

**Diversity Assessment of Seedling Guava (*Psidium guajava* L.)
in Jammu Sub-tropics**

By

ISHA SHARMA

(J-16-M-446)

Thesis submitted to Faculty of Postgraduate Studies
In partial fulfillment of the requirements
For the degree of

**MASTER OF SCIENCE IN AGRICULTURE
HORTICULTURE (FRUIT SCIENCE)**



**Division of Fruit Science
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu
Main Campus, Chatha, Jammu 180009**

2019

M.Sc.


**Diversity Assessment of Seedling Guava (*Psidium guajava* L.)
in Jammu Sub-tropics**

**ISHA
SHARMA**

2019


CERTIFICATE-I

This is to certify that the thesis entitled "**Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropics**" submitted in partial fulfillment of the requirements for the degree of **Master of Science in (Ag.) Horticulture (Fruit Science)** to the Faculty of Post Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, is a record of bonafide research, carried out by **Miss Isha Sharma**, Registration No. **J-16-M-446**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that help and assistance received during the course of thesis investigation have been duly acknowledged.


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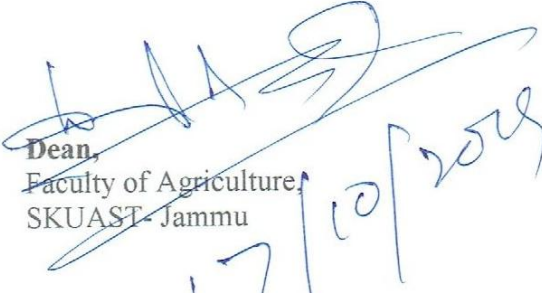
CERTIFICATE-III

This is to certify that the thesis entitled “**Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropics**” submitted by **Miss Isha Sharma**, Registration No. **J-16-M-446**, to the Faculty of Post Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology Jammu, in partial fulfillment of the requirement for the degree of **Master of Science in (Ag.) Horticulture (Fruit Science)**, was examined and approved by the advisory committee and external examiner (s) on 16-9-2019.


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ABSTRACT

Title of the Thesis : “Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropics”
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ABSTRACT

The present study entitled “Diversity assessment of seedling guava (*Psidium guajava* L.) in Jammu sub-tropics” was carried out during the year 2017-2018 in the sub tropical region of Jammu province at three locations viz., Jammu, Samba and Akhnoor to assess the genetic diversity present in the seedling population of guava. Data was recorded on tree and fruit characters and diversity was estimated using different genetic parameters. Results revealed that in the population plant height, plant spread, plant volume, trunk girth, leaf area, fruit weight, fruit diameter, fruit volume, pulp percentage, total sugars, reducing sugar, vitamin C, yield and yield efficiency ranged between 3.16 - 5.98 m, 2.37 - 3.97 m, 12.38 - 74.15 m³, 20.02 - 27.27 cm, 43.67 - 102.52 cm², 86.70 - 177.17 g, 5.13 - 6.70 cm, 92.48 - 180.07 cm³, 96.45 - 99.06%, 6.19 - 10.50%, 3.22 - 6.51%, 128.40 - 215 mg/100 g, 16.0-24.80 kg/tree and 0.34-0.53 Kg/cm² respectively. Phenotypic coefficient of correlation was higher than genotypic coefficient of correlation for all the characters and broad sense heritability ranged between 37.14 to 81.14% for different characters. Fruit yield was significantly correlated with fruit weight fruit diameter, pulp percentage, seed weight, hundred seed weight and yield efficiency. Path analysis revealed that characters like fruit weight, fruit diameter, pulp weight, pulp percentage, seed weight and yield efficiency had direct effect on the fruit yield. On the basis of cluster analysis all the genotypes studies were divided into five cluster having 124.71 to 185.20 inter-cluster distance and 274.40 to 834.74 intra-cluster distance. Five major components were detected using principle component analysis exhibiting 86.07% of total variation. The major characters contributing towards variation were yield, trunk cross sectional area, plant spread, fruit weight, leaf area, leaf width, leaf length and yield efficiency. On the basis of the study six guava genotypes were identified for important horticultural traits.

Key words: Guava, seedling, character association, correlation, path analysis.



Signature of the Major Advisor



Signature of the student

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Chapter-1

Introduction

INTRODUCTION

Guava (*Psidium guajava* L.) is the most important and commercially cultivated fruit crop belonging to the family Myrtaceae. It has originated in tropical America, stretching from Mexico to Peru and gradually became a crop of commercial significance in several countries like Brazil, Mexico, China, Malaysia, Hawaiian Islands, Cuba and India. It was introduced to India during 17th century by Portuguese (Menzel and Paxton, 1985). It is commercially cultivated in different states of India, viz., Uttar Pradesh, Bihar, Punjab, Andhra Pradesh, Karnataka, Gujarat, Maharashtra, West Bengal, Madhya Pradesh and Tamil Nadu. The current guava production in India is 22.70 lakh metric tons from an area of 204 thousand hectares (Anonymous, 2018). The crop has gained considerable prominence in India on account of its high nutritive value, pleasant aroma, good flavor and availability at moderate price. Besides, it is one of the hardiest among the fruits in productivity, adaptability with nutritional quality and hence aptly known as 'Poor man's apple' and 'Apple of tropics'. The fruit contains 165 mg of vitamin C as against a mere 69 mg in orange. It is also an excellent source of beta carotene, lycopene, potassium and soluble fiber. Guava is very rich in antioxidants which can act against the free radicals that damage cells and cause cancer, diabetes and coronary diseases. Guava possesses antiseptic, astringent and anti helminthic properties useful to cure many diseases and ailments. It has been used in ancient Chinese medicine to treat diabetes for a very long time. Recent studies have now proven that it lowers blood sugar therefore it may be a natural way to help in preventing diabetes. It is also rich in Vitamin A and B and thus very useful in the preparation of products for anti-aging skin care. The extract of the guava leaf is used in many skin whitening products. Drinking a glass of guava juice can meet the daily requirement of Vitamin C. It can also save the money often spent on less nutritious soft drinks. Pink pulped guava varieties supply a carotenoid called as Lycopene which is considered a potential agent for prevention of some types of cancers, particularly prostate cancer (Naseer *et.al.*, 2018). Thus, nutritionally it is a fruit of good choice. Besides meeting the daily requirements in terms of quantity, the food should be able to source all the nutritional requirements of the people across the various income groups. Unless this is achieved, scientific and administrative efforts directed towards nurturing the people will not become comprehensive. Deficiency of

vitamin A is found to be one of the most serious nutritional problems faced by human beings especially children from the poor nations. Therefore guava provides a viable alternate to protective foods.

Guava is also grown in sub-tropical regions of Jammu including Kathua, Samba, Jammu, Reasi, Rajouri and Udhampur districts. Guava has long back been introduced in to this area and there is lot of natural population of seedling origin in this region. Being a cross pollinated crop, each guava plant of seedling origin possesses unique gene combination. Therefore, morphologically they are different from each other. From fruit quality point of view, these seedling plants varies from inferior to superior. The chances of success of any crop improvement programme increases to a greater extent if genetic variability is present within the available germplasm. Greater variability in the initial material also ensures evolution of desirable recombination by using suitable breeding methods. Guava being an open pollinated and heterozygous crop with adequate genetic variation helps in selection of desirable commercial types (Nakasone and Paull, 1999). Improvement in any fruit crop needs to be undertaken through breeding and genetic manipulation which has sufficient gene pool. The extent of variability in guava for vegetative and fruit characteristics has been estimated by several workers (Thimmappaiah *et al.*, 1985; Bandopadhyay *et al.*, 1992; Rattanpal and Dhaliwal, 1999; Raghava and Tiwari, 2008 and Bihari and Suryanarayan, 2011) in different regions of India. The variation with regard to growth and bearing habits, yield and quality of different guava cultivars have also been reported by Chadha *et al.* (1981) and Ojha *et al.* (1985) in different parts of the country. Patel *et al.* (2011) also recorded wide range of variation with respect to plant growth, yield and quality traits of fruit in sub-tropics of Meghalaya among five years old eleven guava genotypes *viz.*, RCG-1, RCG-2, RCG-3, RCG-11, RCGH-1, RCGH-4, RCGH-7, Allahabad Safeda, L-49, Lalit and Sangam.

Attempts have been made in the past to utilize this inherent variability of guava germplasm pool and many varieties have been developed through selection e.g. Allahabad Safeda, L-49, Lalit and Shweta etc. For continued improvement of guava through breeding to overcome threats from diseases, insect pests or biotic stresses and to evolve varieties according to consumer preferences, a diverse gene pool is essential. Knowledge about the availability of the genetic diversity would assist in the selection of parents in a hybridization programme. Seedling guava vary greatly with respect to their growth characteristics, fruit quality and yield characters. To expedite

the crop improvement programme, it is necessary to trap the natural variability through surveys and the variability should be conserved *ex situ* and *in situ* to utilize for further hybridization programmes. For primary screening, the morphological characterization is effective and to trace true genetic variation.

Jammu, Samba and Akhnoor region of Jammu province of Jammu and Kashmir are suitable for guava cultivation and a lot of germplasm of seedling origin exists in these areas which can be screened to identify certain superior plant and utilized for developing a cultivar or can be used in further guava breeding programmes. Therefore present investigations were undertaken in Jammu, Samba and Akhnoor region of Jammu province with the following objectives:

1. To study the genetic diversity of seedling guava in Jammu province.
2. To select superior genotypes of seedling guava growing in Jammu province.

Chapter-2

Review of Literature

REVIEW OF LITERATURE

After introduction of guava in India, it has adapted so well to the agro-climatic conditions that now it ranks 4th among fruit crops in terms of importance. Number of selections in guava has been released in India, however, market demand, changing climatic conditions and surge of new biotic and abiotic stresses warrants development of improved cultivars. And the primary source of new cultivars is the existing and created variability in the parent population. An effort towards assessing the variability and measuring the character association in the seedling population of guava would help in designing crop improvement strategies for achieving desirable plant ediotype having superior qualitative and quantitative attributes. The growth and fruit characters of guava which influence yield, vary with different seasons. Hence the work was undertaken to quantify the genetic diversity and to study the character association of guava to assess the variability present in the seedling population and to identify the characters contributing towards yield and quality. In this chapter, the studies done by previous workers have been reviewed and authors are fully acknowledged. Since guava is a cross pollinated crop therefore each guava plant of seedling origin has unique gene combination. These different gene combinations when expressed, leads to different morphological characters. However, morphology is not true expression of gene because there is influence of environment also. Therefore to ascertain the true genetic potential of the individual, genetic parameters should be assessed. Morphological as well as genetic variability of seedling origin guava has been assessed in different parts of India as well as world. The literature pertaining to these studies of given under following heads:

2.1 Phenotypic Plant Characteristics:

2.1.1 Tree height:

Phadnis (1970) evaluated nine guava selections under Pune conditions and found that plant height ranged between 4.2 m in Lucknow-49 to 8.1 m in Seedless. Singh and Khan (1989) studied two year old guava plants and found that the cultivar Red Fleshed showed the maximum height and spread of plant, whereas, minimum height was noted in Sardar guava. Subramanyan and Dinesh (1993) reported the maximum plant height in Beaumont (4.00 m) and minimum in Apple Colour variety (2.10 m). Pandey *et al.* (1997) evaluated seven years old guava cultivars under Rewa

(Madhya Pradesh) condition and reported that plant height varied from 4.35 m in cultivar Seedless to 3.48 m in cultivar Gwalior-27. Under Sabour conditions of Bihar, [Dubey et al. \(2000\)](#) evaluated ten guava cultivars and found that the plant height ranged between 2.09 m in selection R4P5 and 2.99 m in cultivar Allahabad Safeda. [Girwani et al. \(2005\)](#) evaluated 28 accessions, among which Seedless-1, Seedless-2, Sabdana Badri, Lucknow 46-1 and Kohir Safeda were found superior with respect to growth attributes, while Chinese guava and Apple form were comparatively dwarf after four years of planting. [Dubey et al. \(2002\)](#) studied growth behavior of guava germplasm under Sabour conditions for rainy season and reported maximum plant height in Allahabad Safeda (5.4 m). [Sharma et al. \(2002\)](#) carried out an experiment to evaluate the performance of guava (*Psidium guajava* L.) introduced in arid conditions of Western Rajasthan and recorded that plant height, trunk girth was ranged between 1.38 m to 2.10 m, 4.15 cm to 5.82 cm respectively and stated that maximum plant height (2.10 m) and trunk girth (5.82 cm) was observed in cultivar Red Fleshed. They also reported that maximum value for plant spread (3.40 and 3.50 m) was again observed in cultivar Red Fleshed. [Singh \(2003\)](#) studied the performance of ten year old guava cultivars Baraf Khana, Seedless, Behat Coconut, Chittidar, Allahabad Safeda, Lucknow-49 and Red Fleshed under Tripura climatic conditions, India. The maximum plant height (3.70 m) was observed in Seedless followed by Chittidar (3.55 m).. [Girwani et al. \(2005\)](#) studied 28 accessions of guava among which Seedless-1, Seedless-2, Sabdana Badri, Lucknow 46-1 and Kohir Safeda were found superior with respect to growth attributes, while Chinese guava and Apple color were comparatively dwarf after four years of planting. [Athani et al. \(2007\)](#) evaluated 19 guava cultivars under Arabhavi conditions and observed average plant height ranged between 183.67 cm in selection CIW-3 and 466.5 cm in selection Chittidar. At UAS, Bangalore, [Marak and Mukunda \(2007\)](#) evaluated ten seedling progenies of cultivar Apple Colour and found that plant height ranged from 3.22 m in A.C.Seln.10/2 to 1.98 m in A.C.Slen.6/10. [Patel et al. \(2007\)](#) evaluated six genetically diverse hybrids/cultivars under Meghalaya conditions and found that tree height varied from 2.80 m in Hybrid-2 to 1.71 m in L-49. [Patel et al. \(2011\)](#) reported that plant height ranged between 2.04 m in Lucknow 49 to 3.07m in RCGH-1. [Singh et al. \(2011\)](#) studied the performance of guava varieties under Vindhya region of Madhya Pradesh and recorded the maximum plant height (4.85 m) and minimum plant height in China Red as 2.86 m. [Ulemale and Tambe \(2015\)](#) studied morpho-phenological characters

of guava genotypes and reported that maximum height of plant (4.21 m) was recorded in genotype GRS4, followed by genotype GWS6 (3.78 m) and GRS2 (3.65 m) while, genotype GWS8 recorded the lowest height of plant (2.60 m) preceded by genotype GWS5 (2.71 m). Pandey *et al.* (2016) assessed 10 guava cultivars and reported that maximum plant height in hybrid-21 (6.33 m) and minimum in Arka Amulya (4.83 m).

2.1.2 Tree spread:

Phadnis (1970) evaluated nine guava selections of 25 years old under Pune conditions and found that plant spread varied from 8.4 m (N-S) and 9.9 m (E-W) in Sel. Seedless to 4.8 m (N-S) and 6.6 m (E-W) in Sel. Lucknow-46. Pandey *et al.* (1997) evaluated nine guava varieties under Rewa (M.P.) conditions and reported that plant spread ranged between 5.46 m (North South) and 4.94 m (East West) in cultivar Chittidar to 3.96 m (North South) and 4.21 m (East West) in Allahabad Safeda. Singh (2003) studied the performance of ten year old guava cultivars Baraf Khana, Seedless, Behat Coconut, Chittidar, Allahabad Safeda, Lucknow-49 and Red Fleshed under Tripura climatic conditions, India and reported that mean plant spread varied from 5.00 m in Behat Coconut to 6.67 m in Baraf Khana and Seedless. Marak and Mukunda (2007) evaluated ten seedling progenies of cultivars Apple Colour and recorded that plant spread ranged from 3.30 m (North South) to 3.82 m (East West) in A.C. Seln.12/10 to 1.92 m (N-S) and 2.22 m (E-W) in Allahabad Safeda. In an evaluation study on 11 guava cultivars, plant spread varied from 4.17 m (North South) and 4.20 m (East West) in Hybrid-21 to 2.90 m (North South) and 2.97 m (East West) in Hisar Safeda under Lucknow conditions (Pandey *et al.*, 2007). Athani *et al.* (2007) conducted an experiment to evaluate guava cultivars for growth and fruit characters at Kittur Rani Channama College of Horticulture during 2001-02 and 2002-2003 and experiment revealed that maximum plant girth was recorded as 11.10 and 13.25 cm respectively in cultivar Seedless. Among 11 guava selections and genotypes of 5 year age, Patel *et al.* (2011) reported that plant spread ranged between 2.35 m in RCG-3 to 7.66 m in Lalit. Kale (2009) conducted comparative studies of Nucellar and Sathgudi cultivars of sweet orange under Jalna conditions and found that maximum average spread of trees (2.94 m^2) was recorded in Nucellar and minimum was found in (2.48 m^2) in Sathgudi mosambi. Jadhav (2012) reported that trees of the sweet orange varieties *viz.*, Nucellar, Sathgudi and Local Mosambi exhibits wide variation in height with 3.87 m in Nucellar, 3.51 m in Sathgudi and 3.40 m in Local Mosambi. In Nucellar variety of sweet orange, the maximum tree spread 3.20 m in

East-West direction and 3.12 m in North-South direction has been noticed while it was 3.05 m in East-West and 2.92 m in North-South directions in Sathgudi and 2.70 m in East-West and 2.64 m in Local Mosambi. Pandey *et al.* (2016) assessed 10 guava cultivars and reported that maximum canopy spread (7.53 m) in East-West direction was recorded in Hybrid-21 followed by Hisar Safeda (5.82 m) and Hisar Surkha (5.80 m) whereas, minimum canopy spread was found in CISH-G-31 (4.77 m).

2.1.3 Tree volume: Rattanpal and Dhaliwal, (1999) carried out the study on 325 open-pollinated seedlings of Allahabad Safeda, Bangalore Seedling, Sardar Guava and hybrids of Allahabad Safeda × Seedless, with an objective to quantify the variability patterns in tree volume and trunk girth and reported that magnitude of variability for tree volume was substantially more than that for trunk girth. They also found that in seedling types the tree volume ranged from 22.1 to 185.9 m³ and trunk girth from 11.1 to 44.1 cm. Tree volume was recorded maximum in seedlings of Allahabad Safeda × Seedless, followed by Bangalore seedling, Sardar guava and Allahabad Safeda.

2.1.4 Trunk girth

Subramanyam and Dinesh (1993) reported that maximum stem girth was recorded in Beaumont (13.0 cm) and minimum in Red Fleshed (5.5 cm) cultivar of guava. Singh *et al.* (2016) carried out an experiment to evaluate the performance of guava (*Psidium guajava* L.) introduced in arid conditions of western Rajasthan and recorded that plant height ranged between 1.38 m to 2.10 m, 4.15 cm to 5.82 cm respectively and stated that maximum trunk girth (5.82 cm) was observed in cultivar Red Fleshed. Singh (2003) studied the performance of ten year old guava cultivars like Baraf Khana, Seedless, Behat Coconut, Chittidar, Allahabad Safeda, Lucknow-49 and Red Fleshed under Tripura climatic conditions, India and study revealed that stem girth ranged from 44.12 cm in Chittidar to 72.50 cm in Baraf Khana, respectively. Athani *et al.* (2007) reported that cultivar Chittidar recorded maximum plant girth (11.10 and 13.25 cm) in cv. Seedless during 2001-02 and 2002-03. Pandey *et al.* (2007) revealed that among 11 guava cultivars, Pant Prabhat showed higher fruit diameter (7.13 cm), followed by IIHR Hybrid-21 (6.75 cm) and fruit weight varied from 130 g in Hisar Safeda to 275 g in Shweta. 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) as compared to other cultivars/hybrids. Singh *et al.* (2011) studied the performance of guava varieties under Vindhya region of Madhya Pradesh and recorded the maximum plant height (4.85 m) and stem girth (49.25 cm) in Allahabad Safeda whereas, minimum plant height and stem girth was recorded in China Red. Jadhav (2012) reported that trees of the sweet orange varieties *viz.*, Nucellar, Sathgudi and Local Mosambi exhibits wide variation in stem girth and reported that maximum girth of stem was recorded in Nucellar as 41.40 cm and Local Mosambi as 39.80 cm. Whereas, cultivar Sathgudi had recorded maximum stem girth 40.44 cm. Pandey *et al.* (2016) assessed 10 guava cultivars and recorded that plant girth varied from 41.63 to 85.45 cm with maximum in Hybrid-21 a 85.45 cm and minimum in Arka Amulya (41.63 cm).

2.1.5 Leaf area/ leaf size/ leaf length-width ratio:

In general leaves are important for photosynthesis, respiration, transpiration and biophysical reaction of the plant. Teatota *et al.* (1969) studied the morphological, fruiting behaviour and quality of seven important varieties of guava at Basti (U.P.) *viz.*, Baruipur, Behat Coconut, Hafsi, Mirzapur Seeding, Supreme Mild Fleshed, Nasik and Smooth Green. They reported that Mirzapur Seeding had maximum leaf area, leaf length and leaf width. The leaf area of 15 ber cultivars was estimated with planimeter by Chitkara and Khera (1973) and they have reported that leaf area of ber cultivar Umran was less than Illachi. Shiva *et al.* (2017) carried out a study on characterization of guava (*Psidium guajava* L.) germplasm based on leaf and fruit parameters and revealed that guava genotypes showed significant variations in leaf characteristics like leaf length (15.41 cm), leaf width (7.62 cm) and leaf area (60.15 cm²) in Pant Parbat cultivar. They also reported that maximum leaf area (60.92 cm²) in Red Fleshed with Leaf-width ratio (3.16).

2.2 Physical Fruit Characteristics:

2.2.1 Fruit weight:

In an evaluation study of different guava cultivars and selections under Pune conditions, Phadnis (1970) found that weight of fruit ranged from 85 g in Sel. Dharwar-34 to 198.4 g in Lucknow-49 and Dholka-7. Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that cultivar Sardar recorded maximum fruit weight as 171 g. Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that average weight of fruit ranged from 117.50 g in BHR-1 to 327 g in ABD-1. Under Lucknow conditions,

among different guava cultivars, average fruit weight ranged between 118 g in cultivar White Flesh and 220.9 g in cultivar Gunes (Tandon *et al.* 1983). Singh (1988) evaluated 25 guava cultivars under Basti (U.P.) conditions and found that the fruit weight ranged from 51.6 g in cultivar Florida Seedling to 220 g in cultivar Baraf Khana. Chatterjee *et al.* (1992) studied three important cultivars of guava and observed that Allahabad Safeda had highest fruit weight (87.52g) followed by Sardar guava (74.58g) and Red Fleshed (50.25g). Singh and Sharma (1996) observed that highest fruit weight (109 g) was recorded for Lucknow-49 followed by Allahabad Safeda (106.8 g), whereas, seedling guava had the lowest fruit weight as 40.23 g. According to Das *et al.* (1995) the fruit weight among guava seedling populations ranged from 58.60 g to 148.30 g and from 68.70 g to 179.2 g during rainy and winter seasons respectively. Ram *et al.* (1997) evaluated 11 guava selections under Lucknow conditions and reported that average fruit weight ranged from 75 g in C.S.-3 to 300 g in C.S.-5. Singh *et al.* (2002) obtained maximum fruit weight in Allahabad Safeda followed by Safed Jam during both rainy and winter seasons and least fruit weight was found in Kohir Safeda, wherein, rainy-season fruits had less fruit weight than of winter season in all genotypes. The rainy season crop recorded more fruit yield than winter season crop. Patel *et al.* (2005) studied the fruit quality in eight guava cultivars and recorded the highest fruit weight as 192.50 g in Dharidar. Girwani *et al.* (2005) reported that the fruit weight ranged from 16 g in Chinese guava to 167.50 g in Red fleshed, whereas it was varied between 116 g in cultivar Baraf Khana to 49.50 g in cultivar Lucknow-49 in an evaluation study conducted by Aulakh (2005) under Punjab conditions. Gohil *et al.* (2006) studied fruit weight of twelve guava cultivars under Rahuri conditions and found that it varied from 261.7 g in cultivar Seedless Basti to 105 g in cultivar Chittidar. Fruit weight ranged between 97.7 g in Hybrid-2 and 152.50 g in cultivar Lucknow-49 under Meghalaya conditions (Patel *et al.* 2007). Athani *et al.* (2007) evaluated 19 guava selections/cultivars under Arabhavi conditions and found that mean fruit weight ranged from 46.84 g in GW-3 and GR-3 to 156.32 g in cultivar Sardar. Marak and Mukunda (2007) evaluated ten seedling progeny selections of cultivar Apple Colour under Bangalore conditions and reported that fruit weight ranged from 59.21 g in A.C.Seln.6/6 to 176.76 g in A.C.Seln.2/11. Under Bangalore conditions fruit weight varied between 67.28 g in TG selection 8/12 and 122.72 g in TG selection 6/10 in an evaluation study on ten Taiwan Guava selections (Biradar and Mukunda, 2007). Babu *et al.* (2007) studied performance of

eight year old guava selections under Meghalaya conditions and concluded that the fruit weight ranged from 90 g in Selection-10 to 144.20 g in Selection-11. Fruit weight varied from 130 g in cultivar Hisar Safeda to 275 g in cultivar Shweta under Lucknow conditions (Pandey *et al.* 2007). While evaluating 11 pink pulped Navalur guava selections in Karnatka, Patel *et al.* (2011) reported that total fruit weight per plant ranged between 92.48 gm in cv. Sangam to 184.50 in RCGH-4. Pandey *et al.* (2016) assessed ten guava grafted plants and found variation in fruit weight. The maximum average fruit weight was recorded in Pant Prabhat (279.84 g) and minimum fruit weight (157.20 g) was observed in Hisar Surkha. Jat *et al.* (2017) conducted a survey and evaluated physico-chemical characters of guava cultivar L-49 in Jhalawar district of Rajasthan with an aim to identify promising type amongst orchards of guava L-49 and reported that out of 70 sites selected for the purpose of study highest fruit weight (279.98 g) was recorded in Ganganagar area.

