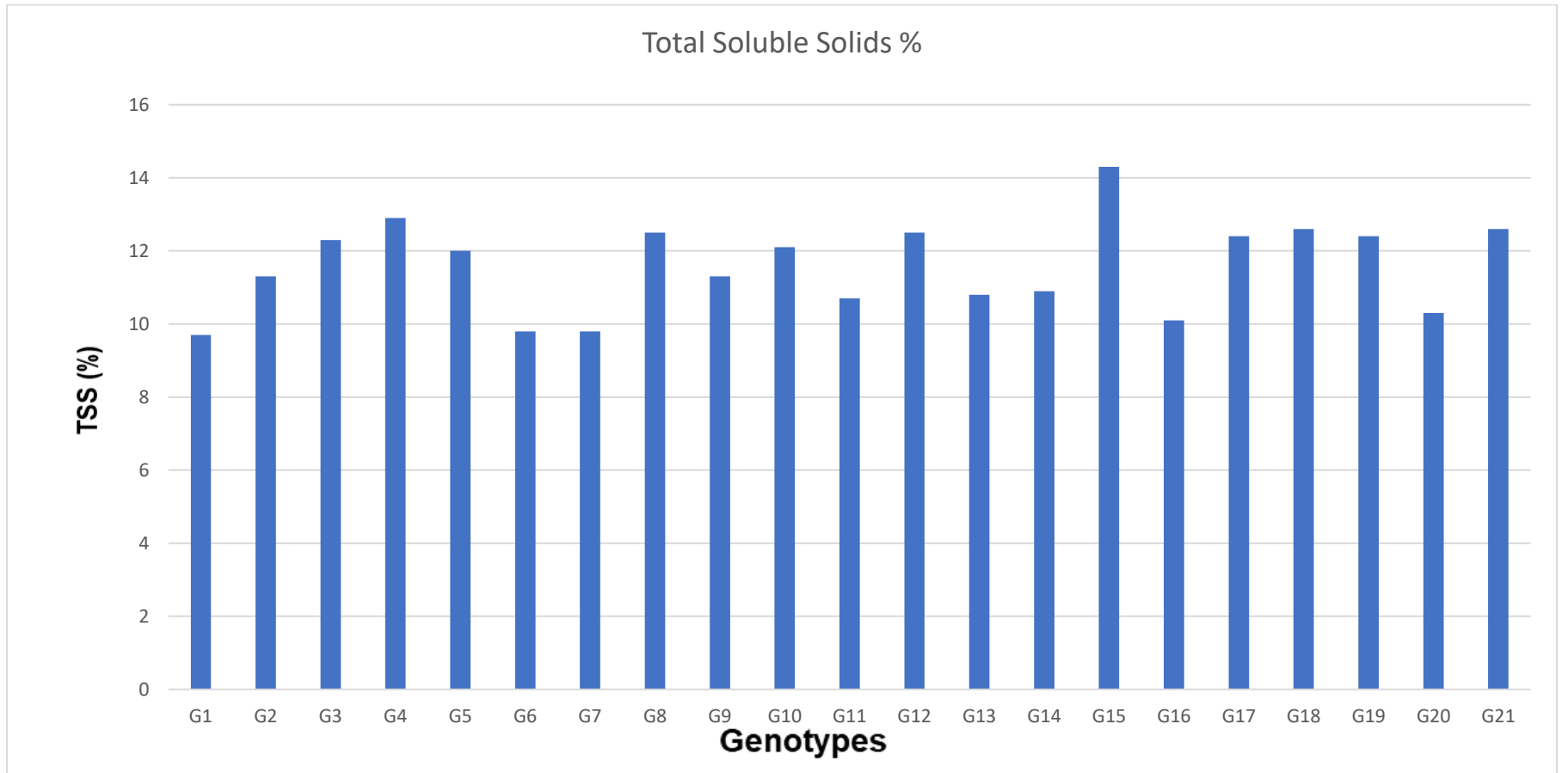


Fig. 4.4: Qualitative parameter of fruits (TSS)

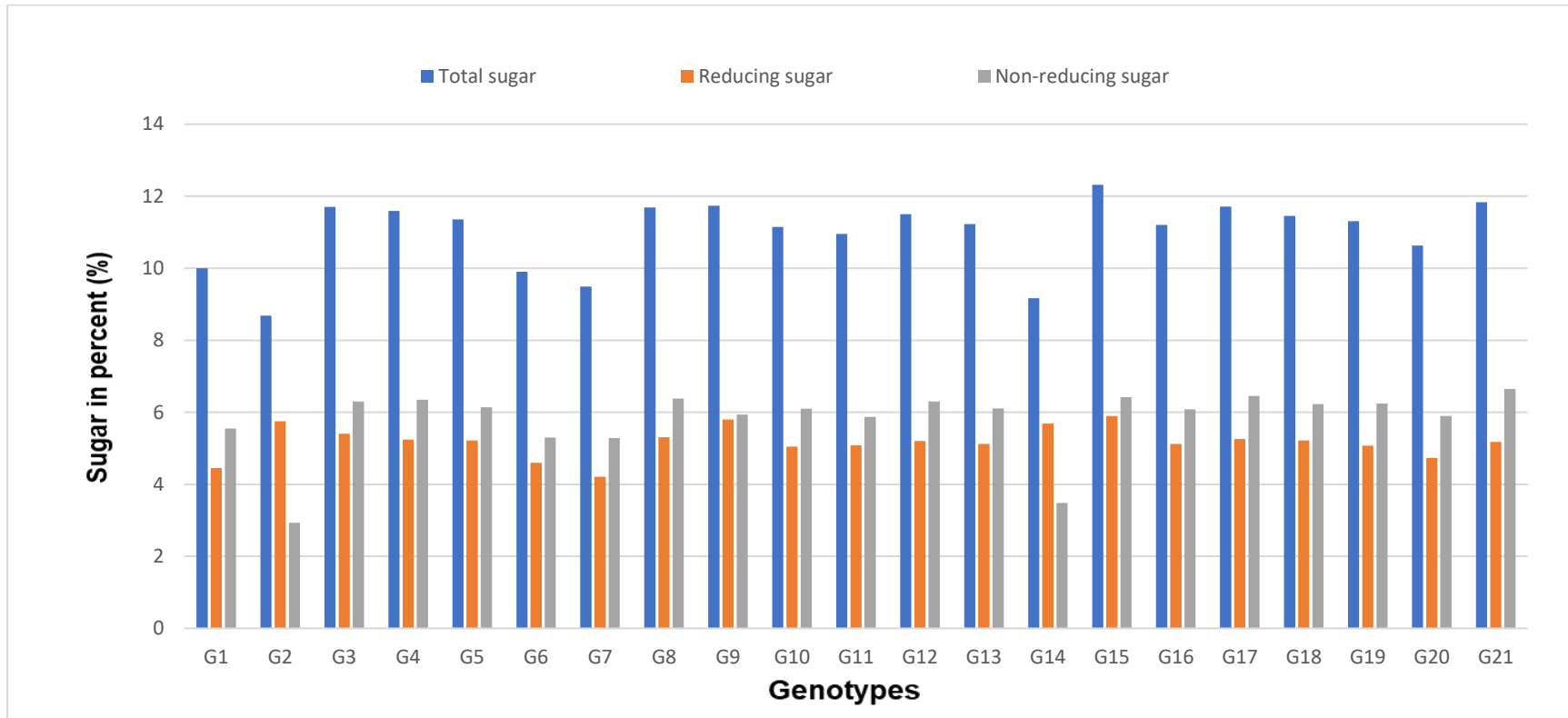


Fig. 4.5: Qualitative parameters of fruits (Total, reducing and non-reducing sugars)