2.2.2 Fruit length:

Phadnis (1970) evaluated nine guava selections under Pune conditions and found that fruit length ranged between 6.2 cm in Sel. Dharwar-34 to 8.9 cm in Sel. Lucknow-46, whereas under Hissar conditions fruit length varied from 7.62 cm in cultivar Seedless to 5.05 cm in cultivar Banarasi Surkha (Chundawat *et al.* 1976). Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that cultivar Sardar recorded maximum fruit length as 6.16 cm as compared to 6.03 cm in cultivar Dharwar. Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that minimum fruit length (6.44 cm) was recorded in BHR-2 and maximum (8.99 cm) in ABD-1. Chatterjee *et al.* (1992) studied three important cultivars of guava fruits and found that Sardar guava attains the maximum fruit length (5.55 cm) followed by Allahabad Safeda (5.49 cm) and Red-Fleshed (4.35 cm.). Mitra *et al.* (1983) evaluated eleven guava cultivars and reported that fruit length ranged between 4.2 cm in cultivar Seedless to 5.8 cm in cultivar Lucknow-49 and Behat Coconut and under West Bengal conditions. Under Lucknow conditions the fruit length varied from 5.1 cm in C.S.-3 to 6.64 cm in C.S.-5 (Ram *et al.* 1997), whereas, under Punjab conditions it varied from 4.73 cm in cultivar Strawberry to 6.40 cm in cultivars Behat coconut and Seedless (Aulakh, 2005). Patel *et al.* (2007) evaluated six hybrids and cultivars under Meghalaya conditions and concluded that fruit length ranged from 5.04 cm in Hybrid-2 to 6.56 cm in Lucknow-49. In an evaluation study under Lucknow conditions, Pandey *et al.*

(2007) found that among 11 newly developed guava hybrids/selections the fruit length varied between 5.83 cm in cultivar Lalit and 7.27 cm in cultivar Arka Amulya. Maximum fruit length was observed as 5.71 cm in TG selection 5/12 followed by TG selection 6/8 (5.70 cm) and minimum (4.48 cm) in TG selection 5/11 in an evaluation study under Bangalore conditions (Biradar and Mukunda, 2007). Babu *et al.* (2007) studied performance of eight years old guava selections under Meghalaya conditions and concluded that fruit length ranged from 50.10 mm in Selection-1 to 62.80 mm in Allahabad Safeda. Marak and Mukunda (2007) evaluated ten seedling progenies of cultivar Apple Colour under Bangalore conditions and found that maximum fruit length (5.65 cm) was recorded in cultivar Allahabad Safeda, followed by A.C. Seln.10/2 (5.43 cm) and A.C. Seln.6/6 (4.26 cm). Among 11 guava selections and genotypes of 5 year age, Patel *et al.* (2011) reported that fruit length ranged between 5.16 cm in cv. Sangam to 7.08cm in RCG-2. While evaluating 11 pink pulped Navalur guava selections in Karnataka, Pandey *et al.* (2016) assessed ten guava grafted plants and found significant variations in fruit weight, fruit length and fruit width. Jat *et al.* (2017) conducted a survey and evaluated physico-chemical characters of guava cultivar L-49 in Jhalawar district of Rajasthan with an aim to identify promising type amongst orchards of guava L-49 and reported that out of 70 sites selected for the purpose of study, maximum fruit length as 7.88 cm was recorded in Ganganagar area.

2.2.3 Fruit diameter:

Phadnis (1970) evaluated guava selections at 25 years age under Pune conditions and found that fruit diameter ranged from 4.6 cm in Sel. Dharwar-34 to 7.5 cm in Sel. Dholka-7. Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that cultivar Sardar recorded maximum fruit diameter (6.19 cm) while it was minimum (5.85 cm) in cultivar Dharwar. Under Parbhani conditions, fruit diameter ranged from 5.83 cm in BHR-1 to 9.27 cm in ABD-1 (Thonte and Chakrawar, 1982). Mitra *et al.* (1983) evaluated four year old guava cultivars and reported that fruit diameter ranged from 4.8 cm in cultivar Seedless to 6.4 cm in cultivar Lucknow-49 under West Bengal conditions, while under Lucknow conditions Ram *et al.* (1997) reported that average fruit diameter ranged from 5.23 cm in C.S.-3 to 8.5 cm in C.S.-5. Fruit diameter varied between 4.60 cm in cultivar Strawberry and 5.80 cm in cultivar Seedless in an evaluation study under Punjab conditions (Aulakh, 2005). Pandey *et al.* (2007) reported that among 11 guava cultivars, Pant Prabhat showed higher fruit diameter (7.13 cm), followed by IIHR

Hybrid-21 (6.75 cm) and fruit diameter varied between 55.52 mm in Selection-1 and 66.32 mm Allahabad Safeda in an evaluation study of eight guava cultivars under Meghalaya conditions (Babu *et al.* 2007). Patel *et al.* (2007) evaluated six genetically diverse hybrids/cultivars at five years age under Meghalaya conditions and found that fruit diameter ranged from 5.63 cm in Hybrid-2 to 6.91 cm in cultivar Lucknow-49. Biradar and Mukunda (2007) evaluated ten seedling progenies of cultivar Taiwan guava under Bangalore conditions and revealed that maximum fruit diameter (6.52 cm) was found in Allahabad Safeda followed by TG selection 6/10 (6.15 cm) while minimum (5.14 cm) in TG selection 5/11. Fruit diameter varied between 5.30 cm (A.C.Seln.6/6) and 6.83 cm (A.C.Seln.10/2) in an evaluation study under Bangalore conditions (Marak and Mukunda, 2007). Among 11 guava selections and genotypes of 5 year age, Patel *et al.* (2011) reported that fruit diameter ranged between 5.25 cm in cv. RCG-1 to 7.08 cm in RCGH-4. While evaluating 11 pink pulped Navalur selections in Karnatka, Jat *et al.* (2017) conducted a survey and evaluation of physico-chemical characters of guava cultivar L-49 in Jalwar district of Rajasthan with an aim to identify promising type amongst orchards of guava L-49 and reported that out of 70 sites selected for the purpose of study, highest fruit diameter (8.80 cm) in L-49 was recorded in Ganganagar area.

2.2.5 Fruit volume:

Sadashivaiah (1989) evaluated twelve clonally propagated progenies of different white and pink pulped Navalur guava selections under Dharwad conditions and reported that fruit volume ranged from 48 ml in cultivar GR-3 to 150.83 ml in cultivar CIW-4 to. Among ten seedling progenies of Taiwan Guava Under Bangalore conditions fruit volume ranged from 69.20 ml in TG selection 5/5 to 119.40 ml in TG selection 6/8 (Biradar and Mukunda, 2007). Raghav and Tiwari (2008) studied 12 different guava cultivars under Pantnagar conditions and recorded variation in fruit volume ranging from 17.88 ml to 209.68 ml. While evaluating 11 pink pulped Navalur selections in Karnatka.

2.2.6 Specific gravity:

Tandon and Kalra (1989) reported that fruit of two guava cultivars i.e. Allahabad safeda and Sardar were divided into three specific gravity groups I, II and III and recorded that maximum specific gravity >1.02 was recorded in Allahabad safeda and 1.02 and <1.02 was recorded in cultivar Sardar. Kuldeep (2014) carried out the study on physico-chemical composition of different cultivars of guava and

reported that highest specific gravity (1.03) was recorded L-49 during winter season whereas, lowest specific gravity (1.01) cultivar Gorakh Bilas Pasand. Shukla and Shukla (2017) carried out an experiment on studies of different guava cultivars suited to degraded soils revealed that cultivar Allahabad safeda recorded maximum specific gravity (1.23) followed by Lucknow-49 (1.03) and Apple guava (1.00).

2.2.7 Pulp percentage and pulp weight:

Mitra *et al.* (1983) evaluated eleven cultivars of guava and reported that weight of pulp ranged from 53.6 g in cultivar Seedless to 77.8 g in cultivar Lucknow-49 under West Bengal conditions. Das *et al.* (1995) found the largest and heaviest fruits of Sardar guava with the highest pulp percentage and lowest number of seeds per fruit. Patel *et al.* (2005) studied eight guava cultivars grown in Rewa, Madhya Pradesh, India and reported that cultivar Dharidar recorded maximum flesh weight as 127.68 g. Gohil *et al.* (2006) evaluated 12 guava cultivars under Rahuri conditions and revealed that the maximum pulp weight (261.7 g) was found in cultivar Seedless Basti, while minimum (76.0 g) in cultivar Pear Shaped. Under Arabhavi conditions maximum pulp weight (131.67 g) recorded in cultivar Sardar followed by cultivar CIW-4 (123.50 g) and SR-1 (94.67 g), while GR-1 showed minimum pulp weight as 26.28 g (Deshpande, 2006). While evaluating 11 pink pulped Navalur guava selections in Karnatka, Meena *et al.* (2013) studied nine guava genotypes and observed that genotype Lalit had highest pulp weight as 95.10 g, while the lowest in genotype FRSG-R7 (20.84 g).

2.2.8 Seed weight per fruit:

Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that cultivar Sardar recorded minimum weight of hundred seeds as 1.53 g, whereas, cultivar Dharwar recorded highest seed weight as 2.39 g. Ojha *et al.* (1985) studied the comparative performance of guava varieties during rainy and winter season and reported that the seed weight per fruit was found highest in Allahabad Safeda. Kurmi (1992) studied physical and chemical characteristics of guava fruits and found that cultivar Dharidar was superior on the basis of seed weight per fruit. Similarly, among Taiwan guava selections lowest weight of 100 seeds (0.71 g) was recorded in TG selection 5/5 and highest (1.21 g) in Allahabad Safeda (Biradar and Mukunda, 2007). Khehra and Bal (2006) studied eighteen distinct genotypes of guava and reported maximum seed weight (5.0 mg) in genotype

ASR/BA-18, whereas, lowest in ASR/RA-2. Among 11 Navalur guava selections and genotypes Meena *et al.* (2013) observed that cultivar Lalit had highest seed weight per fruit as 3.35g, whereas, minimum in FRSG-R4 as 1.72 g.

2.2.9 Number of seeds per fruit:

Under Pune conditions (Phadnis, 1970) reported that number of seeds per fruit ranged from 19 in Sel. Seedless to 443 in Sel. Kothrud-19. In the evaluation study of guava cultivars, Prakash (1976) found minimum seeds per fruit (126.9) in cultivar Dharwar, while, it was maximum in (331.8) in cultivar Sardar. Thonte and Chakrawar (1982) evaluated 11 guava strains under Parbhani conditions and revealed that average number of seed per fruit ranged between 100 in BHR-1 to 260 in ABD-1. Ojha *et al.* (1985) studied that comparative performance of guava varieties during rainy and winter season and reported that maximum number of seeds per fruit was found in Allahabad Safeda. Kurmi (1992) studied physical and chemical characteristics of guava fruits and found that cultivar Dharidar was superior on the basis of number of seeds per fruits. Patel *et al.* (2005) studied eight guava cultivars grown in Rewa, Madhya Pradesh, India, during 2000-01, wherein, maximum number of seeds were recorded as 583.83 in Rewa-72 and minimum number of seeds as 4.66 in Seedless (4.66). Gohil *et al.* (2006) evaluated fruit yield and quality in guava cultivars grown in Rahuri, Maharashtra and recorded that number of seeds per fruit was highest in cultivar Sardar as 355. Khehra and Bal (2006) studied eighteen distinct genotypes of guava and reported that maximum number of seeds per fruit (466) was found in genotype ASR/BA-15 and the minimum number of seeds 112 in genotype ASR/RA-2. Mark and Makunda (2007) evaluated ten seedling progenies of cultivar Apple Colour and recorded that least number of seeds per fruit (142) was noticed in A.C. Seln. 6/10 and the highest number of seeds per fruit (450) was recorded in A.C. Seln. 2/11. Similarly (Patel *et al.*, 2007) reported maximum seed count per fruit as 534 in hybrid 11 and minimum as 171 in hybrid -1 Patel *et al.* (2015) recorded number of seeds per fruit to range between 210.39 in Sel. 5 to 424.40 in Sel. 3. Singh *et al.* (2016) studied seven varieties of guava during the winter season and recorded the highest number of seed in Sharbati (194) whereas, lowest number of seeds (128) were found in cultivar Shweta.

2.2.10 Hundred seed weight per fruit:

Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that cultivar Sardar had minimum weight of hundred seeds as 1.53 g as

compared to cultivar Dharwar where 2.39 g weight of 100 seeds was recorded. Under Bangalore conditions, the weight of 100 seeds was found minimum in A.C.Seln.12/10 as 1.30g and maximum in A.C.Seln.2/11 and 5/5 as 1.60g (Marak and Mukunda, 2007). In a germplasm evaluation study under Lucknow conditions Patel *et al.* (2007) reported that weight of 100 seeds ranged between 0.92 g in cultivar Allahabad Safeda to 1.06 g in Hybrid-2. Patel *et al.* (2011) reported that 100 seed weight ranged between 27.27 in RCG-1 to 94.25 in RCG-11.

2.3 Bio-chemical fruit characteristics:

2.3.1 Total soluble solids/ T.S.S/ acid ratio:

Sachan *et al.* (1969) analyzed the fruits of cultivar Safeda obtained from rainy and winter season crops and concluded that the fruits of winter season crops were superior in quality as the ripe fruits of winter season crop had maximum TSS of 12.37°B. Kumar and Hooda (1974) also reported that winter season fruits of guava were reported to be superior having TSS upto 14.15°B at fully mature stage as compared rainy season crop where the TSS was lesser. Chauhan *et al.* (1986) while studying different guava cultivars reported that TSS ranged between 15.0°B in Allahabad Safeda to 15.4°B in Banarasi Surkha. Sharma *et al.* (1993) studied nine varieties of guava and found that cultivar Allahabad Safeda had highest TSS of 13.0°B content. Ram *et al.* (1997) evaluated 11 guava selections under Lucknow conditions and observed that total soluble solids ranged from 7.0°B in C.B.-4 to 12.60°B in N-3. Bal and Dhaliwal (2004) reported 11.0 per cent TSS in cultivar L-49 and 10.0 per cent in cultivar Allahabad Safeda. Aulakh (2005) evaluated 13 guava varieties and reported that higher TSS (11.0°B) was recorded in fruits of Behat Coconut followed by Tehsildar (10.6°B), Lucknow-49 (10.5°B), Chittidar (10.4°B) and Strawberry guava (10.4°B). Similarly TSS varied between 10.4°B in cultivar Chittidar to 16.9°B in cultivar Apple colour in an evaluation study on 12 guava cultivars under Rahuri conditions (Gohil *et al.* 2006). Under Meghalaya conditions Babu *et al.* (2007) concluded that TSS ranged from 8.5°B in Selection-1 to 11°B in Selection-11. Athani *et al.* (2007) evaluated 19 guava cultivars under Arabhavi conditions and reported that TSS ranged between 6.05°B in GW-3 to 11.55°B in Chittidar. Biradar and Mukunda (2007) evaluated ten selections of Taiwan Guava and observed maximum TSS (11.00°B) in Allahabad Safeda followed by TG selection 6/10 (10.80°B). Under Bangalore conditions among seedling progenies of Apple Colour selections, maximum TSS (13.8°B) was recorded in A.C.Seln.6/10, and

minimum TSS (8.50°B) was observed in A.C.Seln.10/3 (Marak and Mukunda, 2007). Singh *et al.* (2008) studied ten important cultivars of guava to evaluate the physico-chemical attributes in rainy and winter season during 2006-07. Maximum TSS was recorded in the cultivar L-49 during both the seasons followed by cultivar Allahabad Safeda. Patel *et al.* (2011) reported that TSS ranged between 9.35°B in cultivar Lalit to 11.88°B in RCG-11. Ghosh *et al.* (2013) studied twenty guava cultivars and reported the maximum TSS (11.8°B) in cultivar Khaja and minimum TSS (7.8°B) in cultivar Patilo. Singh *et al.* (2016) studied seven varieties of guava during the winter season and recorded highest total soluble solids upto 20.4°B in MPUAT Sel-1 and minimum upto 16.5°B in Red Fleshed.

2.3.2 Titratable acidity:

Prakash (1976) reported 0.42 percent and 0.26 percent titratable acidity in guava cultivars Sardar and Dharwar respectively. Thonte and Chakrawar (1982) reported that average acidity in guava fruit ranged from 0.08 percent in BHR-3 to 0.55 percent in ABD-2 under Parbhani conditions. Mitra *et al.* (1983) evaluated four year old cultivars of guava and found that acidity ranged from 0.24 percent in cultivar Lucknow-49 to 0.38 percent in cultivar Behat Coconut under West Bengal conditions. The acidity varied between 0.33 percent in cultivar Mirzapuri and 0.45 percent in cultivar White Fleshed under Lucknow conditions (Tandon *et al.* 1983). Singh (1988) evaluated 25 guava varieties under Sobour conditions and found that acidity ranged from 0.08 percent in variety Baraf Khana to 1.68 percent in Florida Seedling. Under Punjab conditions acidity in guava pulp varied between 0.20 percent in cultivar Lucknow-49 and 0.46 percent in cultivar Behat Coconut (Aulakh, 2005). Thimmappaiah and Suman (1985) reported that winter crop was superior to rainy season crop. Cultivar Red Fleshed was reported to have minimum acidity of 0.23 percent among Chittidar, Apple Colour, Allahabad Safeda cultivars wherein 0.39 percent, 0.33 percent, 0.29 percent acidity respectively was recorded. Sharma *et al.* (1993) studied nine varieties of guava and found that cultivar Sardar guava had maximum acidity as 0.30 per cent. Patel *et al.* (2005) studied eight guava cultivars grown in Rewa, Madhya Pradesh, India and revealed that Allahabad Safeda fruits had lowest acidity (0.25%). Gohil *et al.* (2006) revealed that the acidity of ripe fruit ranged from 1.08 percent in cultivar Chittidar to 1.98 percent in cultivar Nagpur seedless under Rahuri conditions. In a varietal evaluation study, titratable acidity content ranged between 0.28 percent in Selection-10 and 0.70 percent in pink flesh

Selection-1 (Babu *et al.* 2007). Under Bangalore conditions, Biradar and Mukunda (2007) reported highest acidity (0.27%) in TG selection 5/11 and 5/12, and the least acidity in TG selection 6/8 (0.20%) among ten seedling progeny selections of Taiwan Guava, whereas the maximum acidity was observed in A.C.Seln.6/10 and A.C.Seln.11/3 (0.37%) and minimum (0.26%) in A.C.Seln.11/2 under Bangalore conditions (Marak and Mukunda, 2007). Pandey *et al.* (2007) reported that the acid content varied from 0.16 percent in cultivar Hisar Surkha to 0.36 per cent in cultivar Sangam. Patel *et al.* (2007) revealed that the acidity ranged between 0.33 per cent in Hybrid-11 to 0.81 per cent in Hybrid-2 among guava varieties and hybrids studied under Meghalaya conditions. Among 11 guava selections and genotypes of 5 year age, Patel *et al.* (2011) reported that titratable acidity ranged between 0.45 percent in RCG-11 to 0.61 per cent in Lalit. While evaluating 11 pink pulped Navalur selections in Karnataka, Hashmi and Pawar (2012) reported acidity to vary between 0.23 percent to 0.28 per cent. Patel *et al.* (2015) recorded acidity to range between 0.22 percent in Selection 1 to 0.41 percent in Selection 6. Singh *et al.* (2016) studied seven varieties of guava during the winter season and titratable acidity was found to range between 0.49 percent in Red Fleshed to 0.69 percent in Lalit.

2.3.3 Total sugars:

Pandey *et al.* (1997) carried out study on varietal evaluation involving nine guava varieties under Rewa, Madhya Pradesh conditions and concluded that maximum content of total sugars (11.01%) was found in Sardar variety whereas minimum in cultivar Red-fleshed as 8.71 per cent. Gohil *et al.* (2006) conducted experiment on 12 guava cultivars under Rahuri conditions and revealed that the total sugars ranged between 11.83 per cent cultivar Sardar to 15.67 per cent in cultivar Behat Coconut. The total sugar content varied from 6.72 percent in TG selection 7/2 to 7.48 percent in TG selection 5/13 among ten seedling progeny selections under Bangalore conditions (Biradar and Mukunda, 2007). Under Bangalore conditions Marak and Mukunda (2007) evaluated ten seedling progeny selections of cultivar Apple Colour and reported the maximum percentage of total sugar (8.27%) in A.C. Seln. 6/10 followed by 8.14 percent in A.C. Sel. 11/2 and least in Allahabad Safeda. Pandey *et al.* (2007) evaluated 11 guava varieties and reported that the higher content of total sugar was found in cultivar Hisar Surkha as 9.32 percent, while lower (6.67%) was found in Hisar Safeda. In an evaluation study conducted under

Meghalaya conditions Patel *et al.* (2007) observed that total sugars varied between 4.20 per cent in EC-12 and 8.77 per cent in Hybrid-1. Among 11 guava selections and genotypes of 5 year age, Patel *et al.* (2011) reported that total sugars ranged between 6.04 per cent in RCG-3 to 8.39 per cent in RCGH-7, while evaluating 11 pink pulped Navalur selections in Karnataka.

2.3.4 Reducing sugars:

Mitra *et al.* (1983) reported that percentage of reducing sugars ranged from 2.6 per cent in cultivar Apple colour to 3.4 percent in cultivar Lucknow-49 among 11 cultivars of guava evaluated at four years age and under West Bengal conditions. The reducing sugars varied between 4.57 per cent in cultivar Gwalior-2 and 5.24 percent in cultivar Sardar in an evaluation study of nine guava cultivars under Rewa, Madhya Pradesh conditions (Pandey *et al.* 1997). Gohil *et al.* (2006) conducted experiment on twelve guava cultivars and concluded that reducing sugar ranged from 4.55 percent in cultivar Apple Colour to 7.29 per cent in cultivar Seedless Basti. Marak and Mukunda (2007) examined ten seedling progeny selections of cultivar Apple Colour and noticed that maximum reducing sugar (4.81%) was found in A.C.Seln.6/6 and the least as 4.08 per cent in Allahabad Safeda. The maximum content of reducing sugar (4.03%) was found in TG selection 8/12 and minimum (3.40%) in TG selection 5/5, among ten seedling progeny selections under Bangalore conditions (Biradar and Mukunda, 2007). The percentage of reducing sugar varied from 1.01 per cent in cv. L-49 to 2.67 percent in Hybrid-1 under Meghalaya conditions (Patel *et al.*, 2007). Pandey *et al.* (2007) estimated the content of reducing sugar among 11 guava varieties under Lucknow conditions and reported that it ranged between 4.41 percent CISH-G-31 and 6.40 percent in cultivar Hisar Surkha, while evaluating 11 pink pulped Navalur selections in Karnataka.

2.3.5 Non-reducing sugars:

Phadnis (1970) evaluated nine guava selections at 25 years age under Pune conditions and reported that percentage of non-reducing sugars varied from 1.14 per cent in cultivar Nasik-88 to 5.23 per cent in Lucknow-49. The content of non-reducing sugars ranged between 2.80 percent in Chittidar and 5.13 percent in Allahabad Safeda in an evaluation study under Hissar conditions. Mitra *et al.* (1983) evaluated 11 cultivars of guava at four years age under West Bengal conditions and reported that content of non-reducing sugars varied from 3.10 percent in cultivar Harijha to 3.7 percent in cultivar Banarasi. Under Meghalaya conditions, maximum

content of non-reducing sugar was found in Sardar variety as 5.77 percent, while it was least in cultivar Red Fleshed (4.10%) among nine varieties of guava (Pandey *et al.* 1997). Among the 12 cultivars evaluated under Rahuri conditions the highest content of non-reducing sugar (9.78%) was recorded in cultivar Behat Coconut, while lowest (5.57%) in cultivar Seedless Basti (Gohil *et al.*, 2006). Biradar and Mukunda (2007) evaluated 10 seedling progeny selections of Taiwan Guava and reported that maximum percentage of non-reducing sugar ranged between 3.06 percent in TG selection 6/8 to 3.73 percent in TG selection 5/13. Patel *et al.* (2007) evaluated six guava hybrids/cultivars under Meghalaya conditions and reported that non-reducing sugars ranged from 2.67 percent in EC-12 to 5.37 percent in Hybrid-1, while evaluating 11 pink pulped Navalur selections in Karnatka.