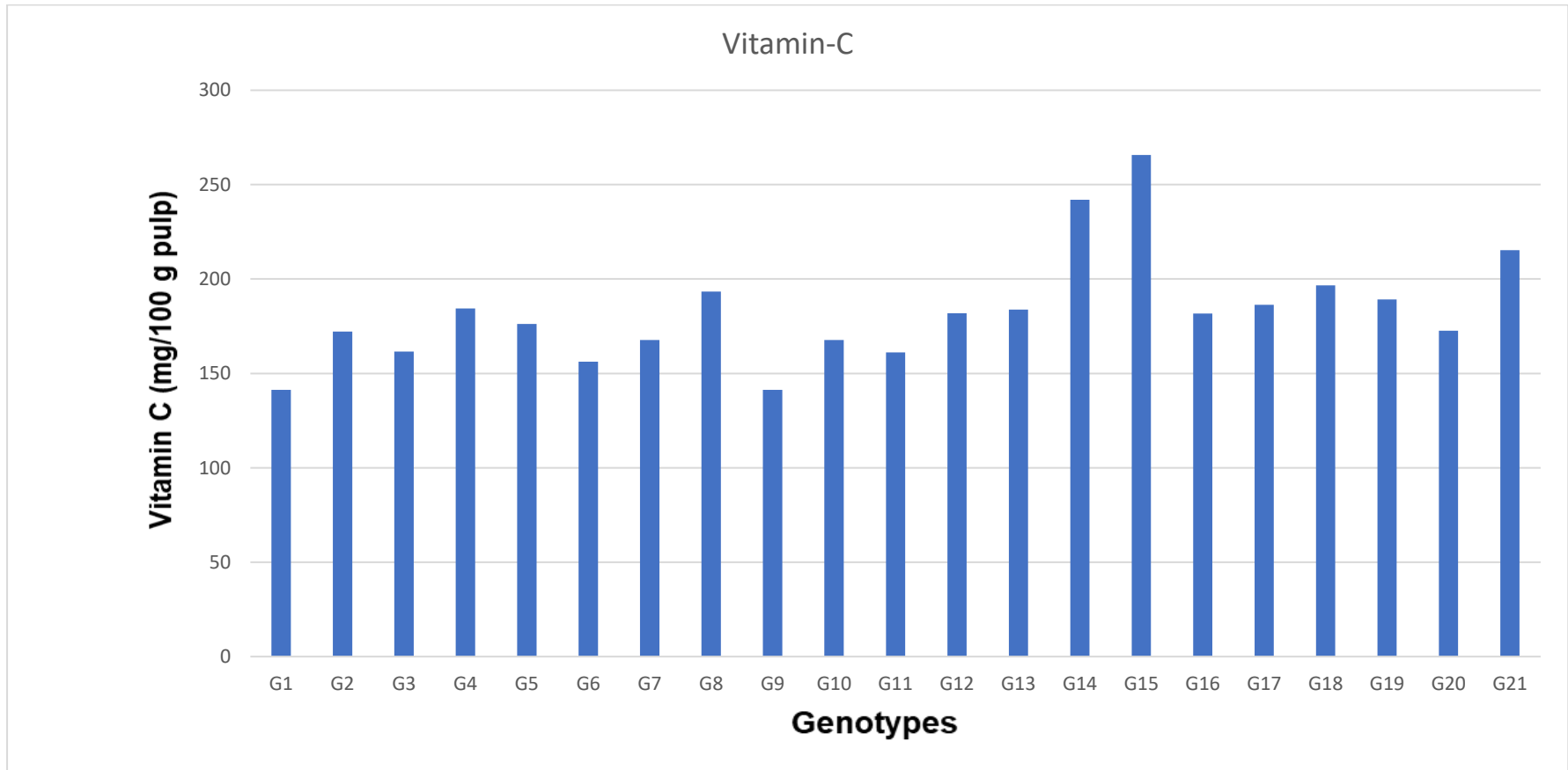


Fig. 4.6: Qualitative parameter of fruits (vitamin C)