2.3.6 Vitamin C (Ascorbic acid):

Phadnis (1970) found that ascorbic acid content varied from 148 mg/100 g in Kothrud-19) to 299mg/100g in Lucknow-24 among nine guava selections under Pune conditions. Prakash (1976) compared two guava cultivars for quality characters of fruit and revealed that cultivar Sardar recorded highest quantity of ascorbic acid as 260 mg/100g followed by 196.9mg/100g in cultivar Dharwar. Mitra *et al.* (1983) evaluated 11 cultivars of guava at four years age and reported that ascorbic acid content ranged from 62.5mg/100g in Red Fleshed to 132.5mg/100 g in cultivar Lucknow-49 under West Bengal conditions. Under Punjab conditions, ascorbic acid content has been reported to range between 145 mg/100g in cultivar Chittidar to 172 mg/100g in cultivar Surkha (Aulakh, 2005). Gupta *et al.* (1984) recorded maximum ascorbic acid (250.33 mg/100 g) in Allahabad Safeda cultivar of guava at 135 days of fruit growth. Patel *et al.* (2005) studied eight guava cultivars grown in Rewa, Madhya Pradesh where Allahabad Safeda fruits had the highest ascorbic acid (250.80 mg/100g). Gohil *et al.* (2006) reported maximum ascorbic acid (121.84 mg/100g) in cultivar Behat Coconut and minimum (31.89 mg/100g) in cultivar Seedless Basti among 12 guava cultivars. Under Lucknow conditions Ascorbic acid content ranged between 58.2 mg/100 g cultivar Guness to 295.7 mg/100g in cultivar Behat Coconut (Tandon *et al.* 1983). Babu *et al.* (2007) reported that Selection-7 from the seedling population was found to be best with respect to ascorbic acid content (192.50 mg/100g) content at eight years age. The content of ascorbic acid varied from 109.50 mg/100g in A.C.Seln.6/6) to 194.85 mg/100g in A.C. Seln.6/10 under Bangalore conditions (Marak and Mukunda, 2007). Patel *et al.* (2007) evaluated six guava

hybrids/cultivars and concluded that highest content of ascorbic acid (296 mg/100 g) was found in Hybrid-1 followed by 267.8 mg/100 g in Hybrid-2, while lowest value (116.25 mg/100 g) was recorded in Hybrid-11. Among the ten seedling progeny selections of Taiwan guava, maximum ascorbic acid content was observed in TG selection 5/11 as 280mg/100g and minimum as 202.40mg/100g in TG selection 6/8 (Biradar and Mukunda, 2007). Pandey *et al.* (2007) estimated the ascorbic acid content among 11 cultivars/hybrids under Lucknow conditions and reported that it ranged between 104.17mg/100g in cultivar Pant Prabhat and 243.75mg/100g in CISH-G-4 (Shweta). In another study on seedling selections, maximum ascorbic acid content was found in Selection-11 as 210.40mg/100g followed by Selection-7 (192.50mg/100g) and it was minimum (104.50mg/100g) in Selection-1 (Babu *et al.*, 2007). Among 11 guava selections and genotypes of 5 year age, Patel *et al.* (2011) reported that ascorbic acid content ranged between 149.13 in cv. RCG-3 to 246.0 in RCGH-1. Ghosh *et al.* (2013) studied twenty guava cultivars and reported that maximum amount of ascorbic acid content was recorded in Supreme (183mg/100 g), while evaluating 11 pink pulped Navalur selections in Karnataka.

2.3.9 Dietary fibre: Singh *et al.* (2002) evaluated 10 different cultivars and selections of guava under Sabour conditions and reported that dietary fibre ranged between 2.50 to 4.12 per cent. Mehta *et al.* (2018) carried out the study on evaluation of physico-chemical parameters of different variety of guava under subtropical conditions of Uttrakhand and reported that maximum dietary fibre in guava fruit was recorded 3.12 percent in Allahabad safeda while minimum 2.61percent in Sangam.

2.4 Yield Characteristics:

2.4.1 Yield and yield efficiency:

Palaniswamy and Shanmugavelu (1986) reported that guava variety Anakapalli was superior to others as it yielded 29.83kg/tree/year against the mean value of 21.52kg/tree followed by Sardar guava (26.41 kg/tree/year), Allahabad Safeda (21.02 kg/tree/year) and Chittidar (20.23 kg/tree/year). Kundu and Mitra (1994) reported that Lucknow-49 was superior with regard to number of fruits and yield per tree. Ghosh and Chattopadhyay (1996) evaluated twelve guava cultivars and reported that Chittidar gave the highest yield per plant (38.0 kg) followed by Lucknow-49 (35.9 kg) and Seedless, Supreme and Allahabad Safeda gave the lowest yield as 6.4, 19.4 and 20.8 kg per plant, respectively. Sharma *et al.* (1998) evaluated nine varieties of guava *viz.*, Allahabad Safeda, Sardar, Chittidar, Red Fleshed,

Seedless, Apple Colour, Dharidar, Gwalior-27 and Rewa-72 for four years and found that Chittidar, Seedless and Sardar were significantly superior to other cultivars 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. Neto *et al.* (1999) studied the performance of four 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. The average number of fruits per plant harvest was 1357 and 1878 for Banarasi and Lucknow-49, respectively. Reddy *et al.* (1999) reported that L-49 is better than Allahabad Safeda in terms of fruit yield, however, fruit quality of Allahabad Safeda was better. Rattanpal and Dhaliwal (2002) carried out a study on new introduced guava varieties such as Apple Colour, Arka Mridula and Arka Amulya etc. at Ludhiana to determine their performance and study revealed that cultivar Sardar had achieved highest yield compared to all other varieties but maximum yield efficiency was achieved in Arka Amulya followed by Arka Mridula, Sardar and Apple Colour cultivars. Sharma *et al.* (2002) carried out an experiment to evaluate the performance of guava introduced in arid conditions of Western Rajasthan and observed highest yield as 10.20 kg/tree in cultivar Red Fleshed followed by 8.60 kg/tree in cultivar L-49, 4.60 kg/tree in cultivar Lalit and 3.50 kg/tree in MPUAT Sel. 1. Singh (2003) observed the highest number of fruits per plant (402.16) in Chittidar followed by Red Fleshed (342.116 fruits per plant). Lucknow-49 gave the highest yield (101.90 q/ha) followed by Chittidar (98.15 q/ha) and Allahabad Safeda (95.02 q/ha). Aulakh (2005) evaluated thirteen guava cultivars of twelve years age under Punjab conditions and found that weight of fruits per tree ranged from 44.6 Kg in cultivar Seedless to 75.34 kg in cultivar Lucknow-49. The total weight of fruits varied between 9.83 kg/tree in Selection-13 to 20.14 kg/tree in Allahabad Safeda under Meghalaya conditions. Gohil *et al.* (2006) studied physico-chemical constituents of twelve cultivars of guava selected under sub-arid zone of Maharashtra in the year 2003-2004. Cultivar Behat Seedless produced maximum yield (104.70 kg/plant) followed by cultivar Sardar and Seedless. Athani *et al.* (2007) revealed significant differences among the different cultivars of guava for fruit yield wherein

selection SR-2 recorded higher number of fruits per plant (359.30). Babu *et al.* (2007) studied the performance of eight-year-old guava selections, comprising red and white flesh types developed at ICAR Research Complex for NEH Region, Barapani, Meghalaya, India, in comparison with Sardar guava and Allahabad Safeda during the rainy season of 2002 and 2003. The highest productivity was recorded in Allahabad Safeda (20.40 kg/tree) followed by Sardar guava (19.25 kg/tree), Red Fleshed and Selection-1 (18.80 kg/tree). Ghosh *et al.* (2013) reported that Banarasi cultivar produced higher average yield (73.7 kg/plant/year) followed by Allahabad Safeda (71.6 kg/plant/year) and Apple Colour (69.5 kg/plant/year). Fruit weight was maximum in Almond Iskbala followed by Red Fleshed and Apple Colour. Gohil *et al.* (2006) studied physico-chemical constituents of twelve cultivars of guava selected under sub-arid zone of Maharashtra in the year 2003-2004 and reported that cultivar Behat Seedless produced maximum yield (104.70 kg/plant) followed by cultivar Sardar and Seedless.

2.5 Diversity assessment and character association parameters:

2.5.1 Range: While finding the selection possibilities for seed content in guava, Rajan *et al.* (2005) reported average fruit weight, pulp:ratio, number of seeds per fruit, 100 seed weight, number of seeds per 100 gram fruit weight and seeds content to range between 41.67-326.33, 17.10 – 5905.31, 2.33 – 463.33, 0.025 – 7.16, 0.859 – 4.55, 1.53 – 443.32 and 0.019 – 6.48 respectively. Singh *et al.* (2018) while studying the variability of different guava genotypes observed that tree height, trunk girth, North South plant spread, East West plant spread, number of fruits per tree fruit yield, fruit length, fruit width, fruit weight, pulp weight, seed weight and of seeds per fruit to varied between 3.50-4.43 m, 39.25 – 55.44 cm, 5.11 – 7.78 m, 5.10 – 7.84 m, 55 – 121, 8.16 – 21.32 kg, 6.23 – 7.84 cm, 6.41 – 7.66 cm, 130 – 229.17 g, 112.33 – 205.55 g, 2.32 – 3.70 and 177 – 346.67 respectively.

2.5.2 Coefficient of variation: Seedling guava varies greatly with respect to their fruit quality and yield potential. To expedite the crop improvement programme, it is necessary to trap the natural variability through survey and their variability should be conserved *ex situ* and *in situ* to utilize for further hybridization programmes. The morphological characterization is effective for primary screening and to trace true genetic variations. The variations with regard to growth and bearing habits, yield, color and quality of different guava cultivars have also been reported by Chadha *et*

al., (1981) and Ojha *et al.* (1985) in different parts of India. Wide range of variation were reported by Rajan *et al.* (2005) among sixty eight guava genotypes from diverse origin where high genetic co-efficient of variation estimates associated with greater genetic advances as percent of mean were recorded for pulp: seed weight ratio, hundred seed weight and number of seeds per fruit which indicated that these three characters had additive gene effect and therefore effective selection can be made from these characters. Patel *et al.* (2011) recorded wide range of variations with respect to plant growth, yield and quality traits of fruit in sub-tropics of Meghalaya among five years old eleven guava genotype *viz.*, RCG-1, RCG-2, RCG-3, RCG-11, RCGH-1, RCGH-4, RCGH-7, Allahabad Safeda, L-49, Lalit and Sangam. On the basis of morphological and productivity characteristics of guava genotype of seedling origin growing in Air-Force Institute at El-Maamoura Zone, East of Alexandria, Egypt, Mratinic and Milica (2012) and reported that in selected 21 apple accessions for an experimental purpose, the higher genotypic and phenotypic coefficient of variation for canopy spread (34.07 and 40.67) while, plant height (16.63 and 19.73) and stem diameter (16.48 and 19.49) are recorded and exhibited the moderate degree of genotypic coefficient of variation and phenotypic coefficient variation (Patel *et al.* 2015).

2.5.3 Correlation:

Hanche *et al.* (1966) observed a high positive genetic correlation among full bloom date, fruit firmness and fruit diameter while studying different cherry cultivars. Later on Hanche *et al.* (1966) established genetic correlation of 0.65 between fruit size and yield indicating that improvement in yield could be expected through increased fruit size. In strawberry, Lacey (1973) reported that vegetative characters associated with yield were found to fall into two main categories *viz.*, those associated with fruit number (the number of leaves during the preceding autumn and winter) and those associated with fruit size (plant size during the preceding seasons). Devyatov and Statskevich (1977) reported that irrespective of the rootstock the most significant correlation was between total yield and trunk girth or trunk cross sectional area. They also observed a similar correlation between yield and the total cross sectional area of the primary branches. Positive correlations were observed between all the growth indices, especially trunk girth, and yield in different apple genotypes (Devyatov and Statskevich, 1971). Thamburaj *et al.* (1980) studied the correlation in fruit characters of guava cultivar Lucknow-49 and reported that the fruit weight was directly

associated with length of fruit upto neck and above and girth of fruit at the broadest portion and at neck and flesh thickness with a significant r value of 0.742, 0.628, 0.638, 0.732 and 0.661 respectively. The number and weight of seeds had no appreciable influence on the weight of the fruit. Chakrawar and Jatur (1980) studied the correlation coefficient between different characters of Kagzi lime and reported highly significant positive correlation between yield and number of fruits per plant. The yield components *viz.*, fruit number and weight of fruit also showed significant positive association with the fruit yield. Thamburaj *et al.* (1981) studied the total correlation of all the fruit characters of guava with the fruit weight and reported that length up to neck ($r = 0.742$), length above neck ($r = 0.629$), girth at the broadest portion ($r = 0.638$) and flesh thickness ($r = 0.631$) were strongly correlated with fruit weight. However, number of seed and seed weight were not correlated significantly with fruit weight. Chakrawar and Solanki (1981) worked out all possible correlation coefficients between physical and chemical characters of fruit in ber and reported a positive and significant correlation between weight and size of fruit. The correlation coefficient between pulp per cent, weight, size of fruit and vitamin C were positive and significant. There was a positive and significant correlation between TSS and total sugars. Further study also revealed a significant negative association between acidity and reducing sugar and vitamin C and reducing sugar. In banana, Swennen and Langhe (1985) reported that taller pseudostems produce leaves at a faster rate, flower earlier and produce fructifying which need more time to mature. A high genotypic coefficient of variation was found for fruit weight, fruit volume and ascorbic acid content and reducing sugars with respect to yield in mango (Prasad, 1987). Sheikh and Hulamani (1993) studied the correlation in guava with different physical and chemical characters and observed positive and significant correlation between fruit diameter and fruit weight. The fruit yield per branch was positively correlated with reducing sugars, fruit weight, diameter of fruit and ascorbic acid while, a negative correlation between total soluble solids and number of fruits per branch. Pandey *et al.* (1997) worked out correlation coefficient between different characters of nine guava varieties and found that number of fruits/plant, length, width and weight/fruit were negatively associated with each other and TSS, reducing, non-reducing and total sugars had positive association with each other. Correlation and regression analysis were also performed by Salvador *et al.* (2006) in apple in order to determine the relationships among fruit quality parameters. Fruit size and fruit weight

were lower with heavy cropping trees than with standard cropping trees. Hence fruit size and fruit weight had negative correlation with number of fruits/tree. Raghava and Tiwari (2008) reported that the fruit yield/tree was positively and significantly correlated with fruit weight and fruit length. Rajan *et al.* (2008) found that at genotypic and phenotypic levels, number of seed per fruit was significantly and positively associated with seed weight per fruit (SWPF), number of seeds/100 g pulp (NSPHP) and fruit weight (FW). Correlation and path coefficient analysis revealed that SWPF, NSPHP and 100 seed weight were deciding factors for realizing improvement for number of seeds per fruit (NSPF). In a study conducted in Pakistan on 132 guava accessions, strong positive correlation was detected among 15 quantitative traits including fruit length and diameter, length and width of leaf blade, no. of seeds and seed weight, fruit weight and diameter of fruit cavity, seed weight and fruit weight (Mehmood *et al.* 2014). Patel *et al.* (2015) reported that fruit yield was significantly and positively correlated with plant height, stem diameter, canopy spread, shoot diameter, number of leaves, days to flowering, fruit set, bud length, bud diameter, petal length, stamen length, number of stamens per flower and pistil length at both genotypic and phenotypic levels while with flowering duration, fruit drop, number of petals per flower and petal width at genotypic level.

2.5.4 Path analysis:

Ranpise and Desai (1994) observed association of 15 characters in 317 genotype of acid lime and revealed that the average fruit weight had direct positive influences on yield. Patel *et al.* (2015) reported that path coefficient analysis indicated positive direct effect on yield were exhibited by petal length (0.306), bud length (0.301), number of petals per flower (0.258), leaf length (0.187), plant height and bud diameter (0.174 each), stamen length (0.163), number of leaves per shoot (0.142), pedicel length (0.133), petal width (0.128), pistil length (0.082), days to flowering (0.041), flowering duration (0.033), fruit drop (0.030), fruit set (0.014), stem diameter (0.013) and canopy spread (0.009) and suggested that these traits must be given due importance while selecting a genotype.

2.5.5 Cluster analysis:

Singh *et al.* (2014) carried out an experiment on genetic diversity analysis on the basis of morphological and physico-chemical traits in Punjab and cultivars selected for an experiment was grouped into five different clusters namely cluster I,

cluster II, cluster III, cluster IV, cluster V and cluster IV. An experiment revealed cluster II had recorded maximum seed weight (1.56 g) and minimum was recorded in cluster V (1.02 g). Boora *et al.* (2015) carried out a work on genetic diversity analysis on guava on the basis of morphological and physico-chemical traits divided into six clusters and reported that maximum value (1.02) for 100 seed weight was recorded in cluster II. Boora *et al.* (2015) carried out a work on genetic diversity analysis on guava on the basis of morphological and physico-chemical traits divided into six clusters and reported that maximum value for number of seeds per fruit (432.57) was recorded in cluster V followed by cluster VI (302.35), cluster IV (260.37), cluster I (213.00), cluster III (210.40) and cluster II (179.30). Singh *et al.* (2018) reported that cluster I, cluster IV, cluster V and cluster VI in guava showed intra cluster distance of 55.12, 55.40, 50.70 and 61.84, respectively. Cluster III had highest mean value for fruit weight (312.39 g), fruit length (109.60 mm), fruit width (72.88 mm) and fruit outer flesh thickness (17.95 mm) and least mean values for seed weight per 100 g of fruit (0.933 g). Cluster V was characterized by minimum mean value for 100-seed weight (1.017 g) and maximum value for total soluble solids (11.60%) and titratable acidity (0.49%). They also reported that contribution towards observed diversity was found to be 47.90 percent, 16.73 percent, 13.11 percent and 10.76 percent for seed weight per fruit, fruit diameter, 100-seed weight and leaf width. Rajan *et al.* (2007) carried out an experiment on genetic divergence related to seed number in fruits and sixty eight guava accessions were grouped into five distinct clusters for the purpose of study. Cluster V had the minimum number of seeds/fruit, seed weight/ fruit, 100 seed weight, number of seeds/100 g, fruit and seed content, and cluster I had high number of seeds fruit and seed weight/fruit.

2.5.7 Heritability:

The concept of heritability is important to determine whether phenotypic differences observed among individuals are due to genetic or environmental factors. Heritability is the transmissibility of traits or characters from parents to off springs. The quantitative measures which provide information about the correspondence between genotypic and phenotypic variance is called heritability. The concept was originally presented by Lush (1945) to describe the ratio between genotypic and phenotypic variance and is now known as broad sense heritability. However, mean genotypic value of the progeny is determined by the average effects of genes transmitted by the parents in question. In other words it is the breeding value of the

parents which determines the genetic properties of the progeny. Hence it is the proportion of phenotypic variance that is made up of variation attributable to the breeding values (additive genetic variance) which is of the prime importance from breeder's point of view. Generally, heritability is used to specify the relative degree to which a character is conveyed from parent to offspring. The ample information on extent and type of genetic variability and their corresponding heritability is very important for any future breeding programme. The selection of elite accession is proportional to the sum of genetic variability present and the extent to which the traits are inherited. The degree of such estimation also implies the extent to which improvement is possible through selection (Omoigui *et al.*, 2006). Raghava and Tiwari (2008) analyzed heritability for thirteen fruit characters in 15 guava genotypes. Higher estimates of heritability were observed for all the fruit traits which ranged from 90.27 to 99.97 percent. Singh and Mishra (2010) studied heritability of the important morphological traits in 15 year old grafted trees of bael for genotypes and reported that broad sense heritability ranged from 48.29 percent for tree height to 99.30 percent for ascorbic acid. On the basis of morphological and productivity characteristics of guava genotype of seedling origin growing in Air-Force Institute at El-Maamoura Zone, East of Alexandria, Egypt, Mratinic and Milica (2012) and reported that high heritability and genotypic co-efficient of variance have been reported for character fruit yield in guava suggesting selection based on phenotypic performance for this trait would be effective in improving directly in the population. Nayak *et al.* (2013) evaluated physico-chemical characteristics of fruits of F₁ mango progenies. High to moderate broad sense heritability was reported for quality traits of different fruits *i.e.* fruit weight (0.82), fruit volume (0.80), total carotenoids (0.97), ascorbic acids (0.83), stone width (0.71), fruit length (0.70), fruit width (0.62), total soluble solids (0.69), stone length (0.68), stone thickness (0.62), titratable acidity (0.58) and peel thickness (0.53). Wide range of variation were reported by Rajan *et al.* (2005) among sixty eight guava genotypes from diverse origin where heritability estimates associated with greater genetic advances as percent of mean were recorded for pulp: seed weight ratio, hundred seed weight and number of seeds per fruit which indicated that these three characters had additive gene effect and therefore effective selection can be made from these characters. Srivastava *et al.* (2014) evaluated twenty one sweet cherry cultivars and low to moderate heritability was observed for different traits, whereas, high broad sense heritability of four traits *viz.*, fruit length (71.00%),

TSS (68.00%), annual extension growth (65.00%) and trunk girth (74.00%) was observed.

2.5.8 Genetic advance:

Sarkar *et al.* (1991) studied genetic variability with respect to fruit characters in nine litchi cultivars and revealed higher genetic advance for fresh seed weight, fruit weight, fruit volume and pulp weight thus these characters allow for selection of improved cultivars. Attri *et al.* (1991) studied the genetic advance for various fruit characters *viz.*, fruit length, fruit breadth, peel, pulp, stone weight, TSS, sugars, ascorbic acid, carotenoids and overall quality in mango. The genetic advance was highest for carotenoids, fruit weight, fruit volume and ascorbic acid content. Kumar *et al.* (2002) recorded high genetic advance for bunch width, number of berry per bunch, 100 berry weight, 100 seed weight, juice content, total soluble solids, reducing sugar, organic acid content and berry yield among fourteen early maturing grape genotypes. Genetic advance was highest for different fruit characters of guava (Raghava and Tiwari, 2008). Bala *et al.* (2009) reported that among different vegetative and fruit characteristics of different genotypes of aonla, fruit weight, TSS, reducing and non reducing sugars exhibited high genetic advance, however, genetic advance was moderate for fruit set and fruit acidity, while, fruit length, fruit width, ascorbic acid and total sugars were exerted low genetic advance. Singh and Mishra (2010) evaluated genetic advance of the important morphological traits in 15 year old grafted trees of bael, where, Higher genetic advance estimates as percentage of mean was observed for fruit weight (70.78%), leaf number per fruit (70.00%), leaf fresh weight (64.12%) and fruit volume (63.72%). Rajan *et al.* (2012) studied genetic advance for different traits of fruits of guava (*Psidium guajava* L.). All the traits except 100 seed weight, almost similar extent of genetic advance and remarkably highest genetic advance was observed for the traits of fruit weight, number of seeds per fruit and fruit to seed weight ratio. Majumdar *et al.* (2012) reported high genetic advance for different characters of mango *i.e.* weight of harvested fruits per plant (81.07%), per cent fruit harvested per inflorescence (67.02%), initial fruit set per inflorescence (66.84%), number of fruits per plant (61.53%), per cent flowering shoot (55.20%) and number of inflorescences per shoot (52.12%). Srivastava *et al.* (2014) while investigating the heritability in twenty one sweet cherry selections stated that the amount of heritable portion of variation cannot be predicted with the help of PCV and GCV alone, but by estimating heritability along with genetic advance which in-turn

helps in predicting the resultant effect of selection on phenotypic expression. They observed that estimates of heritability in broad sense were high for trunk girth, fruit length, fruit yield per plant, annual extension growth and total soluble solids, whereas, these estimates for fruit weight and number of primary and secondary branches were low.

Chapter-3

Materials and Methods

MATERIALS AND METHODS

The present studies entitled “Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropics” were undertaken during the year 2017 – 2018 in Jammu, Samba and Akhnoor areas lying in sub-tropical zone of Jammu province. The area is situated at about 300-400 m above mean sea level experiencing an average annual rainfall (110-140 cm) mostly during rainy season. The method followed and the materials used for the study are described hereunder.

3.1 Geographical situation of survey area:

3.1.1 Jammu:

Jammu region is situated between 32.72° N latitudes and 74.85° E longitudes. The diversity assessment work on seedling guava was conducted in Naugran, Deoli, Kirpind, Amb and Badyal Brahmana villages of Jammu.

3.1.2 Samba:

Samba region lies between 32.55°N latitudes and 75.11°E longitude. The diversity assessment work on seedling guava was conducted in Chackwal, Chack Dulma, Sangwali, Mawa and Madoon villages of Samba.

3.1.3 Akhnoor:

Akhnoor region lies between 32.89°N latitude and 74.73°E longitude. The diversity assessment work on seedling guava was conducted in Chack Kora, Baho pur, Adgan, Ambaran, and Chack Malal villages of Akhnoor.

3.5 Methodology for survey work:

Initially the seedling population of the guava germplasm was identified with the help of personnel from the Department of Horticulture and local consultations with villagers. On the basis of initial consultation, 150 seedling guava plants were identified and thereafter on the basis of visual observation, 70 plants showing morphological variation were marked for taking detailed observations.

3.6 Observations recorded:

3.6.1 Phenotypic characteristics:

3.6.1.1 Tree height (m):

The height of an individual tree was measured in meter from ground level to the top of the crown with the help of measuring staff during February and the height was expressed in meters.

3.6.1.2 Trunk girth (cm):

Trunk girth of each tree was measured in centimeters with the help of measuring tape at a height of 25 cm from the ground level, during the month of February.

3.6.1.3 Tree spread (m):

The horizontal distance from end of the canopy to the other end was recorded in two directions *i.e.* North-South and East-West with the help of measuring staff during the month of February and expressed in m. The average of value of North-South and East-West spread was calculated to work out the tree spread

3.6.1.4 Tree volume (m³):

The tree volume was calculated by the method suggested by Westwood *et al.* (1963) and worked out with the help of given formula.

$$\text{Tree volume (m}^3\text{)} = \frac{4}{3} \pi a^2 b$$

Where, a= tree height

b= tree spread

3.6.1.5 Leaf area (cm²):

Fifty fully developed leaves were randomly collected from all directions of the each experimental tree during August. The leaf area was measured with the help of automatic leaf area meter (221 Systronics) having a sensor and read out unit. The average of 50 leaves was calculated and expressed in square centimeter.

3.6.1.6 Leaf length (cm):

Length of fifty samples was recorded from base to tip in centimeters with the help of scale and average of these fifty observations was recorded and leaf length.

3.6.1.7 Leaf width (cm)

Width of 50 leaves was recorded at the broadest point of the leaf blade in centimeters with the help of scale. The average of 50 observations was recorded as leaf width.

3.6.1.8 Leaf length-width ratio:

The ratio of leaf length to the leaf width was worked out and recorded as leaf length-width ratio.

3.6.2 Physical fruit characteristics:

3.6.2.1 Fruit weight (g):

Weight of 20 randomly selected fruits from each tree was recorded on electronic balance. The average of these 20 fruit samples was worked out to record fruit weight and expressed in grams.

3.6.2.2 Fruit length (cm):

Fruit length of each harvested fruit in each treatment was measured at the longest and widest positions respectively in millimeter (mm) with the help of a Digital Vernier Calliper and all the reading thus obtained were averaged and recorded and expressed in centimeter.

3.6.2.3 Fruit diameter (cm):

The fruit diameter was measured at the widest cheeks of fruit using vernier calipers and expressed in cm.

3.6.2.4 Fruit volume (cm³):

The fruit volume was determined by water displacement method using a measuring cylinder and result was expressed as cubic centimeters (cm³).

3.6.2.5 Specific gravity:

The specific gravity was calculated by dividing the average fruit weight with average fruit volume as given in the following formula.

$$\text{Specific gravity} = \frac{\text{Average weight of fruit}}{\text{Average volume of fruit}}$$

3.6.2.6 Number of seeds per fruit:

The pulp along-with seed of the fully ripened fruits was extracted and mashed thoroughly. The mashed pulp was thoroughly washed through the ordinary sieve and seed were collected and counted to record number of seeds per fruit

3.6.2.7 Hundred seed weight (g):

A total of 100 fresh seeds were sampled randomly from the extracted seeds and their weight was recorded in grams using electronic balance.

3.6.2.8 Pulp percentage (%):

The pulp percentage was calculated by dividing the pulp weight by fruit weight and multiplying with 100 as given in the formula.

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

3.6.3 Yield characteristics:

3.6.3.1 Yield (kg/tree):

Yield was recorded by weighing the total fruits harvested from each tree during January and expressed kg/tree.

3.6.3.2 Yield efficiency (Kg/cm²):

Yield efficiency was determined by taking the ratio of yield per tree and tree cross sectional area in cm² as per the formula suggested by Westwood (1993).

3.6.3.3 Cross trunk sectional area (cm²):

The cross trunk sectional area was measured by using the formula of Glenn and Rogers (1964) as given below.

$$\text{CTSA (cm}^2\text{)} = \frac{(\text{Girth})^2}{4 \pi}$$

3.6.4 Bio-chemical fruit characteristics:

3.6.4.1 Total soluble solids (°B):

The total soluble solid content was determined from fresh strained, thoroughly stirred juice of fully ripe fruits with the help of a digital hand refractometer (0-30). The readings were expressed in °B (A.O.A.C., 1980).

3.6.4.2 Titratable acidity (%):

Titrate acidity was estimated by methods suggested by Ranganna (1979). Fruit pulp from fully ripe fruit was mixed with the help of mixer thoroughly. In case of hard ripe fruits, 100 g fruit pulp was mixed with 100 ml water and mixed thoroughly in grinder. Juice was separated through Whatman no.1 filter paper. Diluted aliquot of the sample were prepared as above with freshly boiled water. Titratable acidity was estimated by titrating the fruit extract with 0.1 N NaOH using 1 per cent phenolphthalein solutions as indicator. The percent titratable acidity was expressed as per cent citric acid equivalent using formula:

$$\text{Titrateable acidity (TA)} = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{Vol. made} \times \text{Eq. wt. of acid}}{\text{Weight of sample taken} \times \text{weight of aliquot taken} \times 1000} \times 100$$

3.6.4.3 TSS/Acid ratio:

TSS/Acid ratio was recorded by dividing total soluble solids by percent acidity of the fruit.

Numerically, it can be found out as follows:

$$\text{TSS/Acid ratio} = \frac{\text{Total sugars}}{\text{Total acidity}}$$

3.6.4.4 Total sugars (%):

To 100 ml of lead free aliquot, 20 ml of 50 percent HCl was added and it was kept for 24 hours at the room temperature. After that it was neutralized with NaOH (10% NaOH in the initial stage and 0.1N NaOH near neutralization point), the final volume was made to 250 ml with distilled water and titrated against standard Fehling solution A and B (5ml each) in presence of methylene blue as indicator to a brick red colour at the end point. The total sugars were expressed on per cent basis as.

$$\text{Total sugar content} = \frac{(\text{Factor} \times \text{Dilution})}{\text{Aliquot used} \times \text{sample weight}} \times 100$$

3.6.4.5 Reducing sugars (%):

Reducing sugars of lead free solution were estimated by titrating against boiling standard Fehling solution A and B(5ml), using methylene blue indicator to a brick red colour at the end point. The reducing sugars were expressed as per cent.

$$\text{Reducing sugar (\%)} = \frac{\text{Factor} \times \text{Dilution}}{\text{Aliquot used} \times \text{Sample weight}} \times 100$$

3.6.4.6 Non-reducing sugars (%):

The non-reducing sugars were expressed on the per cent basis. The non-reducing sugars were calculated as under

$$\text{Non-reducing sugars (\%)} = (\text{Total sugars} - \text{Reducing sugars}) \times \text{factor}$$

3.6.4.7 Ascorbic acid (mg/ 100g pulp)

The ascorbic acid was estimated by the method of AOAC (1994) as follows.

Indophenol dye (0.04%): Weighed 40mg sodium 2,6-dichlorophenol indophenols. Added 150ml hot distilled water. Then added 42ml sodium bicarbonate. Cooled the contents made volume upto 200ml with distilled water and kept in refrigerator.

Metaphosphoric acid (3%): Dissolved 30mg metaphosphoric acid in water and make volume to 1000 ml.

Standard ascorbic acid (0.1%): Dissolved 100mg ascorbic acid in 100ml of oxalic acid .Diluted 10ml to 100ml with metaphosphoric acid (1ml=0.1mg ascorbic acid).

Standard of dye: Taken 5ml standard ascorbic acid and added 5ml HPO₃. Fill a microburette with the dye. Titrate against dye solution to a light pink colour and determine dye equivalent.

Dye equivalent = 0.5/litre

Procedure

Ascorbic acid was extracted from the pulp by macerating 10g of the sample with 3 per cent metaphosphoric acid. The extract was filtered and volume made to 100ml.10ml of the aliquot was titrated against standardized dye (2,6 dichlorophenol indophenol) till the light pink colour appeared at the end point. Results were expressed as mg/100g of sample.

$$\text{Ascorbic acid} = \frac{\text{Titre} \times \text{dye factor} \times \text{volume made up}}{\text{weight of sample}} \times 100$$

3.6.4.9 Dietary fibre (%):

The dietary fiber was estimated by the method suggested by AOAC (1994).

3.6.5 Diversity assessment and character association analysis:

The data recorded on different horticultural traits on the selected trees was analyzed for various statistical parameters such as mean, range, coefficients of variation, heritability, genetic advance, correlation, path analysis, cluster analysis and principle component analysis using multivariate statistical analysis.

3.6.5.1 Range and mean

Range for each character was recorded by taking the difference of highest and lowest values.

Mean

The mean value of each character was worked out by dividing the total by corresponding number of observations.

$$\bar{X} = \frac{\sum X_{ij}}{N}$$

Where,

$\sum X_{ij}$ = Any observation in the i^{th} genotype and j^{th} replication

N = Total number of observations

3.6.5.2 Correlation studies:

$$\text{Genotypic correlation coefficient } r_{xy(g)} = \frac{\sigma^2 xy_{(g)}}{[\sigma^2 x_{(g)} \times \sigma^2 y_{(g)}]^{0.5}}$$

$$\text{Phenotypic correlation coefficient } r_{xy(p)} = \frac{\sigma^2 xy_{(p)}}{[\sigma^2 x_{(p)} \times \sigma^2 y_{(p)}]^{0.5}}$$

where,

$r_{xy(g)}, r_{xy(p)}$ = Genotypic and phenotypic correlation coefficient respectively between characters x and y

$\sigma^2 x_{(g)}, \sigma^2 y_{(g)}$ = Genotypic and phenotypic covariances for a pair of characters x and y respectively

$\sigma^2 x_{(g)}, \sigma^2 y_{(g)}$ = Genotypic variances of the characters x and y respectively

$\sigma^2 x_{(p)}, \sigma^2 y_{(p)}$ = Phenotypic variances of the characters x and y respectively

3.6.5.3 Coefficient of variation:

The coefficient of variation (CV) is a measure of relative variability. It is the ratio of the standard deviation to the mean value and is calculated with the following formula suggestion by reference.

Coefficient of variation = (Standard Deviation/ Mean) \times 100

In symbols: $CV = (SD/\bar{X}) \times 100$

3.6.4 Phenotypic coefficient of variation (PCV)

$$PCV = \frac{\sqrt{\sigma^2_p}}{\bar{X}} \times 100$$

where,

σ^2_p = Phenotypic variance

\bar{X} = Mean value of the parameter

3.6.5 Genotypic coefficient of variation (GCV):

$$GCV = \frac{\sqrt{\sigma^2_g}}{\bar{X}} \times 100$$

Where,

σ^2_g = Genotypic variance

\bar{X} = Mean value of the parameter

3.6.6 Genetic advance (GA)

Genetic advance at 5 per cent selection intensity was worked out using the formula given by Lush (1945) and Johson *et al.* (1955).

$$G.A. = \frac{\sqrt{\sigma^2_p}}{\bar{X}} \times h^2 (b.s) \times K$$

Where,

G.A. = Genotypic advance of the parameter

σ^2_p = Phenotypic variance of the parameter

- \bar{X} = Mean value of the parameter
- h^2 = Estimate of heritability in broad sense
- K = Selection differential and value of K at 5 per cent selection intensity being 2.06

3.6.7 Heritability (broad sense)

Broad sense heritability was estimated as per the procedure given by Johnson *et al.* (1955).

$$h^2 \text{ (b.s)} = \frac{\sigma^2 g}{\sigma^2 p}$$

where,

- h^2 = Estimate of heritability in broad sense
- $\sigma^2 g$ = Genotypic variance and
- $\sigma^2 p$ = Phenotypic variance

3.6.8 Path analysis:

The genotypic correlation coefficients were used to work out path coefficient analysis. Path coefficients were obtained according to Dewey and Lu (1959). A set of simultaneous equations in the following form were solved:

$$r_{ny} = p_{ny} r_{n2} P_{2y} + r_{n3} P_{3y} \dots \dots \dots + r_{nx} P_{xy}$$

Where,

r_{ny} = Correlation coefficient of one character and yield.

P_{ny} = Path coefficient between the character and yield.

$r_{n2} r_{n3} \dots r_{nx}$ = Correlation coefficient of that character and each of other yield components in turn.

The following correlation matrixes were formed:

Matrix A	Matrix B
r _{1y}	1 r ₁₂ , r ₁₃ r _{1n}
r _{2y}	1 r ₂₃ r _{2n}
r _{3y}	1 r _{3n}
r _{4y}	1

The technique given by Goulden (1954) was followed for inversion (B^{-1}) of B matrix.

Path coefficients P_{jy} were obtained as follows:

$$P_{jy} = (B^{-1}) \times (A)$$

The index effects for a particular character through other characters were obtained by multiplication of direct path and particular correlation coefficient between those two characters, respectively.

$$\text{Indirect effect} = r_{ij} \times P_{jy}$$

Where,

$$i = 1 \dots\dots\dots n$$

$$j = 1 \dots\dots\dots n$$

$$P_{jy} = P_{1y} \cdot P_{2y} \dots\dots\dots P_{ny}$$

r_{ij} = Correlation between two independent characters.

3.6.9 Principal component analysis:

Principal component analysis was carried according to procedure described by Banfield (1978). PCA can be performed on two types of data matrices viz, variances – covariance matrix and correlation matrix. With characters of different scale a correlation matrix standardizing the original data set is preferred. If the characters are of a same scale, a variance – covariance matrix can be used. In the present study, PCA was performed on the correlation matrix of traits, thereby removing effective scale (Jackson, 1991). A data matrix of all the 70 genotypes over 28 variables of each genotype was prepared and used for analysis by SPSS computer programme. A covariance matrix derived from the data matrix is converted to correlation matrix. The eigen values and eigen vector pairs created from data matrix were utilized to identify the principal component.

3.6.9.1 Eigen values and Eigen Vectors:

The eigen values and eigen vectors were computed from data matrix. Eigen values define the amount of total variation that is displayed on principal components. The proportion of variation accounted for each principal component (PC) is expressed as the eigen value divided by the sum of the eigen values.

$$\text{Per cent variance explained for PCI} = \frac{\text{Eigen value (PCI)}}{\text{Sum of eigen values}}$$

The eigen vector (loading) defines the correlation of each variable with the principal components.

The principal components were identified by the following procedure.

The j^{th} principal component (Y_j) of the observations X is the linear combination given as follows:

$$Y_j = A_{1j}X_1 + \dots + A_{pj}X_p$$

Where,

A_{ij} are found such that Y_j is uncorrelated Y_1, Y_2, \dots, Y_{j-1} the j^{th} largest variance. The A_{ij} are the elements of the normalized eigen vector associated with the largest j^{th} eigen value. The variance of the j^{th} principal component of the $\lambda_1 + \lambda_2 + \dots + \lambda_p$. The importance of the j^{th} principal component is given by

$$\frac{\lambda_j}{\text{Trace}(S)}$$

This is informative about the proportion of total variation that can be accounted for the i^{th} principal component. The correlation between the i^{th} original variable X_i and the j^{th} principal component Y_j is given by

$$\rho(X_i, Y_j) = \frac{A_{ij}}{\sqrt{S_i}} \sqrt{\lambda_j}$$

Where S_i is the standard deviation of X_i

Thus, a principal component in linear function of the test variables given as follows

$$\text{Principal component} = ax_1 + bx_2 + \dots + hx_1$$

Where, a, b, \dots Are coefficient and x_1, x_2, \dots etc, are the variables in such a way that the principal component has a unit variance as reported by Ehrenberg(1985).

Chapter-4

Results

EXPERIMENTAL RESULTS

The present investigation “Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropics” was carried out at three different regions viz., Jammu, Samba and Akhnoor during the year 2017-18 to quantify the available genetic diversity of seedling guava as well as to identify the superior genotypes of seedling guava. The experimental results obtained are presented under the following headings.

4.1 Tree characteristics:

4.1.1 Tree height (m):

Data presented in table 1 reveals that tree height varied among seedling guava genotypes. The maximum tree height was recorded as 5.98 m in genotypes PSA-65 and PSA-68 in village Anmbaran and Chack Malal of Akhnoor area followed by genotype PSA-58 (5.95 m), PSA-66 (5.96 m) and PSA-67 (5.92 m). Minimum tree height was recorded as 3.16 m in PSS-22 preceded by PSS-21 (3.25 m) and PSS-23 (3.29 m).

4.1.2 Tree spread (m):

The data with respect to tree spread is presented in table 1 depicted that maximum tree spread (3.97 m) was recorded in genotype PSA-65 in village Ambaran of Akhnoor area followed by 3.96 m in PSA-63 and PSA-68, 3.80m in PSA-64 and 3.86 m in PSA-59, whereas, minimum tree spread was recorded in genotype PSS-22 as 2.37 m preceded by 2.52 m in PSJ-2 and 2.65 in PSJ-1.

4.1.3 Tree volume (m³):

The data presented in table 1, indicates a wide range of variation in tree volume recorded among the different genotypes selected for the purpose of study. The highest tree volume (197.01 m³) was recorded in genotype PSA-65 followed by (196.68) in PSA-68 in followed by 147.73 m³ in PSA-6 and 146.35 m³ in PSA-63. Lowest tree volume 37.25 m³ was found in the genotype PSJ-22 preceded by genotypes PSS-21 (41.95 m³).

4.1.4 Trunk girth (cm):

The data with respect to trunk girth is presented in table 1. The maximum trunk girth (27.27 cm) was recorded in PSA-65 in village Chack Malal village of Akhnoor area followed by PSA-66 (27.15 cm), PSA-64 (27.08 cm) and PSA-63 (27.00 cm). Minimum trunk girth (20.02 cm) was recorded in PSS-22 preceded by PSS-21 (20.12 cm) and PSS-23 (20.16cm).

4.1.5 Trunk cross-sectional area (cm²):

The data with respect trunk cross sectional area presented in table 1 reveals that maximum trunk cross sectional area (59.22 cm²) was recorded in genotype PSA-65 in village Ambaran of Akhnoor area followed by PSA-66 (58.70 cm²), PSA-64 (58.39 cm²) and PSA-63 (58.02 cm²). However, the minimum trunk cross sectional area was recorded in genotype PSS-22 as 31.92 cm² preceded by 32.27 cm² in PSS-21 and 32.37 cm² in PSS-23.

4.1.6 Leaf length (cm):

The data presented in table1, indicate that the maximum leaf length was recorded as 15.92 cm in genotypes PSJ-19 and PSJ-18 followed by 15.87 cm in PSJ-20, 15.80 cm in PSJ-16 and 15.52 cm in PSJ-17 in Naugran and Amb villages of Jammu. Minimum leaf length was recorded as 10.41cm in genotype PSS-22 preceded by 10.99 cm in PSS-24 and 11.05 cm in genotype PSS-21.

4.1.7 Leaf width (cm):

It is evident from the data presented in table1 that the highest value for leaf width was recorded in genotype PSJ-17 as 6.48cm in village Amb of Jammu area followed by 6.45 cm in genotype PSJ-20, 6.44 cm in PSJ-19 and 6.43 cm in PSJ-18. However, lowest value for leaf width was recorded as 3.41 cm in PSS-22 preceded by 3.41 cm in PSS-22 and 3.59 cm in PSS-24.

4.1.8 Leaf area (cm²):

It is evident from the data presented in table 1 that leaf area varied among seedling guava genotypes. Genotype PSJ-19 was recorded to have highest leaf area as 102.52 cm² in village Badyal Brahmana area of Jammu followed by 102.38 cm² in PSJ-20 and 102.34 cm² in PSJ-18. However, minimum leaf area was recorded in genotype PSJ-22 as 43.67 cm² preceded followed by 45.67 cm² in PSJ-2 and 45.77 cm² in PSS-21.

4.1.9 Leaf length-width ratio:

The data presented in the table 1 indicates that the maximum leaf length-width ratio was recorded in genotype PSS-40 as 3.79 in village Madoon of Samba area followed by 3.74 in PSS-43, 3.54 in PSS-38 and 3.54 in PSS-39. However, minimum leaf length-width ratio was recorded in genotype PSJ-11 as 2.22 preceded by 2.26 in PSJ-10 and 2.36 in PSJ-15.

4.1.10 Yield:

The data presented in table 1 clearly indicates that yield per tree varied considerably among seedling guava genotypes. Yield per plant ranged from 16 kg/tree to 24.80 kg/tree. Highest value for yield was recorded in genotype PSA-65 as 24.80 kg/tree in village Ambaran of Akhnoor area followed by 24.01 kg/tree in PSA-64, 23.57 kg/tree in PSA-66 and 23.27 kg/tree in PSA-63, whereas, lowest value for yield was recorded in genotype PSJ-3 as 16 kg/tree preceded by genotypes PSJ-1 (16.07 kg/tree) and PSJ-2 (16.04 kg/tree).

4.1.11 Yield efficiency (Kg/cm²):

Perusal of data in table 1 indicates that yield efficiency varied among seedling guava genotypes to a considerable extent. Highest value for yield efficiency was recorded in genotype PSS-36 as 0.53 kg/cm² in village Dulma of Samba area followed by genotypes 0.52 kg/cm² in PSS-37, 0.52 kg/cm² in PSS-40 and 0.50 kg/cm² in PSS-22. The lowest value for yield efficiency was recorded in PSJ-62 as 0.34 kg/cm² preceded by 0.35 kg/cm² in PSJ-11 and 0.36 kg/cm² in PSJ-3.

Table 1: Tree characteristics of seedling origin guava genotypes.

Genotype	Tree height (m)	Tree spread (m)	Tree volume (m3)	Trunk girth (cm)	TCSA (cm2)	Leaf length (cm)	Leaf width (cm)	Leaf length/width ratio	Leaf area (cm2)	Yield (Kg)	Yield efficiency(k/cm2)
PSJ1	4.15	2.65	61.06	22.58	40.67	11.59	3.95	2.94	46.10	16.07	0.39
PSJ2	4.20	2.54	56.92	22.47	39.92	11.08	4.12	2.69	45.67	16.04	0.40
PSJ3	4.24	2.73	66.09	23.67	43.35	12.08	4.24	2.85	51.90	16.00	0.36
PSJ4	4.43	2.74	69.46	22.44	40.09	12.71	4.59	2.77	58.35	16.69	0.41
PSJ5	4.65	2.85	79.31	22.77	41.29	15.02	5.04	2.98	75.72	16.71	0.40
PSJ6	4.65	2.86	79.50	23.75	44.71	15.00	5.79	2.59	86.64	17.08	0.38
PSJ7	4.74	2.86	80.98	22.63	40.78	15.07	5.73	2.63	86.28	17.63	0.43
PSJ8	4.85	2.90	85.71	23.75	44.90	14.67	5.63	2.62	82.31	17.13	0.38
PSJ9	4.84	2.81	80.01	23.17	42.75	14.52	5.59	2.60	81.11	16.89	0.39
PSJ10	4.88	2.88	84.94	24.16	46.44	14.00	6.20	2.26	86.75	17.46	0.39
PSJ11	5.19	3.12	105.84	25.05	49.93	13.72	6.17	2.22	84.94	17.63	0.35
PSJ12	5.31	3.13	108.75	24.06	46.08	14.09	6.20	2.27	87.33	17.86	0.38
PSJ13	5.90	3.13	121.16	25.21	50.59	15.49	6.25	2.48	96.79	18.11	0.36
PSJ14	5.12	3.20	109.91	24.17	46.50	15.20	6.40	2.37	97.11	19.11	0.41
PSJ15	5.17	3.14	106.56	23.50	43.98	14.82	6.27	2.36	92.10	18.33	0.41
PSJ16	5.45	3.23	119.12	23.67	44.61	15.80	6.31	2.51	99.66	18.48	0.38
PSJ17	5.63	3.23	122.80	23.75	44.64	15.52	6.48	2.40	100.51	18.00	0.40
PSJ18	5.58	3.23	121.96	24.92	49.43	15.92	6.43	2.48	102.34	19.43	0.39
PSJ19	5.90	3.25	130.83	23.90	45.48	15.92	6.44	2.47	102.52	20.11	0.44
PSJ20	5.95	3.26	132.82	25.92	49.43	15.87	6.45	2.46	102.38	20.24	0.41
PSS21	3.25	2.48	41.95	20.12	32.27	11.05	3.96	2.79	45.77	16.09	0.49
PSS22	3.16	2.37	37.25	20.02	31.92	10.41	3.41	3.08	43.67	16.19	0.50
PSS23	3.29	2.51	43.26	20.16	32.37	11.40	3.91	2.97	50.23	16.26	0.50
PSS24	3.40	2.64	49.72	20.21	32.50	10.99	3.59	3.07	57.02	16.26	0.50
PSS25	3.60	2.84	60.92	20.89	34.73	13.44	3.75	3.63	74.05	16.28	0.50
PSS26	3.62	2.88	62.70	21.04	34.91	13.32	4.07	3.30	83.64	16.29	0.46
PSS27	3.55	2.79	57.95	20.75	34.73	13.18	4.38	3.01	81.36	16.38	0.47
PSS28	3.64	2.87	62.81	21.08	35.38	12.64	4.46	2.87	80.65	16.58	0.46
PSS29	3.65	2.88	63.22	21.09	36.54	12.63	4.25	2.98	77.78	16.79	0.46
PSS30	3.73	2.96	68.31	22.07	38.79	12.67	4.03	3.14	84.75	17.13	0.44
PSS31	3.73	2.96	68.68	22.15	39.06	12.13	4.18	2.90	83.27	17.17	0.44
PSS32	3.59	2.82	59.95	20.40	33.13	12.70	4.02	3.16	87.33	17.20	0.51
PSS33	3.79	3.01	72.03	22.19	39.19	13.59	4.08	3.34	94.13	17.07	0.43
PSS34	3.77	3.01	71.40	22.17	39.13	13.43	4.24	3.18	95.45	16.79	0.43
PSS35	3.69	2.99	69.11	21.10	34.89	12.94	4.21	3.08	91.10	17.24	0.49
PSS36	3.32	2.64	48.31	20.17	32.40	13.85	4.27	3.24	98.00	17.29	0.53
PSS37	3.96	3.23	86.45	21.12	35.52	14.19	4.38	3.24	99.17	18.23	0.52
PSS38	4.00	3.32	92.48	22.73	41.15	13.73	3.90	3.54	101.11	18.57	0.45

Cont..