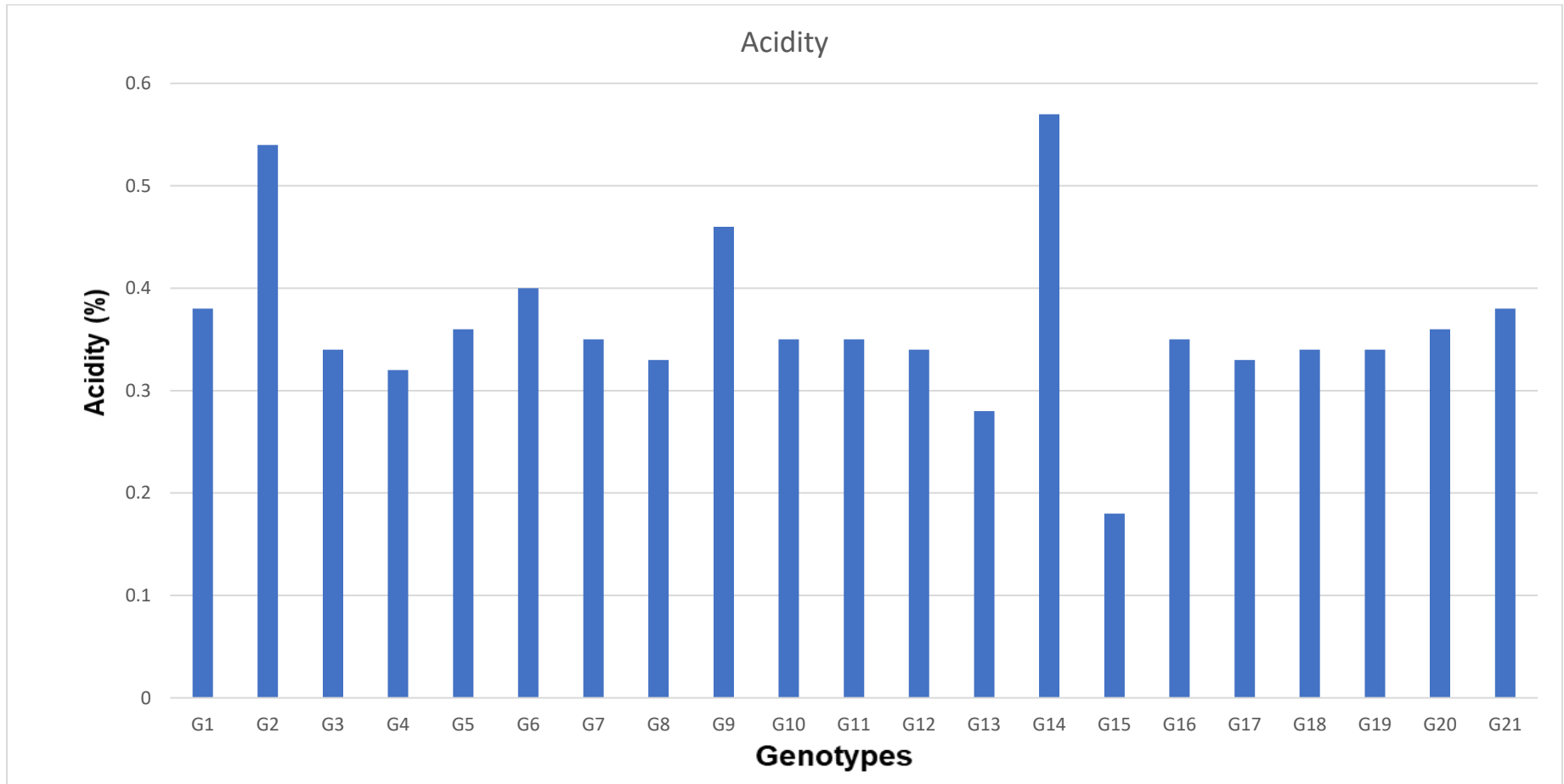


Fig. 4.7: Qualitative parameter of fruits (Acidity)