Genotype	Tree height (m)	Tree spread (m)	Tree volume (m3)	Trunk girth (cm)	TCSA (cm2)	Leaf length (cm)	Leaf width (cm)	Leaf length/width ratio	Leaf area (cm2)	Yield (Kg)	Yield efficiency(k/cm2)
PSS39	4.12	3.32	94.87	23.19	42.82	13.50	4.04	3.34	99.52	19.92	0.47
PSS40	4.25	3.40	103.05	23.14	39.07	14.12	3.76	3.79	99.71	19.95	0.52
PSS41	3.71	3.05	72.15	22.03	38.64	12.73	4.03	3.19	96.44	18.56	0.47
PSS42	3.53	2.86	60.43	21.49	36.77	12.69	4.20	3.06	95.79	17.57	0.47
PSS43	3.63	2.95	66.39	21.08	35.39	13.92	3.77	3.74	94.31	16.88	0.47
PSS44	3.72	3.05	72.59	21.78	37.69	13.98	4.22	3.34	92.11	18.23	0.48
PSS45	3.66	3.05	71.33	22.04	38.67	13.99	4.15	3.39	93.16	17.55	0.45
PSA46	4.27	2.93	76.62	22.69	40.98	12.20	3.97	3.08	48.40	18.03	0.44
PSA47	4.27	2.95	77.73	23.11	42.51	11.75	4.45	2.64	53.86	18.35	0.43
PSA48	4.30	3.13	88.51	23.92	45.55	13.05	4.47	2.92	58.26	18.85	0.42
PSA49	4.39	2.99	82.10	23.92	45.58	13.66	5.01	2.76	68.28	19.43	0.39
PSA50	4.68	3.14	96.81	24.30	47.02	15.03	4.88	3.08	73.38	18.92	0.41
PSA51	4.62	3.24	101.32	24.30	46.49	15.04	5.79	2.60	87.11	19.84	0.43
PSA52	4.78	3.24	105.12	24.35	47.22	15.05	5.73	2.63	86.21	17.93	0.38
PSA53	4.96	3.48	125.60	24.49	47.76	14.67	5.63	2.62	82.33	18.12	0.38
PSA54	4.87	3.16	101.81	24.53	47.89	14.56	5.59	2.61	81.11	18.55	0.39
PSA55	4.89	3.44	121.15	24.38	47.35	14.13	5.70	2.48	80.58	18.25	0.39
PSA56	5.29	3.56	140.81	25.05	49.95	13.84	5.92	2.34	81.94	19.17	0.38
PSA57	5.34	3.57	142.49	24.06	46.08	14.15	5.94	2.38	84.08	19.86	0.43
PSA58	5.95	3.65	165.98	25.06	50.59	15.22	5.62	2.71	85.49	20.00	0.39
PSA59	5.12	3.86	160.10	25.17	49.73	15.19	5.92	2.57	89.93	21.00	0.41
PSA60	5.17	3.38	123.74	26.02	53.91	14.93	5.80	2.58	86.60	20.94	0.38
PSA61	5.47	3.28	123.36	24.07	46.13	15.23	5.77	2.64	87.92	20.45	0.44
PSA62	5.78	3.73	168.77	26.84	57.37	15.07	5.87	2.57	88.52	19.44	0.34
PSA63	5.76	3.96	189.12	27.00	58.02	15.16	5.73	2.65	86.90	23.27	0.40
PSA64	5.90	3.80	178.27	27.08	58.39	15.08	5.69	2.65	85.73	24.01	0.41
PSA65	5.98	3.97	197.01	27.27	59.22	15.64	5.88	2.66	92.06	24.80	0.42
PSA66	5.96	3.91	191.22	27.15	58.70	14.67	5.68	2.58	83.29	23.57	0.40
PSA67	5.92	3.87	185.53	26.67	56.64	14.66	5.64	2.60	82.63	22.82	0.40
PSA68	5.98	3.96	196.68	26.78	57.11	14.68	5.01	2.93	73.51	22.61	0.40
PSA69	5.87	3.77	174.79	25.60	52.18	15.12	5.66	2.67	77.73	22.48	0.43
PSA70	5.85	3.69	166.57	26.73	56.87	15.17	4.90	3.10	74.32	23.22	0.41
C.V.	19.13	12.39	42.11	8.50	16.94	9.78	18.58	12.96	19.23	11.63	10.55

4.2 Physico-chemical fruit characteristics:

4.2.1 Fruit weight (g):

As shown in table 2, maximum value for fruit weight was observed as 177.17 g in PSJ-20 (Plate 1, Fig. 1) and PSA-65 (Plate 2, Fig. 1) in villages Badyal Brahmana and Ambaran of Jammu and Akhnoor area respectively, followed by 176.97 g in PSA-62 (Plate 3, Fig. 1), 176.74 g in PSJ-17 (Plate 4 Fig. 1) and 176.66 g in PSA-66 (Plate 5, Fig. 1), whereas, minimum value for fruit weight was observed in PSS-27 (Plate 6, Fig. 1), as 86.70 g preceded by 89.52 g in PSJ-8 and 89.71 g in PSA-53.

4.2.2 Fruit length (cm):

Perusal of data presented in table 2 reveals that maximum fruit length was recorded as 6.98 cm in genotype PSA-65 in village Ambran of Akhnoor area followed by 6.95 cm in PSJ-38, 6.94 cm in PSA-63 and 6.93 cm in PSJ-11. Minimum fruit length was observed in PSJ-9 as 5.53 cm preceded by 5.54cm in genotype PSJ-7 and 5.54 cm in genotype PSA-54.

4.2.3 Fruit diameter (cm):

It is evident from table 2 that the genotype PSS-32 had maximum fruit diameter as 6.70 cm in village Madoon of Samba region followed by genotypes PSJ-11 (6.64cm) and PSJ-20 (6.63cm), whereas, minimum fruit diameter was recorded in genotypes PSJ-9 and PSA-54 as 5.13 cm preceded by 5.20 cm in PSJ-7 and 6.37 cm in PSJ-13.

4.2.4 Fruit volume (cm³):

It is evident from table 2 that the genotype PSA-65 had recorded maximum fruit volume as 180.07 cm³ in village Ambaran of Akhnoor area followed by 179.76 cm³ in genotype PSJ-20, and 178.97 cm³ in PSA-70 and 178.04 cm³ in PSA-67. Minimum fruit volume was recorded in genotype PSJ-8 as 92.48 cm³ preceded by 92.62 cm³ in PSA-53 and 96.43 cm³ in PSS-27.

4.2.5 Specific gravity:

Perusal of data presented in table 2 indicates that specific gravity ranged from 1.00 to 1.15. Genotype PSJ-17 had recorded maximum specific gravity as 1.15 in village Amb of Jammu and minimum value for specific gravity was recorded as 1.00

in genotypes PSS-23, PSS-25, PSS-26, PSS-27, PSS-28, PSS-29 and PSA-52 preceded by 1.01 in genotypes PSJ-7 and PSJ-11.

4.2.6 Pulp percentage (%) and pulp weight (g):

The data in table 2 clearly indicates that pulp percentage varied among different seedling origin guava genotypes. Maximum pulp percentage was recorded as 99.06 per cent in the genotype PSJ-1 in village Naugran of Jammu region followed by 99.04 per cent in PSS-21, 99.01 per cent in PSJ-2 and 98.76 per cent in PSJ-3. However, minimum pulp percentage was recorded in PSA-52 as 96.45 preceded by 96.56 per cent in PSA-53 and 96.82 per cent in PSA-52. On the other hand maximum value for pulp weight was recorded in genotype PSA-62 as 173.38 g in village Ambaran of Akhnoor area followed by 172.96 g in PSA-69, 172.95 g in PSJ-20 and 172.74 g in PSA-65. Minimum was recorded in genotype PSS-27 as 84.91 g followed by 85.94 g in PSS-28 and 86.62 g in PSA-53.

4.2.7 Number of seeds per fruit:

Data presented in table 2 clearly indicates that seed number per fruit varied from 135.66 to 301.00. Highest seed number per fruit were recorded in genotype in PSA-66 as 301.00 in village Chack Malal of Akhnoor area followed by genotype PSA-65 (300.65), PSA-64 (297.66) and PSA-67 (292.66), whereas, minimum value for seed number per fruit were recorded in genotypes PSJ-1 as 135.66 preceded by 137.33 in PSS-23 and 140 in PSJ-2.

4.2.8 Hundred seed weight (g):

Perusal of data presented in table 2 indicates that hundred seed weight ranged from 1.01 g to 1.57 g. Genotype PSJ-20 in village Badyal Brahmana of Jammu area scored the maximum value (1.57 gm) for hundred seed weight followed by PSJ-18 (1.54 g), PSS-41 (1.54 g) and PSS-42 (1.53 g). However, it has been also observed that minimum value for hundred seed weight was recorded as 1 gm in genotypes PSS-26 and preceded by 1.02 g in PSJ-6 and 1.01 g in PSJ-1 and PSJ-2.

Table 2. Physico-chemical characteristics of fruits in seedling origin guava genotypes.

Genotype	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm³)	Specific gravity	No. of seeds per fruit	Hundred seed weight	Seed weight per fruit (gm)	TSS (°B)	Acidity (%)	TSS/acid ratio	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (%)	Dietary fibre (%)
PSJ1	144.97	6.03	5.69	151.41	1.06	135.67	1.01	1.36	7.68	0.30	25.38	6.22	3.22	2.86	129.71	11.04
PSJ2	142.91	6.07	5.77	148.85	1.06	140.00	1.01	1.41	7.79	0.27	28.55	6.26	3.60	2.52	129.68	11.07
PSJ3	120.48	6.18	5.86	127.12	1.05	142.67	1.05	1.49	7.26	0.28	25.71	6.31	3.75	2.44	130.79	11.03
PSJ4	100.49	5.85	5.47	101.93	1.09	156.67	1.04	1.62	7.25	0.28	26.24	6.59	3.31	3.12	135.95	11.13
PSJ5	99.66	5.91	5.60	101.67	1.08	154.00	1.05	1.62	6.87	0.28	24.29	6.99	3.71	3.12	143.85	11.22
PSJ6	99.57	5.79	5.46	101.32	1.08	166.00	1.02	1.69	7.82	0.29	26.96	6.80	3.83	2.97	139.07	11.77
PSJ7	90.30	5.54	5.20	99.77	1.01	178.67	1.09	1.95	8.69	0.29	29.65	7.09	3.96	3.06	138.07	13.09
PSJ8	89.52	5.72	5.39	92.48	1.07	176.67	1.02	1.80	9.13	0.30	30.10	6.33	3.85	2.48	141.97	14.08
PSJ9	100.15	5.53	5.13	102.38	1.08	177.33	1.06	1.88	8.70	0.32	26.96	6.45	3.71	2.59	147.76	12.19
PSJ10	136.68	6.57	6.26	140.01	1.08	213.33	1.07	2.28	9.01	0.31	29.15	6.66	3.84	2.68	152.74	13.10
PSJ11	146.48	6.93	6.64	160.86	1.01	221.00	1.32	2.92	9.16	0.31	29.89	7.21	4.70	1.87	154.56	13.75
PSJ12	150.01	6.87	6.60	162.40	1.02	241.00	1.33	3.21	9.13	0.31	29.22	7.29	4.00	3.63	169.94	12.41
PSJ13	168.75	6.68	6.37	168.03	1.10	242.33	1.32	3.21	9.66	0.30	32.18	7.45	3.64	3.89	162.45	11.71
PSJ14	153.41	6.64	6.25	167.71	1.01	239.33	1.43	3.43	9.75	0.33	29.54	9.48	4.85	4.31	151.70	13.92
PSJ15	168.89	6.77	6.43	168.73	1.10	205.00	1.43	2.93	9.92	0.29	33.88	9.18	4.61	4.04	177.13	11.92
PSJ16	173.00	6.83	6.56	169.37	1.12	215.33	1.52	3.27	10.12	0.29	35.38	9.08	4.73	4.22	169.49	12.10

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Genotype	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm ³)	Specific gravity	No. of seeds per fruit	Hundred seed weight	Seed weight per fruit(gm)	TSS (°B)	Acidity (%)	TSS/acid ratio	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (%)	Dietary fibre (%)
PSSJ17	176.59	6.86	6.58	168.45	1.15	217.67	1.48	3.23	7.15	0.28	25.23	9.21	4.76	4.42	208.05	13.06
PSSJ18	173.33	6.52	6.17	176.59	1.08	225.00	1.54	3.46	8.55	0.32	26.75	6.42	3.73	2.55	198.64	12.05
PSSJ19	175.72	6.73	6.40	178.06	1.09	251.67	1.52	3.83	10.41	0.33	31.18	9.33	4.94	4.17	210.71	13.35
PSSJ20	177.17	6.90	6.63	179.76	1.09	268.67	1.57	4.23	9.25	0.34	27.22	10.01	5.66	4.13	214.67	14.08
PSS21	138.74	5.90	5.61	141.89	1.08	129.67	1.02	1.33	6.95	0.28	24.54	6.19	3.54	2.52	128.64	9.59
PSS22	138.44	6.05	5.76	141.56	1.08	139.00	1.00	1.39	7.58	0.25	30.75	6.19	3.68	2.39	128.41	9.66
PSS23	112.31	5.98	5.64	124.47	1.00	137.33	1.04	1.42	6.47	0.27	23.70	6.30	3.98	2.21	129.79	9.79
PSS24	98.06	6.03	5.71	100.07	1.08	152.33	1.04	1.58	6.52	0.28	23.68	6.43	3.48	2.80	134.95	9.91
PSS25	96.83	6.11	5.73	107.50	1.00	147.33	1.13	1.67	6.75	0.28	23.84	6.86	4.07	2.58	142.84	9.98
PSS26	99.04	5.95	5.61	109.95	1.00	167.00	1.00	1.68	7.56	0.29	26.08	6.74	4.17	2.44	138.07	10.16
PSS27	86.70	6.03	5.71	96.43	1.00	176.67	1.02	1.80	7.77	0.29	26.53	7.08	4.26	2.67	137.23	11.34
PSS28	87.72	6.18	5.81	97.24	1.00	170.67	1.04	1.78	8.00	0.30	26.41	6.30	4.22	1.97	141.31	11.89
PSS29	88.42	5.94	5.64	97.78	1.00	174.33	1.02	1.78	8.13	0.31	26.03	6.48	4.44	1.95	147.09	12.12
PSS30	133.45	6.31	5.94	146.57	1.01	204.00	1.03	2.11	8.75	0.32	27.68	6.58	4.18	2.29	152.06	12.89
PSS31	142.88	6.70	6.38	150.76	1.05	217.00	1.17	2.54	8.94	0.32	27.97	7.41	4.48	2.79	153.13	12.68
PSS32	144.50	6.97	6.70	155.15	1.03	238.00	1.20	2.86	9.04	0.32	27.99	6.65	3.68	2.81	169.27	12.57
PSS33	165.34	6.48	6.26	160.68	1.13	238.00	1.10	2.62	9.46	0.30	31.24	7.43	4.56	2.73	161.82	11.37

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Genotype	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm³)	Specific gravity	No. of seeds per fruit	Hundred seed weight	Seed weight per fruit(gm)	TSS (°B)	Acidity (%)	TSS/acid ratio	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (%)	Dietary fibre (%)
PSS34	150.13	6.60	6.25	164.69	1.01	233.00	1.17	2.72	9.14	0.31	29.56	9.19	4.64	4.32	150.75	13.62
PSS35	166.42	6.77	6.41	166.42	1.10	198.67	1.44	2.85	9.44	0.31	30.46	9.12	4.94	3.97	177.32	12.05
PSS36	166.91	6.67	6.35	168.59	1.09	204.00	1.49	3.04	10.09	0.28	36.08	9.04	4.80	4.03	168.82	11.91
PSS37	173.38	6.91	6.53	166.89	1.14	212.67	1.44	3.07	6.34	0.28	22.66	9.20	4.97	4.02	203.80	12.65
PSS38	168.84	6.95	6.65	168.85	1.10	221.00	1.49	3.29	8.69	0.31	27.78	6.40	4.24	2.05	197.64	12.27
PSS39	165.83	6.89	6.56	174.62	1.05	245.67	1.48	3.64	9.00	0.32	28.46	9.27	4.88	4.17	210.29	13.11
PSS40	167.61	6.92	6.62	174.27	1.06	263.33	1.51	3.99	9.13	0.34	27.14	9.81	5.12	4.45	212.26	13.61
PSS41	166.88	6.84	6.45	174.56	1.06	241.33	1.54	3.72	8.76	0.33	26.81	10.50	5.81	4.45	213.35	14.61
PSS42	167.09	6.79	6.39	167.09	1.10	263.33	1.53	4.03	8.83	0.31	28.56	9.65	5.27	4.40	212.61	13.33
PSS43	166.20	6.72	6.37	166.21	1.10	219.67	1.52	3.35	7.90	0.31	25.50	9.33	5.04	4.08	210.74	12.86
PSS44	167.14	6.74	6.41	167.14	1.10	219.00	1.03	2.26	8.82	0.29	30.79	9.98	5.64	4.02	210.00	14.01
PSS45	167.61	6.82	6.47	167.60	1.10	285.33	1.04	2.96	7.98	0.31	25.75	9.84	5.24	4.37	209.65	13.33
PSA46	145.04	6.05	5.69	152.18	1.05	252.00	1.16	2.93	7.63	0.30	25.49	6.30	3.99	2.95	130.04	11.37
PSA47	143.13	6.09	5.77	149.13	1.06	253.00	1.16	2.94	7.81	0.26	29.68	6.33	4.36	3.02	130.07	11.37
PSA48	120.81	6.21	5.86	127.40	1.05	255.67	1.18	3.03	7.27	0.29	25.38	6.42	3.57	3.13	130.20	11.40
PSA49	100.52	5.86	5.47	101.61	1.09	257.67	1.21	3.11	7.25	0.27	26.58	6.63	3.82	2.89	135.63	11.46

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Genotype	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm³)	Specific gravity	No. of seeds per fruit	Hundred seed weight	Seed weight per fruit(gm)	TSS (°B)	Acidity (%)	TSS/acidity ratio	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (%)	Dietary fibre (%)
PSA50	99.95	5.92	5.60	101.34	1.09	260.33	1.22	3.18	6.87	0.28	24.56	7.12	3.72	3.23	144.49	11.54
PSA51	99.87	5.85	5.46	101.56	1.08	257.00	1.20	3.09	7.82	0.29	27.29	6.94	4.02	2.95	139.27	12.20
PSA52	90.33	5.66	5.20	99.86	1.00	261.33	1.23	3.21	8.69	0.30	28.96	7.13	4.37	2.62	138.85	13.42
PSA53	89.71	5.82	5.39	92.62	1.07	256.67	1.20	3.09	9.13	0.30	30.10	6.35	3.63	2.58	142.64	14.74
PSA54	100.52	5.54	5.13	102.64	1.08	261.67	1.22	3.20	8.70	0.32	26.96	6.51	4.43	2.54	148.09	12.89
PSA55	136.86	6.61	6.26	140.00	1.08	263.33	1.24	3.27	9.01	0.31	29.15	6.79	4.47	2.20	152.77	13.54
PSA56	146.84	6.93	6.64	161.19	1.01	265.67	1.26	3.34	9.16	0.31	29.89	7.44	4.85	2.46	154.93	13.81
PSA57	150.11	6.89	6.60	162.10	1.03	272.00	1.31	3.56	9.13	0.31	29.22	7.33	4.03	2.80	169.94	12.78
PSA58	169.41	6.68	6.37	168.67	1.10	265.33	1.25	3.33	9.66	0.30	32.18	7.45	5.07	2.57	163.21	12.02
PSA59	153.78	6.68	6.25	167.46	1.02	266.67	1.26	3.36	9.75	0.33	29.54	9.48	5.35	3.93	152.88	14.29
PSA60	168.93	6.77	6.43	168.92	1.10	263.00	1.24	3.25	9.92	0.29	33.88	9.97	5.98	3.76	177.74	12.67
PSA61	173.01	6.84	6.56	169.37	1.12	271.67	1.29	3.50	10.12	0.29	35.38	9.08	6.14	2.79	169.53	12.92
PSA62	176.97	6.91	6.58	168.73	1.15	273.67	1.31	3.59	9.88	0.28	34.93	9.82	5.99	3.64	142.15	13.54
PSA63	173.74	6.94	6.17	177.29	1.08	287.67	1.39	3.99	10.08	0.32	31.52	9.96	6.33	3.31	199.33	14.07
PSA64	176.30	6.93	6.40	178.21	1.09	297.67	1.45	4.31	10.89	0.33	32.70	10.11	6.40	3.52	212.33	13.50
PSA65	177.17	6.98	6.63	180.07	1.08	300.67	1.47	4.43	10.75	0.33	32.62	10.21	6.51	3.51	215.00	14.08

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Genotype	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm ³)	Specific gravity	No. of seeds per fruit	Hundred seed weight	Seed weight per fruit(gm)	TSS (°B)	Acidity (%)	TSS/acidity ratio	Total sugar (%)	Reducing sugars (%)	Non-reducing sugars (%)	Ascorbic acid (%)	Dietary fibre (%)
PSA66	176.73	6.88	6.50	175.67	1.11	301.00	1.47	4.43	10.43	0.32	32.63	10.18	6.33	3.66	198.91	13.78
PSA67	176.03	6.80	6.43	178.04	1.09	292.67	1.41	4.13	9.87	0.29	34.05	9.92	5.93	3.79	196.49	13.74
PSA68	175.86	6.85	6.54	178.47	1.09	286.33	1.37	3.93	9.43	0.29	32.53	9.75	5.73	3.82	191.34	14.12
PSA69	176.74	6.77	6.48	177.88	1.09	282.00	1.34	3.78	10.07	0.30	33.60	10.03	6.34	3.74	189.26	13.79
PSA70	175.87	6.78	6.49	178.97	1.08	272.67	1.30	3.54	9.86	0.28	35.26	9.88	5.95	3.73	190.87	13.68
C.V.	22.28	7.04	7.62	20.59	3.72	21.33	14.62	30.52	13.15	6.51	11.45	18.95	19.27	23.35	17.78	10.26

4.2.9 Total soluble solids (°B):

Perusal of data presented in table 2 indicates that total soluble solids ranged from 6.24°B to 10.89°B. Among different seedling origin genotypes PSA-64 had scored highest value (10.89°B) for total soluble solids in village Anmbaran of Akhnoor area followed by 10.75°B in PSA-65, 10.43°B in PSA-66 and 10.41°B PSJ-19. However, it has been also observed that minimum value for total soluble solids was recorded in genotype PSA-34 as 6.37°B preceded by 6.47°B in PSS-23 and 6.52°B in PSS-24.

4.2.10 Titratable acidity (%):

The data presented in table 2 reveals that minimum titratable acidity was recorded in genotype PSS-22 as 0.25 per cent in village Chackwal of Samba area followed by 0.27 per cent in PSJ-2 and 0.28 per cent in PSJ-3. However, maximum acidity was recorded in genotype PSJ-20 and PSJ-40 as 0.34 per cent followed by 0.33 per cent in PSS-41, 0.33 per cent in PSA-59 and PSA-65.

4.2.11 T.S.S/acid ratio:

Perusal of data presented in table 2 indicates that TSS/acid ratio ranged from 22.66 to 36.08 among different seedling origin guava genotypes. Highest TSS/acid ratio was recorded in genotype PSS-36 as 36.08 in village Madoon of Samba area followed by genotypes 35.38 in PSJ-16, 35.38 in PSA-61 and 35.26 in PSA-70. Minimum TSS/acid ratio was recorded as 22.66 in genotype PSS-37 followed by 23.68 in PSS-24 and 23.70 in PSS-23.

4.2.12 Total sugars (%):

The data presented in table 2 reveals that total sugars among different seedling origin guava genotypes ranged from 6.19 to 10.50 per cent. Highest value for total sugars was recorded in genotype PSS-41 as 10.50 per cent in village Mawa of Samba area followed by 10.21 per cent in PSA-65, 10.18 per cent in PSA-66 and 10.11 per cent in PSA-64, however, lowest value for total sugars was recorded as 6.19 per cent in genotype PSS-21 and PSS-22 preceded by 6.22 per cent in PSJ-1 and 6.26 per cent in PSJ-2.

4.2.13 Reducing sugars (%):

It is evident from the table 2 that genotype PSA-65 in village Ambaran of Akhnoor area had recorded maximum value for reducing sugars as 6.51 per cent followed by genotypes 6.40 per cent in PSA-64, 6.34 per cent in PSA-69 and 6.33 per cent in PSA-63. Minimum value for reducing sugars was recorded as 3.22 per cent in genotype PSJ-1 preceded by 3.31 per cent in genotype PSJ-4 and 3.48 per cent in PSS-24.

4.2.14 Non reducing sugar (%):

It is also evident from the table 2 that the genotype PSS-40 and genotype PSS-41 in village Mawa of Samba area had scored maximum value for non reducing sugars as 4.45 per cent followed by the genotypes 4.40 per cent in PSJ-17, 4.40 per cent in PSS-42 and 4.37 per cent in PSS-45, whereas, minimum value for non reducing sugars was recorded as 1.87 per cent in PSJ-12 preceded by 1.95 per cent PSS-29 and 1.97 per cent in PSS-28.

4.2.15 Vitamin-C as ascorbic acid (mg/100g):

The data in table 2 clearly indicate that ascorbic acid content varied considerably among different seedling origin guava genotypes. Ascorbic acid per fruit ranged from 128.40 mg/100g to 215 mg/100g. Highest value for ascorbic acid was recorded in genotype PSA-65 as 215mg/100g in village Anmbaran of Akhnoor area followed by genotypes 213.15mg/100g in PSS-41, 212.60mg/100g in PSS-42 and 212.26mg/100g in PSS-40, whereas, lowest value for ascorbic acid was recorded as 128.41mg/100g in genotype PSJ-22 preceded by 128.64 mg/100g in genotype PSJ-21 and 129.68mg/100g in PSJ-2.

4.2.16 Dietary fibre (%):

Perusal of data presented in table 2 clearly indicate that dietary fibre varied among seedling guava genotypes to a considerable extent. Highest dietary fibre was recorded as 14.74 per cent in genotype PSA-53 in village Bahopur of Akhnoor area followed by 14.61 per cent in PSA-59, 14.29 per cent in PSA-59 and 14.12 per cent PSA-68. Minimum value for dietary fiber was recorded in genotype PSS-21 as 9.59 per cent preceded by genotypes 9.66 per cent in PSS-22 and 9.79 per cent in PSS-23.

4.3 Diversity assessment and character association parameters:

4.3.1 Range and Mean:

The magnitude of variability in various tree and physico-chemical traits of seedling origin guava is presented in table 3.

Perusal of data presented in table 3 indicates existence of wide range of variability among all the traits studied. Highest range was recorded as 165.34 for the character number of seeds per fruit followed by 90.47 for fruit weight, 88.47 for pulp percentage and 86.49 fruit volume with a mean of 226.33, 142.7, 97.96 and 146.9 respectively, however, minimum range was recorded for the traits acidity (0.07), specific gravity (0.15), yield efficiency (0.19) and hundred seed weight (0.57) with the mean of 0.30, 1.07, 0.43 and 1.25 respectively.

4.3.2 Phenotypic and genotypic coefficient of variation:

Phenotypic and genotypic coefficients of variation for various traits are presented in table 3. The data reveals that the estimates of phenotypic variance were higher than the corresponding estimates of genotypic variance for all the traits. The magnitude of phenotypic coefficient of variation was low (less than 10 %) for trunk girth, fruit length, fruit diameter, and specific gravity and pulp percentage whereas it was moderate (10-30 %) for tree height, tree spread, tree volume, T.C.S.A, leaf length, leaf length-width ratio, leaf area, fruit weight, fruit volume, number of seeds per fruit, hundred seed weight, pulp weight, T.S.S, T.S.S/acid ratio, ascorbic acid content, total sugars reducing sugars, non reducing sugars, acidity, dietary fiber, yield and yield efficiency. However, seed weight per fruit was found to have high phenotypic coefficient of variation (>30 %). Similarly, the magnitude of genotypic coefficient of variation was low (less than 10%) for tree height, trees spread, trunk girth, T.C.S.A, leaf length, leaf length-width ratio fruit length, fruit diameter, specific gravity, pulp percentage, acidity, dietary fiber and yield efficiency, whereas, it was moderate (10-30 %) for tree volume, leaf area, leaf width, fruit weight, fruit volume, number of seeds per fruit, hundred seed weight, seed weight per fruit, pulp weight, T.S.S, T.S.S/acid ratio, total sugars, reducing sugars and non reducing sugars.

4.3.3 Heritability (Broad sense):

The estimates for broad sense heritability presented in table 3 reveals that heritability in broad sense ranged from low to high for different traits. Heritability was grouped in three classes wherein less than 10 per cent heritability was classified

as low, 10-30 per cent as medium and 30-60 per cent as high heritability. Highest heritability of 76.60 per cent was recorded in hundred seed weight followed by 67.12 per cent in number of seeds per fruit, 66.88 per cent in leaf length-width ratio, 66.28 per cent in fruit volume and 63.78 per cent fruit weight, however, lowest heritability (less than 10%) was recorded for the character tree height (37.14%) preceded by 48.66 per cent in fruit diameter and 44.96 per cent in trunk cross sectional area.

4.3.4 Genetic advance and genetic gain:

Genetic advance and genetic gain were grouped into three distinct classes wherein less than 20 per cent genetic gain was classified as low, 20-40 per cent as medium and greater than 40 per cent as high genetic gain. Highest genetic advance was recorded as 54.40 per cent for the trait ascorbic acid followed by number of seeds per fruit 51.72 percent, whereas, lowest genetic advance was recorded as 0.12 per cent for the trait yield efficiency preceded by acidity 0.13 per cent and specific gravity 0.27per cent. Similarly, highest genetic gain 40.84 per cent was recorded for hundred seed weight, whereas, lowest genetic gain was recorded as 11.03 per cent for the trait pulp percentage preceded by fruit volume 14.31%percent and fruit weight 14.63 per cent.

Table 3: Range, mean, phenotypic coefficient of variation, genotypic coefficient of variation, heritability, genetic advance and genetic gain of the seedling origin guava genotypes.

Characters	Range	Mean	CV	PCV	GCV	Heritability (Broad sense)	Genetic advance	Genetic gain
Tree height	2.73	4.62	19.13	19.17	7.12	37.14	1.38	29.88
Tree spread	1.60	3.15	12.39	14.41	7.39	51.28	1.12	35.6
Tree volume	40.61	298.75	42.11	37.18	20.61	55.43	99.01	33.14
Trunk girth	7.10	23.43	8.50	8.53	5.23	61.31	8.61	36.73
TCSA	27.30	43.89	16.94	16.97	7.63	44.96	9.93	22.62
Leaf area	56.52	82.09	19.23	21.35	12.5	58.55	14.25	17.36
Leaf length	4.15	13.92	9.78	14.17	7.32	51.66	3.96	28.46
Leaf width	3.07	5.03	18.58	19.04	11.5	60.40	1.15	22.86
Leaf LW ratio	1.41	2.83	12.96	14.28	9.55	66.88	0.45	15.8
Fruit length	1.44	6.45	7.04	9.12	5.14	56.36	1.70	26.39
Fruit diameter	1.57	6.1	7.62	9.7	4.72	48.66	1.93	31.62
Fruit weight	90.47	142.7	22.28	22.28	14.21	63.78	20.88	14.63
Fruit volume	86.49	146.9	20.59	20.61	13.66	66.28	21.02	14.31
Specific gravity	0.15	1.07	3.72	7.2	4.01	55.69	0.27	29.01
No. of seeds/fruit	165.34	226.33	21.33	21.35	14.33	67.12	51.72	22.85
100 seed weight	0.57	1.25	14.62	18.93	14.5	76.60	0.51	40.84
Seed weight per fruit	3.07	2.88	30.52	30.65	24.87	81.14	0.76	26.51
Pulp percentage	88.47	97.96	18.91	4.6	2.5	54.35	10.80	11.03
Pulp weight	2.58	139.81	18.50	23.32	17.2	73.76	20.59	14.73
T.S.S	4.42	8.69	13.15	20.57	12.94	62.91	2.96	34.03
Acidity	0.07	0.3	6.51	11.33	7.96	70.26	0.13	43.5
TSS/Acid ratio	12.02	28.91	11.45	17.34	10.97	63.26	6.78	23.45

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Characters	Range	Mean	CV	PCV	GCV	Heritability (Broad sense)	Genetic advance	Genetic gain
Ascorbic acid	86.59	165.21	17.78	19.18	12.03	62.72	54.40	32.93
Dietary fibre	4.53	12.52	10.26	16.79	9.99	59.50	3.95	31.53
Total sugars	3.99	7.94	18.55	21.48	11.68	54.38	2.51	31.61
Reducing sugar	3.29	4.61	19.27	22.21	10.94	49.26	1.49	32.28
Non reducing sugar	2.58	3.21	23.35	25.86	14.55	56.26	0.94	29.25
Yield	7.57	18.59	11.63	15.75	10.54	66.92	4.64	24.97
Yield efficiency	0.19	0.43	10.55	11.35	8.11	71.45	0.12	26.9

4.3.5 Correlation coefficient:

Correlation coefficients of different tree and physico-chemical characteristics were estimated and results are presented in table 4. Results reveal that tree characteristics *viz.*, tree height showed a positive correlation with tree volume, TCSA, leaf area, leaf length, leaf length-width ratio, fruit length, fruit diameter, fruit weight, fruit volume, specific gravity, seed number per fruit, hundred seed weight, TSS, acidity, ascorbic acid, dietary fiber, yield and yield efficiency, whereas, it was negatively correlated with tree spread, trunk girth and leaf width. Tree spread was found to be positively correlated with tree volume, trunk girth, TCSA, leaf area, leaf length, leaf length-width ratio, fruit length, fruit diameter, fruit weight, fruit volume, specific gravity and seed number per fruit, hundred seed weight, TSS, acidity, ascorbic acid, dietary fiber, yield and yield efficiency and negatively correlated with tree height. Tree volume showed a positive correlation with trunk girth, TCSA, leaf area, leaf length, leaf length-width ratio, fruit length, fruit diameter, fruit weight, fruit volume, and specific gravity and seed number per fruit, hundred seed weight, TSS, total sugars, acidity, ascorbic acid, dietary fiber, yield and yield efficiency and negatively correlated with tree height, tree spread. Leaf area showed a positive correlation with tree volume, TCSA, leaf area, leaf length, leaf length-width ratio, fruit length, fruit diameter, fruit weight, fruit volume, specific gravity and seed number per fruit, hundred seed weight, TSS, TSS/ acid ratio, total sugars, reducing sugars, non reducing sugars, ascorbic acid, dietary fiber, yield and yield efficiency and showed a negative correlation with acidity. Pulp percentage also showed a positive correlation with hundred seed weight, seed weight per fruit, pulp weight, acidity, TSS/acid ratio dietary fiber, total sugars, reducing sugars, non reducing sugars, yield and yield efficiency and negative correlated with TSS, acidity and ascorbic acid. Total sugars was positively correlated with reducing sugars, yield and yield efficiency and negatively correlated with non reducing sugars. Ascorbic acid showed a positive correlation with dietary fiber, total sugars, reducing sugars, non reducing sugars, yield and yield efficiency and yield showed a highly positive correlation with tree spread, tree volume, fruit weight, fruit diameter, fruit volume, seed number per fruit, 100 seed weight, TSS and yield efficiency.

Table 4: Correlation among different characters in seedling origin guava genotypes.

S.N.	Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Tree height	-	-0.118	0.235	-0.147	0.221	0.289	0.724*	-0.250	0.181	0.211	0.170	0.89	0.190	0.081	0.111
2	Tree spread		-	0.380	0.236	0.281*	0.232	0.111	0.088	0.091	0.130	0.126	0.190	0.216	0.056	0.130
3	Tree volume			-	0.241	0.243	0.311*	0.170	0.143	0.065	0.254	0.252	0.288	0.227	0.068	0.051
4	Trunk girth				-	0.430*	0.341*	0.161	0.168	0.116	0.144	0.106	0.147	0.191	0.121	0.058
5	TCSA					-	0.261	0.218	0.262	0.182	0.261	0.276	0.296	0.290*	0.110	0.099
6	Leaf area						-	0.297*	0.361*	0.269*	0.333*	0.348*	0.198	0.265	0.047	0.072
7	Leaf length							-	0.130	0.260*	0.232	0.217	0.293*	0.172	0.061	0.067
8	Leaf width								-	-0.257	0.101	0.021	0.198	0.180	0.090	0.081
9	Leaf LW ratio									-	0.155	0.130	0.181	0.102	0.072	0.062
10	Fruit length										-	0.121	0.258	0.347	0.160	0.431*
11	Fruit diameter											-	0.453*	0.531*	0.148	0.498*
12	Fruit weight												-	0.543*	0.219	0.380*
13	Fruit volume													-	0.263	0.333*
14	Specific gravity														-	0.234
15	No. seeds/fruit															-
16	100 seed weight															
17	Seed wt. per fruit															
18	Pulp percentage															
19	Pulp weight															
20	TSS															
21	Acidity															
22	TSS/Acid ratio															
23	Ascorbic acid															
24	Dietary fibre															
25	Total sugars															
26	Reducing sugars															
27	Non reducing															
28	Yield															
29	Yield efficiency															

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		16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	Tree height	0.107	0.098	0.131	0.166	0.372	0.446	0.380	0.309	0.134	0.324	0.272	0.262	0.145	0.170
2	Tree spread	0.225	0.056	0.253	0.259	0.271	0.249	0.252	-0.051	0.252	0.271	0.255	0.098	0.305*	0.298*
3	Tree volume	0.038	0.036	0.178	0.009	0.258	0.253	0.258	0.002	0.040	0.351	0.282	0.350	0.290*	0.220
4	Trunk girth	-0.056	0.020	0.098	0.107	0.022	0.085	0.011	0.050	0.005	0.267	0.259	0.249	0.240	0.195
5	TCSA	0.009	0.101	0.072	0.044	0.032	-0.051	0.034	0.101	0.069	-0.052	0.075	0.058	0.195	-0.340*
6	Leaf area	0.054	0.066	0.180	0.102	0.178	-0.095	0.114	0.088	0.158	0.178	0.201	0.116	0.177	0.102
7	Leaf length	0.101	0.056	-0.012	0.085	0.006	0.053	0.084	0.026	0.025	-0.156	0.147	0.128	0.078	0.230
8	Leaf width	0.032	0.090	0.058	0.056	0.020	0.030	0.048	0.049	0.067	0.131	0.134	0.110	0.189	0.179
9	Leaf LW ratio	0.020	0.033	0.031	0.008	0.026	0.011	0.012	0.009	0.008	0.095	0.087	0.082	0.128	0.194
10	Fruit length	0.242	0.210	0.280	0.182	0.150	0.051	-0.075	0.163	0.098	-0.270	0.121	-0.140	0.225	0.245
11	Fruit diameter	0.295	0.278	0.354	0.781	0.033	0.359	-0.08	-0.174	0.117	0.084	0.350	-0.290	0.330*	0.309*
12	Fruit weight	0.280	0.355	0.310	0.663	-0.035	-0.431	0.014	0.076	0.253	0.222	0.390	0.252	0.309*	0.291*
13	Fruit volume	0.302	0.326	0.328	0.241	0.0104	-0.098	0.088	-0.055	0.216	0.196	-0.250	0.080	0.285*	0.311*
14	Specific gravity	0.062	-0.115	0.052	0.086	0.059	-0.069	0.031	-0.102	0.048	0.698	0.182	-0.041	0.048	0.087
15	Seed no./fruit	-0.245	-0.178	-0.048	-0.275	0.144	-0.071	0.046	-0.087	0.036	0.497	0.114	-0.011	0.286*	0.305*
16	100 seed weight	-	-0.225	-0.099	0.221	0.110	-0.102	0.022	-0.085	0.015	0.058	0.098	-0.069	0.341*	0.386*
17	Seed wt. per fruit		-	-0.235	-0.304	0.091	-0.075	0.045	-0.025	0.028	0.445	0.058	0.022	0.348*	0.287*
18	Pulp percentage			-	0.377	-0.204	-0.145	0.010	-0.056	0.085	0.522	0.112	0.010	0.284*	0.352*
19	Pulp weight				-	-0.158	-0.130	0.025	-0.087	0.091	0.052	0.084	0.031	0.339*	0.284*

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		16	17	18	19	20	21	22	23	24	25	26	27	28	29
20	TSS					-		0.085	0.532	0.552	0.623	0.550	0.332	0.144	0.195
21	Acidity						-	-0.151	-0.522	0.156	-0.096	-0.225	-0.098	0.201	0.158
22	TSS/Acid ratio							-	0.112	0.224	0.203	0.198	0.140	0.099	0.050
23	Ascorbic acid								-	0.047	0.091	0.053	0.048	0.085	0.048
24	Dietary fibre									-	0.055	-0.011	0.087	0.110	0.104
25	Total sugars										-	0.220	-0.149	0.039	0.055
26	Reducing sugars											-	0.068	0.051	0.024
27	Non reducing												-	-0.183	0.080
28	Yield													-	0.483*
29	Yield efficiency														-

4.3.6 Path analysis:

Direct and indirect contribution of several tree and physico-chemical characteristics *viz.*, tree height, tree spread, tree volume, leaf area, fruit weight, pulp percentage, TSS, total sugars and yield were estimated through partitioning of their genotypic correlation coefficient analysis. The results obtained are presented in table 5. Fruit volume with is recorded to have maximum positive direct effect (0.088) on yield followed by fruit weight (0.078), leaf width (0.057), seed number per fruit (0.048) and fruit length (0.036), while, specific gravity showed a maximum negative direct effect (-0.076) on yield followed by T.S.S (-0.068), acidity (-0.055) and leaf length (0.035). Highest positive indirect effect on yield came from fruit volume through fruit weight, leaf width, seed number per fruit and fruit length. Highest negative indirect effect came from specific gravity.

Table 5. Path analysis of various tree and fruit characters towards fruit yield of seedling origin guava.

Sr. No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Tree height	0.032	0.116	0.102	0.009	-0.159	0.180	-0.094	-0.137	0.147	-0.021	0.005	-0.114	0.032	-0.102	-0.106
2	Tree spread	0.013	0.156	0.120	0.001	0.012	-0.013	-0.007	-0.009	0.010	-0.001	0.022	-0.009	0.001	-0.008	-0.008
3	Tree volume	0.006	0.006	0.019	-0.002	-0.009	-0.008	-0.003	-0.007	0.010	0.004	0.005	-0.007	0.006	0.001	-0.001
4	Trunk girth	-0.001	0.037	0.05	0.111	-0.002	-0.003	-0.009	-0.006	0.001	-0.004	-0.001	0.040	0.019	-0.002	-0.002
5	TCSA	0.061	0.060	0.065	-0.008	0.133	-0.069	-0.028	-0.053	0.069	0.015	0.027	-0.052	0.036	-0.016	-0.019
6	Leaf area	-0.148	-0.142	-0.135	0.023	0.148	0.140	0.087	0.128	-0.142	0.006	-0.029	0.091	-0.045	0.072	0.075
7	Leaf length	-0.101	-0.099	-0.057	0.105	0.078	0.014	-0.035	0.154	-0.067	0.146	0.109	0.003	0.063	0.141	0.178
8	Leaf width	0.346	0.293	0.331	-0.163	-0.350	-0.394	-0.361	0.057	0.354	-0.154	-0.034	-0.230	0.051	-0.227	-0.318
9	Leaf LW ratio	0.035	0.031	0.046	-0.003	-0.044	-0.041	-0.015	-0.034	0.012	0.021	0.023	-0.032	0.031	-0.002	-0.010
10	Fruit length	0.008	0.007	-0.026	-0.017	0.014	-0.003	-0.050	-0.023	-0.033	0.036	-0.066	0.013	-0.056	-0.060	-0.060
11	Fruit diameter	0.001	-0.001	0.020	0.003	-0.014	-0.007	0.020	0.003	0.019	0.034	0.186	-0.020	0.026	0.026	0.025
12	Fruit weight	0.009	0.009	0.010	0.0002	-0.011	-0.009	-0.0002	-0.007	0.010	0.003	0.008	0.078	0.004	0.003	0.001
13	Fruit volume	0.006	0.002	0.021	0.016	-0.016	-0.009	0.010	-0.004	0.022	0.026	0.023	-0.009	0.088	-0.014	-0.009
14	Specific gravity	0.176	0.188	0.001	-0.040	-0.072	-0.152	-0.227	-0.156	0.015	-0.282	-0.235	0.057	-0.144	-0.076	-0.272
15	No. of seeds/fruit	-0.106	-0.103	-0.017	0.026	0.051	0.092	0.166	0.127	-0.042	0.164	0.132	-0.011	0.053	0.157	0.048
16	100 seed weight	-0.046	-0.046	0.014	-0.042	-0.003	0.017	0.005	-0.004	0.032	0.088	0.053	0.001	0.039	0.085	0.043
17	Seed weight/fruit	0.038	0.059	-0.033	-0.009	-0.008	-0.034	-0.060	-0.011	-0.041	-0.108	-0.107	0.057	-0.076	-0.128	-0.084

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18	Pulp percentage	0.021	0.024	0.163	-0.025	-0.122	-0.056	0.144	0.009	0.161	0.254	0.270	-0.190	0.177	0.198	0.207
19	Pulp weight	0.244	0.251	0.181	-0.135	-0.220	-0.292	-0.262	-0.256	0.194	-0.199	-0.132	-0.062	-0.030	-0.282	-0.258
20	TSS	0.015	0.007	0.069	0.036	-0.056	-0.025	0.070	0.001	0.076	0.147	0.134	-0.104	0.102	0.112	0.089
21	Acidity	0.117	0.091	0.160	-0.013	-0.153	-0.149	-0.047	-0.129	0.167	0.071	0.088	-0.115	0.114	0.003	-0.030
22	TSS/Acid ratio	-0.018	-0.015	-0.029	-0.003	0.028	0.026	0.001	0.016	-0.034	-0.021	-0.019	0.015	-0.028	-0.005	-0.001
23	Ascorbic acid	0.025	0.021	0.057	0.017	-0.047	-0.027	0.034	-0.007	0.060	0.086	0.082	-0.059	0.067	0.057	0.046
24	Dietary fibre	0.025	0.042	0.040	0.030	0.069	0.015	0.052	0.038	0.092	0.166	0.127	-0.042	0.164	0.103	0.002
25	Total sugars	-0.074	-0.028	-0.037	-0.067	-0.003	-0.044	-0.103	-0.048	0.164	0.132	-0.011	0.053	0.066	-0.003	0.031
26	Reducing sugars	-0.004	0.031	-0.047	0.029	0.062	0.052	0.038	0.013	0.026	-0.026	0.025	0.042	0.040	0.030	-0.031
27	Non reducing	0.037	-0.031	0.136	-0.028	-0.130	-0.103	-0.048	-0.052	-0.063	-0.042	-0.074	-0.028	-0.037	-0.067	0.104
28	Yield efficiency	-0.016	-0.365	-0.003	0.346	0.201	-0.016	-0.365	-0.003	0.346	0.201	0.040	0.070	-0.278	-0.264	-0.006

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Sr. No.		16	17	18	19	20	21	22	23	24	25	26	27	29
1	Tree height	-0.060	-0.050	0.014	-0.138	0.020	0.124	0.088	0.053	0.026	0.38	-0.087	-0.088	0.011
2	Tree spread	-0.005	-0.006	0.001	-0.011	0.001	0.007	0.006	0.004	0.010	0.0002	-0.011	-0.350	-0.361
3	Tree volume	0.001	0.002	0.006	-0.005	0.005	0.009	0.007	0.006	0.001	-0.004	-0.001	0.003	-0.007
4	Trunk girth	0.005	-0.001	0.002	-0.007	-0.005	0.001	-0.001	0.003	0.188	0.001	-0.040	-0.072	0.046
5	TCSA	0.002	-0.004	0.031	-0.047	0.029	0.062	0.052	0.038	0.092	0.166	0.127	-0.042	0.132
6	Leaf area	0.018	0.037	-0.031	0.136	-0.028	-0.130	-0.103	-0.048	0.164	0.132	-0.011	0.053	-0.089
7	Leaf length	0.007	0.084	0.104	0.160	0.103	-0.054	-0.007	0.077	0.188	0.001	-0.040	-0.072	0.055
8	Leaf width	0.013	-0.037	-0.016	-0.365	-0.003	0.346	0.201	0.040	0.070	0.001	0.076	0.147	0.009
9	Leaf LW ratio	0.010	0.013	0.026	-0.026	0.025	0.042	0.040	0.030	0.069	0.015	0.027	-0.052	-0.069
10	Fruit length	-0.043	-0.052	-0.063	-0.042	-0.074	-0.028	-0.037	-0.067	-0.003	-0.044	-0.041	-0.015	-0.005
11	Fruit diameter	0.013	0.027	0.035	0.014	0.035	0.018	0.018	0.033	0.021	0.024	0.163	-0.025	-0.056
12	Fruit weight	-0.0001	0.006	0.010	-0.003	0.011	0.010	0.006	0.010	-0.008	-0.003	-0.007	0.010	0.005
13	Fruit volume	0.009	0.017	-0.021	0.003	-0.024	0.021	0.024	-0.025	-0.046	0.014	-0.042	-0.003	0.005
14	Specific gravity	-0.192	-0.289	-0.231	-0.278	-0.264	-0.006	-0.045	-0.210	0.006	-0.005	0.005	0.009	0.006
15	Seed no./fruit	0.057	0.110	0.139	0.147	0.122	-0.032	0.002	0.098	0.046	-0.003	-0.044	-0.041	-0.034
16	100 seed weight	-0.012	0.094	0.066	0.048	0.068	0.037	0.052	0.073	-0.227	-0.156	0.015	-0.282	0.057
17	Seed weight/fruit	-0.094	-0.032	-0.094	-0.086	-0.116	-0.057	-0.059	-0.099	-0.008	-0.003	-0.007	0.010	0.005
18	Pulp percentage	0.128	0.182	-0.020	0.096	0.286	0.140	0.139	0.272	-0.014	-0.007	0.020	0.003	0.034
19	Pulp weight	-0.111	-0.199	-0.113	0.056	0.141	0.132	0.105	-0.076	0.015	0.027	-0.052	0.036	-0.019
20	TSS	0.065	0.111	0.142	0.059	-0.068	0.083	0.059	0.142	0.003	-0.014	-0.007	0.020	0.019
21	Acidity	0.045	0.069	0.088	0.070	0.107	-0.055	0.136	0.120	-0.153	-0.149	-0.047	-0.129	0.071
22	TSS/Acid ratio	-0.014	-0.016	-0.019	0.012	-0.016	-0.029	-0.011	-0.025	-0.033	-0.009	-0.008	-0.034	-0.011
23	Ascorbic acid	0.045	0.061	0.086	0	0.091	0.060	0.058	-0.015	0.020	0.003	0.019	-0.062	-0.282
24	Dietary fibre	0.163	-0.025	-0.122	-0.056	0.144	0.009	0.161	0.025	0.039	0.015	-0.013	-0.153	-0.060
25	Total sugars	0.181	-0.135	-0.220	-0.292	-0.262	-0.256	0.194	-0.199	0.021	0.041	-0.003	0.028	0.144
26	Reducing sugars	-0.074	-0.028	-0.037	-0.067	-0.003	-0.044	0.069	0.036	-0.056	0.011	0.024	-0.074	-0.262
27	Non reducing	-0.004	0.031	-0.047	0.029	0.062	0.052	0.160	-0.013	-0.153	-0.052	0.036	0.010	0.070
28	Yield efficiency	-0.034	0.041	-0.019	0.015	0.067	-0.003	-0.044	-0.103	-0.048	0.164	0.008	0.007	0.148

4.3.7 Cluster analysis:

Based on D^2 statistics, seventy seedling origin guava genotypes were grouped into five clusters as presented in table 6. The results indicate that cluster II and cluster III contained maximum number of genotypes. Cluster II consists of seventeen guava genotypes *viz.*, PSJ-4, PSJ-5, PSJ-6, PSJ-7, PSJ-8, PSJ-9, PSJ-10, PSA-46, PSA-47, PSA-48, PSA-49, PSA-50, PSA-51, PSA-52, PSA-53, PSA-54 and PSA-55. Cluster III also consists of seventeen genotypes *viz.*, PSJ-11, PSJ-12, PSJ-13, PSJ-14, PSJ-15, PSJ-16, PSJ-17, PSJ-18, PSJ-19, PSJ-20, PSA-56, PSA-57, PSA-58, PSA-59, PSA-60, PSA-61 and PSA-62. Cluster IV has sixteen guava genotypes *viz.*, PSS-30, PSS-31, PSS-32, PSS-33, PSS-34, PSS-35, PSS-36, PSS-37, PSS-38, PSS-39, PSS-40, PSS-41, PSS-42, PSS-43, PSS-44 and PSS-45. Cluster I contains twelve guava genotypes *viz.*, PS-J1, PSJ-2, PSJ-3, PSS-21, PSS-22, PSS-23, PSS-24, PSS-25, PSS-26, PSS-27, PSS-28, PSS-29 and cluster V contains eight guava genotypes *viz.*, PSA-63, PSA-64, PSA-65, PSA-66, PSA-67, PSA-68, PSA-69 and PSA-70.