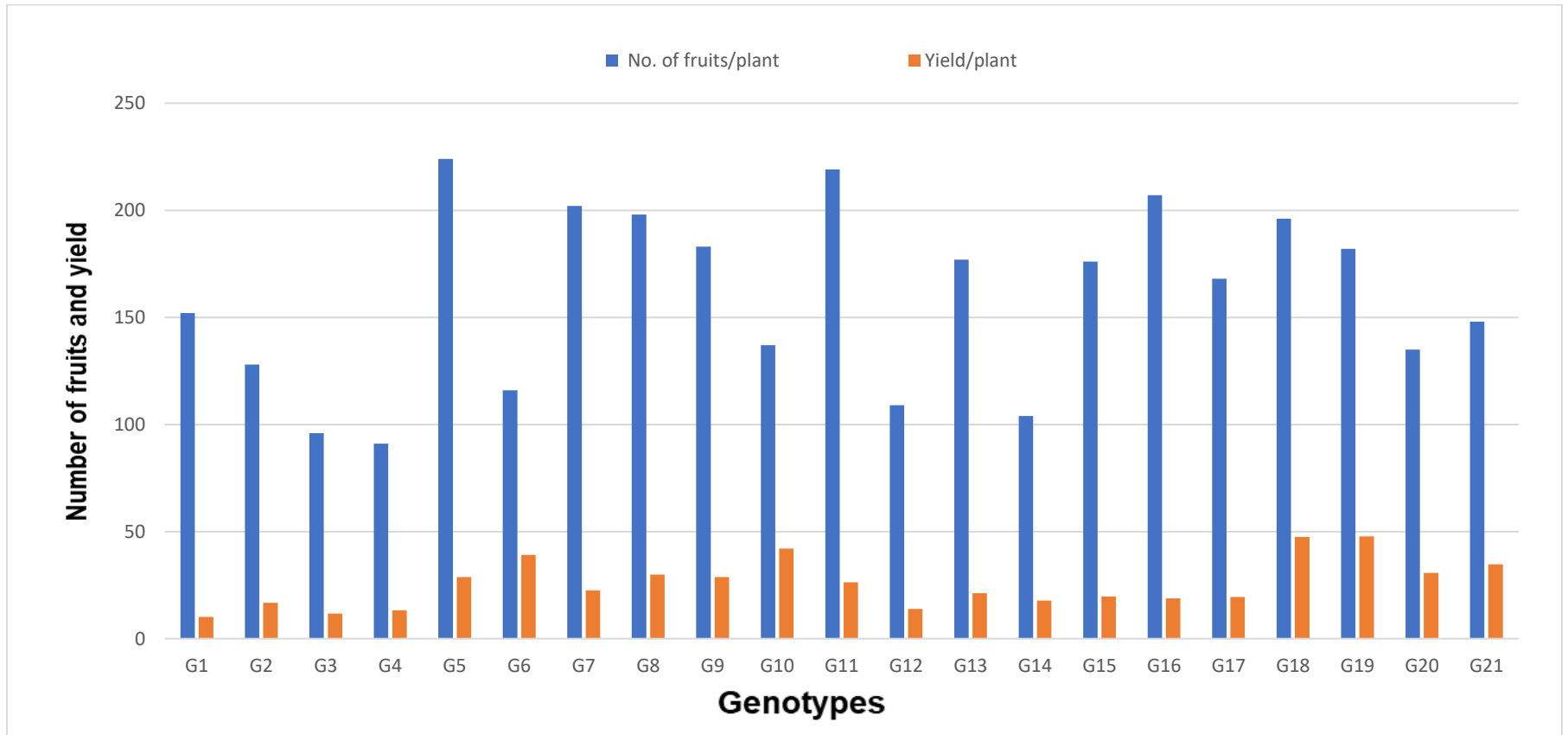


Fig. 4.8:Yield attributes

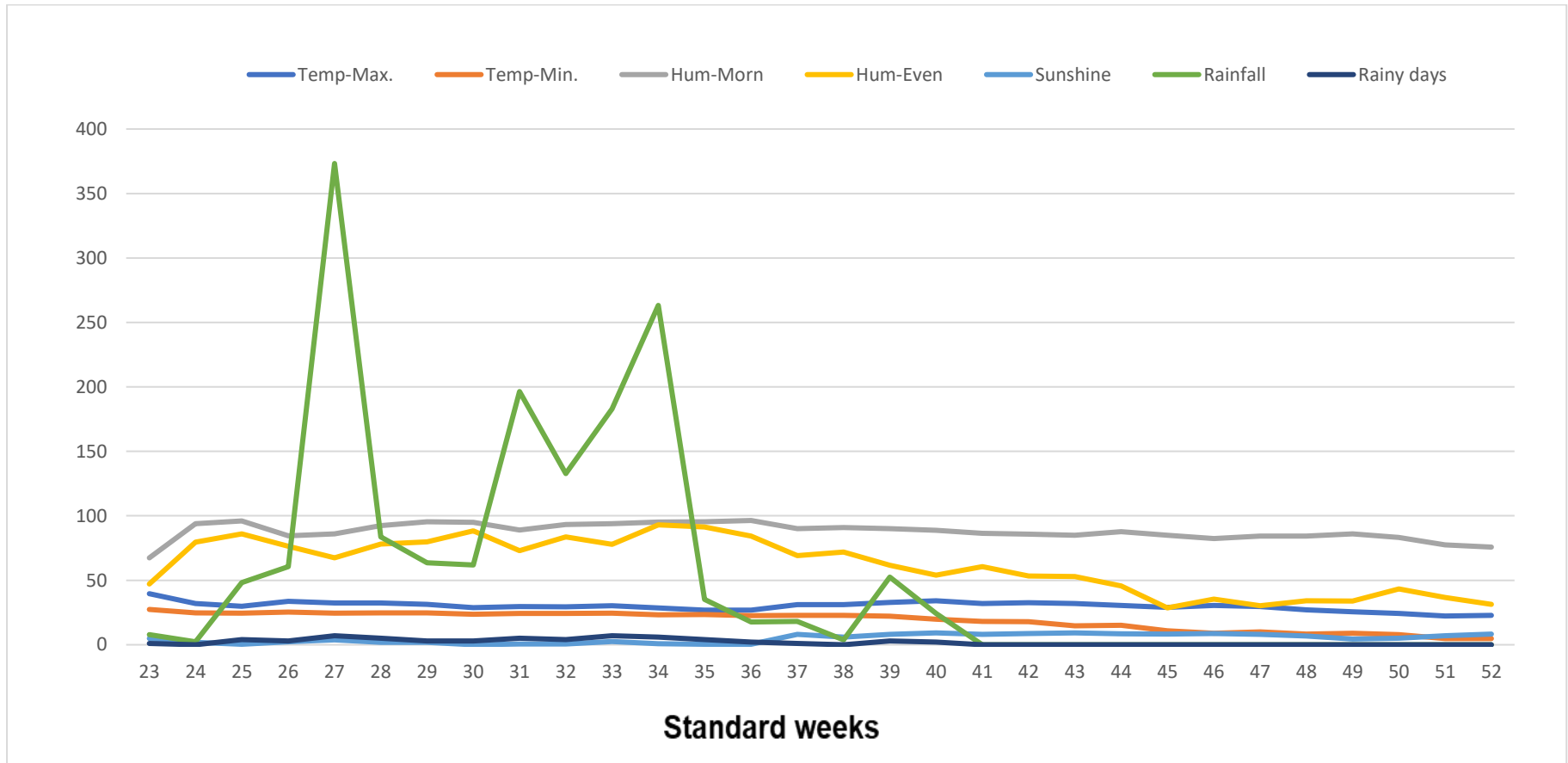


Fig. 3.1:Weekly Metrological observation during the study period(June to December 2018)



G-1

G-2

G-3



G-4

G-5

G-6



G-7

G-8

G-9

Plate-4.1:Physical standards of guava genotypes



G-10

G-11

G-12



G-13

G-14

G-15



G-16

G-17

G-18

Plate-4.2:Physical standards of guava genotypes



G-19

G-20

G-21

Plate-4.3: Physical standards of guava genotypes