Mean intra and inter cluster distance (D^2) values are presented in table 7. The perusal of the results revealed that cluster I had maximum intra cluster distance (185.20) followed by cluster V (168.65), cluster II (162.71), cluster III (150.00) and cluster IV (124.71), whereas, maximum inter cluster distance was recorded as 834.74 between cluster I and cluster IV, followed by 613.66 between cluster II and cluster IV and 592.83 between cluster I and cluster II. Perusal of data on cluster means for various quantitative traits presented in table 8 reveals that Cluster I had a leaf area of 61.49 cm², leaf length of 11.98 cm, leaf width of 4.01 cm, leaf length-width ratio of 3.02, fruit weight of 112.89 gm, fruit length of 6.04 cm, fruit diameter of 5.7 cm, fruit volume of 120.36 cm³, specific gravity of 0.93, number of seeds per fruit of 151.05, hundred seed weight of 1.03 g, seed weight of fruit of 1.56 g, pulp weight of 111.33 g, pulp percentage of 98.54, T.S.S of 7.37 per cent, acidity of 0.28 per cent, T.S.S/acid ratio of 25.93, ascorbic acid of 134.87mg/100g fruit, dietary fiber of 10.63 per cent, total sugars of 6.45 per cent, reducing sugars of 3.87 per cent, non reducing sugars of 2.45 per cent, tree height of 3.65 m, tree spread of 2.68 m, tree volume of 150.36 m³, trunk girth of 21.17 cm, TCSA of 35.77 cm², yield of 16.27 kg/tree and yield efficiency of 0.46 kg/cm². Cluster II had a leaf area of 75.10 cm², leaf length of 14.13cm, leaf width of 5.28 cm, leaf length-width ratio of 2.70, fruit weight of 108.42 gm, fruit length of 5.91 cm, fruit diameter of 5.55 cm, fruit volume of 112.23 cm³, specific gravity of 0.97, number of seeds per fruit of 223.60, hundred

seed weight of 1.15 g, seed weight of fruit of 2.58 g , pulp weight of 105.84 g, pulp percentage of 97.58, T.S.S of 8.10 per cent, acidity of 0.29 per cent, T.S.S/acid ratio of 27.50, ascorbic acid of 140.67 mg/100 g fruit, dietary fiber of 12.38 per cent, total sugars of 6.67 per cent, reducing sugars of 3.92 per cent, non reducing sugars of 2.83 per cent, tree height of 4.65 m, tree spread of 3.04 m, tree volume of 273.48 m³, trunk girth of 23.69 cm, TCOSA of 44.67 cm², yield of 17.99 kg/tree and yield efficiency of 0.40 kg/cm². Cluster III had a leaf area of 92.36 cm², leaf length of 15.06 cm, leaf width of 6.13 cm, leaf length-width ratio of 2.46, fruit weight of 164.85 gm, fruit length of 6.79 cm, fruit diameter of 6.47 cm, fruit volume of 168.61 cm³, specific gravity of 0.98, number of seeds per fruit of 247.35, hundred seed weight of 1.38 g, seed weight of fruit of 3.39 g , pulp weight of 161.46 g, pulp percentage of 97.94 per cent, T.S.S of 9.45 per cent, acidity of 0.31 per cent, T.S.S/acid ratio of 30.91, ascorbic acid of 173.39 mg/100 g fruit, dietary fiber of 12.96 per cent, total sugars of 8.54 per cent reducing sugars of 4.88 per cent non reducing sugars of 3.48 per cent tree height of 5.49 m, tree spread of 3.35 m, tree volume of 417.76 m³, trunk girth of 24.73 cm, TCOSA of 48.50 cm², yield of 19.30 kg/tree and yield efficiency of 0.39 kg/cm². Cluster IV had a leaf area of 94.08 cm², leaf length of 13.39 cm, leaf width of 4.09 cm, leaf length-width ratio of 3.29, fruit weight of 161.26 gm, fruit length of 6.76 cm, fruit diameter of 6.42 cm, fruit volume of 165.01 cm³, specific gravity of 0.98, number of seeds per fruit of 231.50, 100 seed weight of 1.32 g, total seed weight of fruit of 3.07 g , pulp weight of 158.20 g, pulp percentage of 98.11 per cent, T.S.S of 8.77 per cent, acidity of 0.31 per cent, T.S.S/acid ratio of 28.40, ascorbic acid of 188.34 mg/100 g, dietary fiber of 12.93 per cent, total sugars of 8.71 per cent, reducing sugars of 4.84 per cent, non reducing sugars of 3.68 per cent, tree height of 3.76 m, tree spread of 3.04 m, tree volume of 182.35 m³, trunk girth of 21.80 cm, TCOSA of 37.64 cm², yield of 17.83 kg/tree and yield efficiency of 0.41 kg/cm² and cluster V had a leaf area of 82.02 cm², leaf length of 15.02 cm, leaf width of 5.52 cm, leaf length-width ratio of 2.73, fruit weight of 176.06 gm, fruit length of 6.87 cm, fruit diameter of 6.46 cm, fruit volume of 178.08 cm³, specific gravity of 0.99, number of seeds per fruit of 290.08, hundred seed weight of 1.39 g, total seed weight of 4.07 g , pulp weight of 171.99 g, pulp percentage of 97.69, T.S.S of 10.17 per cent, acidity of 0.31 per cent, T.S.S/acid ratio of 33.11, ascorbic acid of 199.19 mg/100 g fruit, dietary fiber of 13.85 per cent, total sugars of 10.01 per cent, reducing sugars of 6.19 per cent, non reducing sugars of 3.64 per cent, tree height of 5.90 m, tree spread of 3.87 m, tree volume of 554.96 m³, trunk girth of 26.79 cm, TCOSA of 57.14 cm², yield of 23.35 kg/tree and yield efficiency of 0.47 kg/cm².

Table 6: Cluster membership of different seedling origin guava genotypes.

Cluster	Number of members	Genotypes
Cluster I	12	PSJ1, PSJ2, PSJ3, PSS21, PSS22, PSS23, PSS24, PSS25, PSS26, PSS27, PSS28, PSS29
Cluster II	17	PSJ4, PSJ5, PSJ6, PSJ7, PSJ8, PSJ9, PSJ10, PSA46, PSA47, PSA48, PSA49, PSA50, PSA51, PSA52, PSA53, PSA54, PSA55
Cluster III	17	PSJ11, PSJ12, PSJ13, PSJ14, PSJ15, PSJ16, PSJ17, PSJ18, PSJ19, PSJ20, PSA56, PSA57, PSA58, PSA59, PSA60, PSA61, PSA62
Cluster IV	16	PSS30, PSS31, PSS32, PSS33, PSS34, PSS35, PSS36, PSS37, PSS38, PSS39, PSS40, PSS41, PSS42, PSS43, PSS44, PSS45
Cluster V	8	PSA63, PSA64, PSA65, PSA66, PSA67, PSA68, PSA69, PSA70

Table 7: Inter and intra cluster distances.

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	185.20	322.71	592.83	834.74	374.98
Cluster II	322.71	162.71	395.28	613.66	388.04
Cluster III	592.83	395.28	150.00	274.40	353.28
Cluster IV	834.74	613.66	274.40	124.71	532.70
Cluster V	374.98	388.04	353.28	532.70	168.65

*Figures in bold letters are intra-cluster distances.

Table 8: Cluster means of different characters.

Characters	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Leaf area	61.49	75.10	92.36	94.08	82.02
Leaf length	11.98	14.13	15.06	13.39	15.02
Leaf width	4.01	5.28	6.13	4.09	5.52
Leaf LW ratio	3.02	2.70	2.46	3.29	2.73
Fruit weight	112.89	108.42	164.85	161.26	176.06
Fruit length	6.04	5.91	6.79	6.76	6.87
Fruit diameter	5.71	5.55	6.47	6.42	6.46
Fruit volume	120.36	112.23	168.61	165.01	178.08
Specific gravity	0.93	0.97	0.98	0.98	0.99
SNP	151.05	223.60	247.35	231.50	290.08
100 seed weight	1.03	1.15	1.38	1.32	1.39
SWPF	1.56	2.58	3.39	3.07	4.07
PW	111.33	105.84	161.46	158.20	171.99
PP	98.54	97.58	97.94	98.11	97.69
T.S.S	7.37	8.10	9.45	8.77	10.17
Acidity	0.28	0.29	0.31	0.31	0.31
TSS: Acid Ratio	25.93	27.50	30.91	28.40	33.11
Ascorbic Acid	134.87	140.67	173.39	188.34	199.19
Dietry fibre	10.63	12.38	12.96	12.93	13.85
Total sugar	6.45	6.67	8.54	8.71	10.01
Reducing sugar	3.87	3.92	4.88	4.84	6.19
Non-reducing sugar	2.45	2.83	3.48	3.68	3.64
Tree height	3.65	4.65	5.49	3.76	5.90
Tree spread	2.68	3.04	3.35	3.04	3.87
Tree volume	150.36	273.48	417.76	182.35	554.96
Trunk girth	21.17	23.69	24.73	21.80	26.79
TCSA	35.77	44.67	48.50	37.64	57.14
Yield	16.27	17.99	19.30	17.83	23.35
Yield efficiency	0.46	0.40	0.39	0.41	0.47

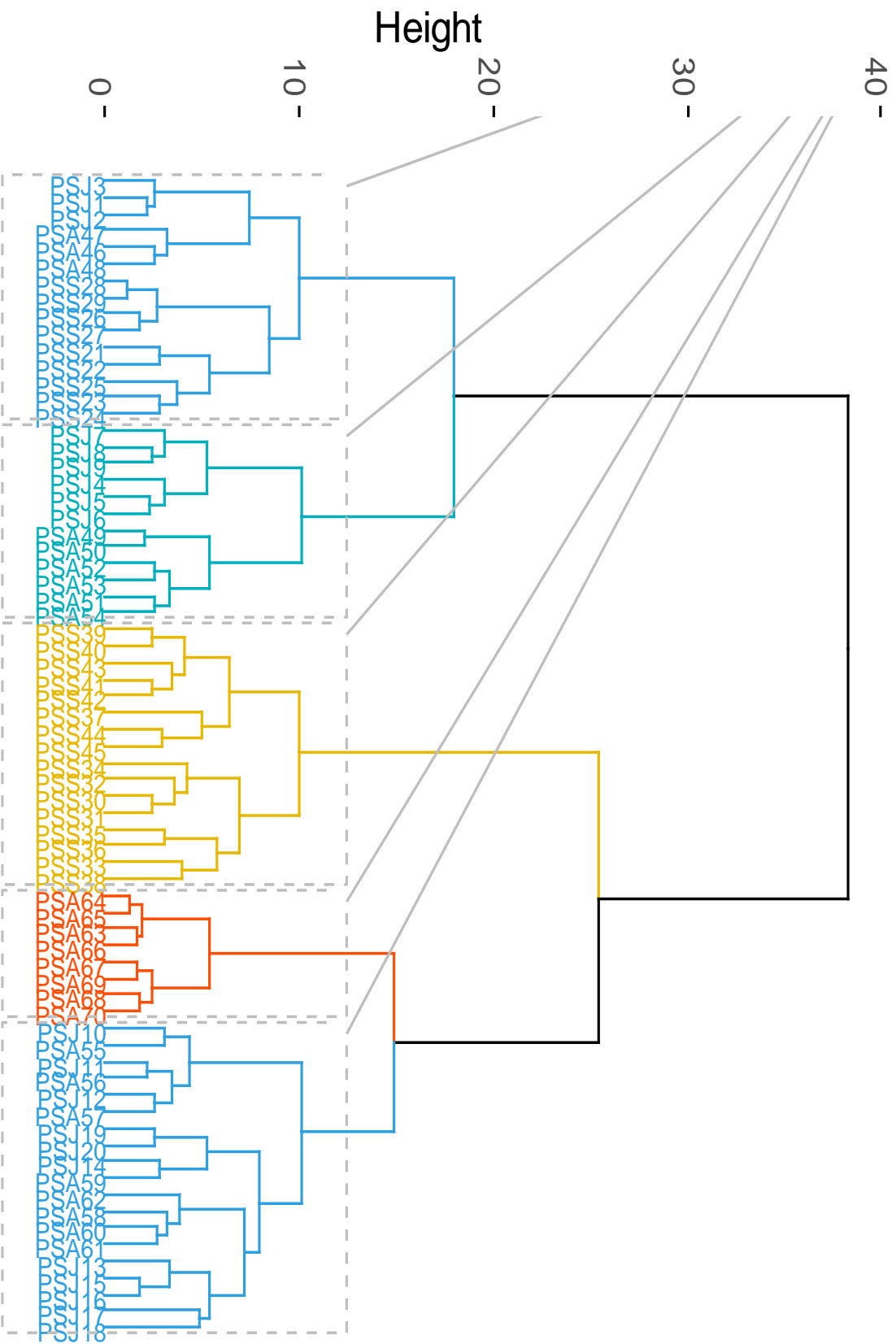


Fig. 2. Cluster Dendrogram

4.3.8 Principal component analysis:

Principal component analysis (PCA) was performed to provide an easy visualization of the complete data set in reduced dimensions. Previously, PCA has been used to establish genetic relationships among different fruit crops (Brovelli *et al.*, 1999 and Lavilla *et al.*, 2002) and to study correlations among fruit traits (Kazem *et al.*, 2008 and Umran and Dalkilic, 2011). The results presented in table 9 reveal that the 1st five principal components (PC's) possessed Eigen value greater than 1.0, with per cent contribution towards total variance as 51.62 per cent, 18.06 per cent, 6.70 per cent, 4.96 per cent and 4.70 per cent. The total contribution by first five PCs towards total variance was 86.07 per cent. Perusal of the data presented in table 10 reveals that yield, trunk cross sectional area, plant spread, fruit weight, leaf area, leaf width, leaf length and yield efficiency are major characters contributing 37.55 per cent, 26.12 per cent, 12.80 per cent, 10.22 per cent, 5.25 per cent, 3.72 per cent, 3.14 per cent and 0.55 per cent respectively are the total variation present in the population.

Table 9: Eigen values and component loadings in seedling origin guava genotypes.

Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	Percent of variance	Cumulative percentage	Total	Percent of variance	Cumulative percentage
1	12.904	51.617	51.617	12.904	51.617	51.617
2	4.524	18.095	69.712	4.524	18.095	69.712
3	1.675	6.700	76.413	1.675	6.700	76.413
4	1.241	4.963	81.376	1.241	4.963	81.376
5	1.174	4.695	86.071	1.174	4.695	86.071
6	0.843	3.371	89.442			
7	0.565	2.262	91.704			
8	0.476	1.903	93.607			
9	0.387	1.549	95.156			
10	0.317	1.269	96.425			
11	0.302	1.208	97.633			
12	0.164	0.654	98.287			
13	0.130	0.518	98.806			
14	0.109	0.434	99.240			
15	0.068	0.271	99.511			
16	0.054	0.218	99.729			
17	0.024	0.096	99.824			
18	0.013	0.052	99.876			
19	0.009	0.037	99.913			
20	0.007	0.026	99.940			
21	0.006	0.025	99.965			
22	0.004	0.015	99.980			
23	0.002	0.010	99.990			
24	0.002	0.009	99.999			
25	0.000	0.001	100.000			

Table: 10 Percent contribution of different characters towards diversity in seedling origin guava genotypes.

Characters	Percent contribution
Yield (Kg/tree)	37.55
Trunk cross sectional area (cm ²)	26.12
Plant spread (m)	12.80
Fruit weight (g)	10.22
Leaf area (cm ²)	5.25
Leaf width (cm)	3.72
Leaf length (cm)	3.14

Percent variation explained by first five components = 85.52 %

Chapter-5

Discussion

DICUSSION

The present investigation “**Diversity Assessment of Seedling Guava in Jammu Sub-tropics**” was carried out at three different regions *viz.*, Jammu, Samba and Akhnoor during the year 2016-17. The detailed study of selected genotypes was carried out on tree characters, physico-chemical fruit characters, diversity assessment and character association. The results are discussed in light of research work done in India and abroad.

The greater diversity in the material, the more is the genetic potential and greater chance of producing desirable (elite) types. Keeping in mind, 70 genotypes of guava were selected for the study of various parameters.

5.1 Tree characteristics:

5.1.1 Tree height:

As a consequence of the seedling origin of studied genotypes leading to differences in the genetic makeup of selected genotypes, they showed considerable variability. The soil and microclimatic conditions also added in exhibiting the inherent characters of different genotypes and also the presence of strong apical dominance in genotypes PSA-65 and PSA-68 in villages Anmbaran and Chack Malal respectively of Akhnoor area may have attributed to maximum tree height. Similarly Dubey *et al.* (2002), Singh *et al.* (2011) and Ulemale and Tambe (2015) also reported considerable variation in tree height while exploring seedling origin guava plants.

5.1.2 Tree spread:

The results on the tree spread ranged between 2.37m-3.97 m. Highest plant spread was recorded as 3.97 m in genotype PSA-65 in village Ambaran of Akhnoor area while minimum tree spread was found as 2.37 m in PSS-22. The considerable variation in tree spread might be due to the difference in genotypic makeup of individual genotypes, climatic conditions under which tree is growing and the age of the tree (Sharma *et al.*, 1998). These findings are conformity with those reported by Singh and Khan (1989), Subramanyam and Dinesh (1993) and Singh (2003). Similar results have also been observed by Kale (2009) in sweet orange and Pandey *et al.* (2016) and Singh *et al.* (2016) in guava.

5.1.3 Tree volume:

The results reveal that tree volume was ranged between 197.01 m³ in PSA-68 to 37.25m³ in PSS-22. Rattanpal and Dhaliwal (1997) while studying 325 open-pollinated seedlings of Allahabad Safeda, Bangalore Seedling, Sardar Guava and hybrids of Allahabad Safeda × Seedless also reported tree volume to range from 22.1 to 185.9 m³

5.1.4 Trunk girth:

Trunk girth among the genotypes studies varied between 20.02 - 27.27 cm. Higher trunk girth in genotypes PSA-65 (27.27 cm) was recorded in Akhnoor region of Jammu sub-tropic village Chack Malal may be due to the height of the trees. Variation in trunk girth in different genotypes is a genetic feature of individual genotypes and moreover, these genotypes have grown-up under different ecological conditions. Similarly Singh (2003), Meena *et al.* (2013) and - *et al.* (2015) also reported huge variation in trunk girth of seedling origin guava plants.

5.1.5 Leaf length:

Leaf length ranged between 10.41 cm in genotypes PSJ-1 to 15.92 cm in PSJ-18, whereas, minimum leaf length was recorded as 10.41 in genotype PSS-22. Variation in leaf length among different seedling plants may be attributed to the genetic make-up of the plant alongwith the local agro-climatic conditions (Shiva *et al.*, 2017). Similarly types of results are obtained by Sanou *et al.* (2006) in agro-morphological traits of shea trees in Mali.

5.1.6 Leaf width:

As given in results, leaf length also showed wide variations among different genotypes. Leaf width ranged between 3.41 cm to 6.48 cm. The highest value for leaf width was recorded in genotype PSJ-17 in village Amb of Jammu area, however, lowest value for leaf width was recorded in genotype PSS-22. Variation in leaf width may also be due to differences in the genetic make-up of the plant and the agro-climatic conditions under which plants are growing (Shiva *et al.*, 2017). Lone and Wafai (1995) reported that cherries show remarkable diversity in leaf size and divided the varieties into two groups i.e. small and large leaved on this basis.

5.1.7 Leaf length-width ratio:

Leaf length-width ratio showed wide variations among genotypes studied with the leaf length-width ratio ranging between 2.22 cm in PSJ-11 to 3.79 cm in PSS-40.

Highest leaf length-width ratio was recorded in genotype PSS-40 in village Madoon of Samba area. Variation in leaf length in different genotypes may also be due to genetic make of the plant and the prevailing agro-climatic conditions.

5.1.8 Leaf area:

Among the seedling origin guava genotypes studied, leaf area ranged between 43.67 cm² in PSJ-22 to 102.53 cm² in genotype PSJ-19. Variation in leaf area is also due the different genetic make of individual seedling affected by the local agro-climatic conditions (Chitkara and Khera, 1973).

5.2 Physico-chemical characteristics:

5.2.1 Fruit weight:

The results obtained on fruit weight in the present investigations suggest that the different genotypes varied markedly with respect to fruit weight. The higher fruit weight (177.17 gm) in genotypes PSJ-20 and PSA-65 in village Badyal Brahmana and Ambaran, respectively might be due to less number of fruits per tree and high canopy volume, which leads to high diversion of food material to the optimum number of fruits to attain good size. The variation in fruit weight may also be due to the fact that each seedling has different genotype which also affected by local agro-climatic conditions (Jana *et al.*, 2010a; Jana *et al.*, 2010b). Similarly Singh (2003) and Patel *et al.* (2005) also reported huge variation in fruit weight among the seedling origin guava plants. Hashmi and Pawar (2012) also found similar variation in fruit weight of custard apple. Present results are also in accordance with the findings of, Haji *et al.* (2012) and Boora *et al.* (2015) in guava.

5.2.2 Fruit length:

The fruit length ranged between 5.53cm-6.98cm and the maximum fruit length was found in genotype PSA-65 (6.98 cm) in Akhnoor region village Anmbran. Fruit length, being a genetic trait varies from genotype to genotype but to some extent influenced by the crop load on the tree, number of fruits per tree, soil moisture status, fertility status, source sink relation and other factors. These findings are in agreement with the work of Patel *et al.* (2007), Pandey *et al.* (2016) and Boora *et al.* (2015) in guava.

5.2.3 Fruit diameter:

The result on the fruit length ranged between 5.13 -6.70 cm and the maximum fruit length was found in genotype PSS-40 (6.70 cm) in Samba region village

Madoon. Along with the different genetic make-up of different seedling guava plants, the variation in fruit diameter may also be attributed to climatic conditions, soil moisture and source sink relation. Similarly Patel *et al.* (2007) and Boora *et al.* (2015) also reported considerable variation in the fruit diameter of seedling origin guava plants.

5.2.4 Fruit volume:

In the present study, fruit volume ranged between 92.48 cm³ in PSJ8 to 180.07cm³ in PSA65. Significant variation in relation to volume of fruit was also observed in jamun as reported by Agrawal *et al.* (2017). Highest fruit volume of 1.01cc was recorded in JJ-1 which was significantly superior to other genotypes. It was followed by JJ-15 with 1.65 cc, whereas it was lowest in genotype JJ-2 (1.01 cc) against mean value of 1.32 cc. Garnayak *et al.* (2008) also reported that volume of fruit is another important factor like that of its weight in determining fruit quality. In the market, the consumers have a preference to select the large sized fruits and accordingly the price of those fruits goes higher with size.

5.2.5 Specific gravity:

The result on the specific gravity of the fruit indicate that various cultivars significantly. The specific gravity was recorded between 1.00 (PSS-23, PSS-25, PSS-26, PSS-27, PSS-28, PSS-29 and PSA-52) to 1.15 (PSJ-17). Shukla and Shukla (2017) also reported specific gravity to range between 1.00 to 1.23 among different guava cultivars.

5.2.6 Pulp percentage and pulp weight:

Higher pulp content is a desirable character for table purpose guava and for breeding quality fruits. Highest pulp weight was recorded in genotype PSA-62 as 173.62 g and minimum in PSS-27 as 84.91 g. The pulp percentage ranged from 96.45 per cent in PSA-96.45 to 99.06 per cent in PSJ-1. Variability in pulp percentage and pulp weight of fruits may be due to their genetic makeup and phenotypic expressions that are influenced by local climatic conditions as well as micro climatic conditions (Mitra *et al.*, 1983). Similar results were also recorded by Dass *et al.* (1995) and Deshpande (2006) while working on seedling origin guava plants.

5.2.7 Seed weight per fruit:

Characters like minimum seed weight, minimum pericarp weight and maximum pulp weight are good criterion for selecting the superior genotypes. In the present study, seed weight per fruit ranged between 1.33-4.43g. Variation in seed weight among different plans is due to heterogenous nature of the crop. Lower seed weight per fruit may also be attributed to minimum diversion of photosynthetic substances towards seeds. The results are in agreement with the findings of Gohil *et al.* (2006) and Khehra and Bal (2006) in guava.

5.2.8 Number of seeds per fruit:

The fruits having more number of seeds would not fetch higher price in market as it likely to be failed to attract the consumer. The fruits having less number of soft seeds are preferred both in table and processing purpose. The lowest number of seeds in genotype seed number per fruit were recorded in genotypes PSJ-1 (135.66) might be due to high pulp per cent (Kurmi, 1992). Similar results were also obtained by Gohil *et al.* (2006) in guava and Patel *et al.* (2005) in guava.

5.2.9 Hundred seed weight:

In the present study , the hundred seed weight ranged from 1.01 gm to 1.57 gm. Genotype PSJ-20 (1.57 gm) having the maximum hundred seed weight followed by PSJ-18 (1.54 gm), PSS-41 (1.54 gm) and PSS-42 (1.53 gm). At genotypic and phenotypic levels seed hardness was significantly and positively correlated with hundred seed weight of the fruit. Similar results were also reported by Singh *et al.* (2014) in guava.

5.2.10 Total soluble solids:

Total soluble solid indicate higher sugar content in the fruits and is considered as one of the important criterion for dessert quality. Total soluble solid content ranged between 6.34°B-10.89°B in the studied population. Variation in TSS of ripe fruits in the heterogenous population is due genetic composition of individual plants which is modified by agro-climatic factors. Similarly, Bal and Dhaliwal (2004), Gohil *et al.* (2006), Babu *et al.* (2007) and Ghosh *et al.* (2013) and Boora *et al.* (2015) also reported variation for TSS in seedling guava population.

5.2.10 Acidity:

Acidity content ranged between 0.26 per cent in PSA-47 to 0.34 per cent in PSS-40. Being a genetic parameter, heterogenous population like seedling origin guava may reveal considerable variation in acid content of fruit. The higher and lower values of acidity which is due to inheritance, is quite helpful in finding the suitable elite types as per requirements. Some other climatic factors like temperature and humidity, sun shine hours at the time of fruit development also affect the chemical composition of the fruits. The results in the present study are conformation with the findings of are in agreement with the findings of Patel *et al.* (2005), Ghosh *et al.* (2013) and Singh *et al.* (2016), Boora *et al.* (2015) Jana *et al.* (2010a) in guava.

5.2.11 Total sugars:

Total sugar ranges between 6.19 per cent-10.51 per cent. Highest total sugar in guava genotypes PSS-41 (10.50%) might be due to high total soluble solids in these genotypes. The variation observed in total sugar might be as an inherent effect and also influence of agro-climatic conditions. These results are in agreement with Patel *et al.* (2007), Pandey *et al.* (2007) and Jana *et al.* (2010) in guava.

5.2.12 Reducing sugars:

The reducing sugar of fruits from different genotypes varied due to difference in genetic makeup of the genotypes, it ranged between 3.13 per cent-6.51 per cent High reducing sugar (6.51%) in genotypes PSA-65 might be attributed to the presence of more monosaccharide and disaccharides like glucose and fructose in these genotype's fruits during maturity. These results are in agreement with the findings of Jana *et al.* (2010a), Meena *et al.* (2013) and Pandey *et al.* (2016) in guava.

5.2.13 Non-reducing sugars:

The non-reducing sugar ranged between 1.87 per cent to 4.45 per cent, non – reducing sugar of fruits from different genotypes varied due to difference in genetic makeup of the genotypes. These parameters may vary from place to place depending on climatic factors and management practices. Similar results were also reported by Patel *et al.* (2007) and Meena *et al.* (2003) in guava.

5.2.14 Vitamin C (ascorbic acid content):

Higher ascorbic acid content (212.33 mg/100 mg) was observed in the genotype PSA-64, while PSS-22 genotype had lowest ascorbic acid content (128.41mg/100mg). The larger variation in ascorbic acid content may be attributed as a varietal character and due to favorability of seasonal conditions Gohil *et al.* (2006). Similar results have also been reported by Ghosh *et al.* (2013) in guava.

5.2.15 Yield and yield efficiency:

Considerable variation in the parameter yield per tree was reported in present study. The results pertaining to yield efficiency ranged between 0.34 kg/cm² - 0.53 kg/cm² showed variation among the studied genotypes. Although, the size of the fruit is having varietal character, it may be up to some extent influenced by the total number of fruits born on the tree, age of tree, soil moisture, source sink relation and other factors. Similar results were obtained by Ghosh and Chhattachopadhyay (1996) and Aulakh (2005) in guava. However, higher yield in genotype PSA-65 (24.80 kg/tree) may be due to higher spread of the tree in comparison to others which produced more number of fruits per tree with better size. The results are in agreement of the earlier worker (Babu *et al.*, 2007) and Jana *et al.* (2010a) in guava. The variability in respect to yield characteristic have also been reported in jamun of seedling origin (Singh and Singh, 2012). According to Lombard *et al.* (1998) potential yield increases with tree size, although not linearly since bigger trees are less efficient. Baba (2015) studied variability in yield efficiency of 45 cherry genotypes in Kashmir region. He reported that yield efficiency ranged from 0.21 to 1.44 with lowest yield efficiency (0.21) in three genotypes CHR-SGR-009, CHR-BLA-020 and CHR-BLA-023 whereas highest yield efficiency of 1.44 was observed in CHR-SHP-038, followed by 1.35, 1.28 and 1.25 in CHR-SHP-033, CHR-SHP-032 and CHR-SHP-036 respectively. Wani *et al.* (2010) reported variation in yield and yield efficiency of quince due to variation in the age of the tree and other yield attributing characteristics like tree height, tree spread, trunk girth etc. and genetic constitution of the individual.

5.3 Diversity assessment and character association parameter:

5.3.1 Range and mean:

The results regarding magnitude of variability present in various tree and physico-chemical traits reveals that wide range of variability was recorded among all the traits studied. Perusal of results revealed that maximum range was recorded in number of seeds per fruit (165.34) followed by fruit weight (90.47), pulp percentage (88.47) and fruit volume (86.49) with a mean of 226.33, 142.7, 97.96 and 146.9, respectively. However, lower range was recorded in acidity (0.07), specific gravity (0.15), yield efficiency (0.19) and hundred seed weight (0.57) with the mean of 0.3, 0.432 and 1.25, respectively. Agrawal *et al.* (2017) studied the genetic resources of jamun in Madhya Pradesh and revealed that all the characters studied indicated sufficient diversity among the genotypes.

5.3.2 Coefficient of variation:

Very long gestation period and requirement of wider spacing in fruit trees for the improvement programmes pose difficulties as compared to other field crops which require lesser time and space. The factors including time, space and resources have been found to be the main constraints assessing the genetic parameters and inheritance patterns in fruit crops. Total phenotypic variance is the outcome of summation of genotypic and environmental variance, however for a breeder it is the genotypic variability which is of paramount importance. Presence of adequate amount of genetic variability in the base population is indispensable for right and effective selection. Genetic improvement of a crop through direct improvement of traits in which breeder is interested for indirect improvement through component characters can be performed effectively on the basis of sound genetic information generated from magnitude and nature of variability (Biswati, 2012). The results related to coefficients of variation have been obtained for 24 tree and fruit physico-chemical characters during the present investigations. All the characters under study *viz.*, tree height, tree volume, tree spread, leaf area, leaf width, leaf length, leaf length-width ratio, fruit weight, specific gravity, pulp percentage, T.S.S., acidity, ascorbic acid, yield efficiency etc. showed positive phenotypic and genotypic variances. The results revealed that the estimates of phenotypic variance were higher than the corresponding estimates of genotypic variance. Similar findings have been reported by Bisati (2012) and Srivastava *et al.* (2014) for different characters. A better idea can be gained by

comparing the relative magnitude of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for the actual strength of variability. The higher values of phenotypic coefficient than their corresponding estimates of genotypic coefficient of variations indicates influence of environment on the expression of these traits. The magnitude of phenotypic and genotypic coefficient of variation was low (less than 10 per cent) for fruit weight and specific gravity whereas it was moderate (10-30 per cent) for fruit size, pulp: seed ratio, TSS, acidity, ascorbic acid and it was high (more than 30 %) for and yield efficiency. The estimates of PCV and GCV indicated the presence of fairly high degree of variability for yield efficiency. The phenotypic coefficient of variation followed same trend indicating that the scope for improvement of these traits during selection could be based on phenotypic variability. These findings are in line with those of Barua and Sharma (2002) wherein significant differences between genotypes of apple for various traits have been observed and PCV and GCV were highest for yield per plant.

5.3.3 Heritability:

The amount of heritable portion of variation cannot be predicted with the help of PCV and GCV alone, but by estimating heritability along with genetic advance which in turn helps in predicting the resultant effect of selection on phenotypic expression. Heritability is the measure of the degree to which parents transfer heritable characteristics to their offspring. The differences in the degree of transfer of these characteristics result in variation in genotypes among the offspring. This variation is usually referred to as genetic variance (additive and non-additive variance) and that of the environment as environmental variance (Suzuki *et al.*, 1986). Additive genetic variance is responsible for the similarities between relatives and the population in response to selection and mostly transmissible by seed (Wright, 1976). Heritability is also useful in predicting genetic gain from selection and in selecting superior phenotypes on the basis of the phenotypic performance of quantitative characters. Heritability was grouped in three classes wherein less than 10 per cent heritability was classified as low, 10-30 per cent as medium and 30-60 per cent as high heritability (Robinson, 1966). Highest heritability of 76.60 per cent recorded in hundred seed weight followed by number of seeds per fruit (67.12%), leaf length-width ratio (66.88%), fruit volume (66.28%) and fruit weight (63.78%). However, lowest heritability (less than 10 %) was recorded in tree height (37.14%) followed by

fruit diameter (48.66%) and T.C.S.A (44.96%). Heritable variation is useful for permanent genetic improvement of any crops species (Singh, 2000). The most important function of heritability in the genetic study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value (Dabholkar, 1992). The GCV, along with heritability estimates, provides reliable estimates of the amount of GA to be expected through phenotypic selection (Burton, 1952).

5.3.4 Genetic advance and genetic gain

Heritable variation is useful for permanent genetic improvement (Singh, 2000). The most important function of heritability in the study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value (Dabholkar, 1992). The GCV, along with heritability estimates provides reliable estimates of the amount of GA to be expected through phenotypic selection (Burton, 1952). Genetic gain being the function of heritability, selection intensity and phenotypic standard deduction indicates that magnitude of improvement in desired direction that can be expected in a particular trait by selecting a certain portion of the population. Genetic advance and genetic gain was grouped into three distinct classes wherein less than (20%) genetic gain was classified as low, (20-40%) as medium and greater than (40%) as high genetic gain. Highest genetic advance (more than 40%) was recorded for ascorbic acid and number of seeds per fruit, whereas, lowest genetic advance (less than 10%) was recorded for yield efficiency followed by acidity and specific gravity. Similarly, highest genetic gain (40.84%) was recorded for hundred seed weight, whereas, lowest genetic gain (less than 10%) was recorded for pulp percentage as 11.03% followed by fruit volume (14.31%) and fruit weight (14.63%). High heritability coupled with high genetic gain is usually more useful than either of these parameters taken alone in predicting the resultant effect of selecting the best genotypes (Johnson *et al.*, 1955). The main drawbacks of heritability (broad sense) as obtained in the present study are non-additive and epistatic gene effects as well. Traits with high heritability together with high genetic advance are by and large controlled by additive gene effects (Panse, 1957). High values of genetic advance are indicative of additive gene action, whereas, low values are indicative of non-additive gene action (Singh and Narayanan, 1993). Thus, the heritability estimates will be reliable if accompanied by high genetic

advance. Higher heritability coupled with high genetic advance was observed for fruit yield per plant, which may be due to the additive gene action, and thus selection would be effective for this character. Similar results were also reported by Shah *et al.* (2010).

5.3.5 Correlation:

Correlation between traits could be due to linkage or pleiotropy. Correlation due to linkage can be manipulated or changed through recombination but it could be impossible to overcome the correlation due to pleiotropy. High coefficients of correlation allow indirect selection, while the existence of low coefficients does not represent lack of association between the character, but rather the lack of a cause-effect relationship (Vencovsky and Barriga 1992). Correlation studies are very important from breeding point of view because they reveal the magnitude of association between one or more traits and also give the indication of traits that could be useful so as to identify more important ones for a particular improvement programme.

The results on correlation coefficients revealed that tree height showed a positive correlation with tree volume, TCSA, leaf area, leaf length, dietary fiber, yield and yield efficiency whereas, it was negatively correlated with tree spread, trunk girth and leaf width. Tree spread was found to be positively correlated with tree volume, trunk girth, TCSA, leaf area, specific gravity and seed number per fruit, hundred seed weight, TSS, acidity, ascorbic acid, dietary fiber, yield and yield efficiency and negatively correlated with tree height. Tree volume showed a positive correlation with trunk girth, TCSA, leaf area, leaf length, leaf length-width ratio, TSS, total sugars, acidity, ascorbic acid, dietary fibre, yield and yield efficiency and negatively correlated with tree height, tree spread. Leaf area showed a positive correlation with tree volume, TCSA, leaf area, leaf length, leaf length-width ratio, fruit volume, specific gravity and seed number per fruit, hundred seed weight, TSS, total sugars, reducing sugars, non reducing sugars, ascorbic acid, dietary fiber, yield and yield efficiency and showed a negative correlation with acidity. Pulp percentage also showed a positive correlation with hundred seed weight, seed weight per fruit, pulp weight, acidity, yield and yield efficiency and negative correlated with TSS, acidity and ascorbic acid. Total sugars was positively correlated with reducing sugars, yield and yield efficiency and negatively correlated with non reducing sugars. Ascorbic

acid showed a positive correlation with dietary fiber, total sugars, reducing sugars, non reducing sugars, yield and yield efficiency showed a highly positive correlation with yield efficiency.

5.3.5 Path analysis:

Correlation studies alone are not adequate to establish clear-cut associations among the traits as more variables need to be considered. Hence, the knowledge of actual contribution of individual characters towards yield per plant becomes essential. In order to determine an efficient criterion for selection of various quantitative traits to improve the yield efficiency, it is essential to know the direct and indirect contribution of the traits towards this improvement through the study of cause and effect relationship. According to Silva *et al.* (2005) the success of this analysis is in the formulation of the cause and effect relationship between the characters studied, which depends on prior knowledge of the researcher. The application of path coefficient analysis was carried out which provides an idea of direct and indirect effects of various dependent and independent variables. Direct and indirect contribution of seven different tree characteristics and physic-chemical characteristics *viz.*, tree height, tree spread, tree volume, leaf area, fruit weight, fruit size, specific gravity, T.S.S, total sugars, acidity and dietary fibers as well as ascorbic acid towards yield were estimated through partitioning of their genotypic correlation coefficient analysis. Fruit volume recorded the maximum positive direct effect on yield followed by fruit weight, leaf width, seed number per fruit and fruit length while, specific gravity showed a maximum negative direct effect on yield followed by T.S.S, acidity and leaf length. Highest positive indirect effect on yield came from fruit volume through fruit weight, leaf width, seed number per fruit and fruit length. Highest negative indirect effect came from specific gravity.

5.3.6 Cluster analysis:

Based on the performance, seventy genotypes were grouped into seven clusters. Cluster II and cluster III contains maximum number of genotypes. Cluster II consist of seventeen guava genotypes *viz.*, PSJ-4, PSJ-5, PSJ-6, PSJ-7, PSJ-8, PSJ-9, PSJ-10, PSA-46, PSA-47, PSA-48, PSA-49, PSA-50, PSA-51, PSA-52, PSA-53, PSA-54 and PSA-55. Cluster III also consists of seventeen genotypes *viz.*, PSJ-11, PSJ-12, PSJ-13, PSJ-14, PSJ-15, PSJ-16, PSJ-17, PSJ-18, PSJ-19, PSJ-20, PSA-56, PSA-57, PSA-58, PSA-59, PSA-60, PSA-61 and PSA-62, whereas, cluster IV

contains sixteen guava genotypes *viz.*, PSS-30, PSS-31, PSS-32, PSS-33, PSS-34, PSS-35, PSS-36, PSS-37, PSS-38, PSS-39, PSS-40, PSS-41, PSS-42, PSS-43, PSS-44 and PSS-45. Cluster I contains twelve guava genotypes *viz.*, PS-J1, PSJ-2, PSJ-3, PSS-21, PSS-22, PSS-23, PSS-24, PSS-25, PSS-26, PSS-27, PSS-28, PSS-29 and cluster V contains eight guava genotypes *viz.*, PSA-63, PSA-64, PSA-65, PSA-66, PSA-67, PSA-68, PSA-69 and PSA-70. Classification of genotypes into various clusters employing D^2 statistics has also been reported by (Srivastava *et al.* 2014). The pattern of group constellation revealed that geographical diversity was not an essential factor for clustering of genotypes from particular origin into a specific cluster. From this it can be concluded that although geographical diversity is very important but not the only criteria in determining the genetic divergence. Thus the grouping of various genotypes from different environments into a particular cluster can be attributed to the admixture or free exchange of plant material from one place to another.

Among different clusters, cluster I had maximum intra cluster distance (185.20) followed by cluster V (168.65), cluster II (162.71), cluster III (150.00) and cluster IV (124.71). Whereas, maximum inter cluster distance was recorded in cluster I and cluster IV (834.74), followed by cluster II and cluster IV (613.66), cluster I and cluster II (592.83). From the results obtained, it is clear that the clusters have more inter-cluster distances among themselves; hence the selection of parents for hybridization from such clusters would help to evolve novel hybrids. The parents for hybridization could be selected on the basis of their large inter-cluster distance for isolating useful recombinants in the segregating generations. Similarly Boora *et al.* (2015) in guava .

Results on cluster means revealed that Cluster-I had a 61.49 cm² leaf area, 11.98 cm leaf length, 4.01 cm leaf width, 3.02 leaf length-width ratio, 112.89 gm fruit weight, 6.04 cm fruit length, 5.71 cm fruit diameter, 120.36 cm³ fruit volume, 0.93 as specific gravity, 151.05 as number of seeds per fruit, 1.03 g hundred seed weight, 1.56 g seed weight, 111.33 g pulp weight, 98.54 per cent pulp percentage, 7.37°B T.S.S, 0.28 per cent acidity, 25.93 T.S.S/acid ratio, 134.87 mg/100g ascorbic acid, 10.63 per cent dietary fibre, 6.45 per cent total sugars, 3.87 per cent reducing sugars, 2.45 per cent non reducing sugars, 3.65 m tree height, 2.68 m tree spread, 150.36 m³ tree volume, 21.17 cm trunk girth, 35.77 TCSA, 16.27 kg/tree yield and

0.46 kg/cm² yield efficiency. Cluster II had a leaf area of 75.10 cm², leaf length of 14.13 cm, leaf width of 5.28 cm, leaf length-width ratio of 2.70, fruit weight of 108.42 gm, fruit length of 5.91 cm, fruit diameter of 5.55 cm, fruit volume of 112.23 cm³, specific gravity of 0.97, number of seeds per fruit of 223.60, hundred seed weight of 1.15 g, seed weight of fruit of 2.58 g, pulp weight of 105.84 g, pulp percentage of 97.58, T.S.S of 8.10 per cent, acidity of 0.29 per cent, T.S.S/ acid ratio of 27.50, ascorbic acid of 140.67 mg/ 100 g fruit, dietary fibre of 12.38 per cent, total sugars of 6.67 per cent, reducing sugars of 3.92 per cent, non reducing sugars of 2.83 per cent, tree height of 4.65 m, tree spread of 3.04 m, tree volume of 273.48 m³, trunk girth of 23.69 cm, TCOSA of 44.67 cm², yield of 17.99 kg/tree and yield efficiency of 0.40 kg/cm². Cluster III had a leaf area of 92.36 cm², leaf length of 15.06 cm, leaf width of 6.13 cm, leaf length-width ratio of 2.46, fruit weight of 164.85 gm, fruit length of 6.79 cm, fruit diameter of 6.47 cm, fruit volume of 168.61 cm³, specific gravity of 0.98, number of seeds per fruit of 247.35, hundred seed weight of 1.38 g, seed weight of fruit of 3.39 g, pulp weight of 161.46 g, pulp percentage of 97.94 per cent, T.S.S of 9.45 per cent, acidity of 0.31 per cent, T.S.S/acid ratio of 30.91, ascorbic acid of 173.39 mg/100g fruit, dietary fibre of 12.96 per cent, total sugars of 8.54 per cent, reducing sugars of 4.88 per cent, non reducing sugars of 3.48 per cent, tree height of 5.49 m, tree spread of 3.35 m, tree volume of 417.76 m³, trunk girth of 24.73 cm, TCOSA of 48.50 cm², yield of 19.30 kg/tree and yield efficiency of 0.39 kg/cm². Cluster IV had a leaf area of 94.08 cm², leaf length of 13.39 cm, leaf width of 4.09 cm, leaf length-width ratio of 3.29, fruit weight of 161.26 gm, fruit length of 6.76 cm, fruit diameter of 6.42 cm, fruit volume of 165.01 cm³, specific gravity of 0.98, number of seeds per fruit of 231.50, seed weight of 1.32 g, seed weight of 3.07 g, pulp weight of 158.20 g, pulp percentage of 98.11 per cent, T.S.S of 8.77^oB, acidity of 0.31 per cent, T.S.S/acid ratio of 28.40, ascorbic acid of 188.34 mg/100 g fruit, dietary fiber of 12.93 per cent, total sugars of 8.71 per cent, reducing sugars of 4.84 per cent, non reducing sugars of 3.68 per cent, tree height of 3.76 m, tree spread of 3.04 m, tree volume of 182.35 m³, trunk girth of 21.80 cm, TCOSA of 37.64 cm², yield of 17.83 kg/tree and yield efficiency of 0.41 kg/cm² and cluster V had a leaf area of 82.02 cm², leaf length of 15.02 cm, leaf width of 5.52 cm, leaf length-width ratio of 2.73, fruit weight of 176.06 gm, fruit length of 6.87 cm, fruit diameter of 6.46 cm, fruit volume of 178.08 cm³, specific gravity of 0.99, number of seeds per fruit of 290.08, hundred seed weight of 1.39 g, seed weight of

4.07 g , pulp weight of 171.99 g, pulp percentage of 97.69 per cent, T.S.S of 10.17°B, acidity of 0.31 per cent, T.S.S/acid ratio of 33.11, ascorbic acid of 199.19 mg/100 g fruit, dietary fibre of 13.85 per cent, total sugars of 10.01 per cent, reducing sugars of 6.19 per cent, non reducing sugars of 3.64 per cent, tree height of 5.90 m, tree spread of 3.87 m, tree volume of 554.96 m³, trunk girth of 26.79 cm, TCSA of 57.14 cm², yield of 23.35 kg/tree and yield efficiency of 0.47 kg/cm². So, for the improvement of any particular trait should be selected from their respective genotypes cluster showing highest cluster mean for those traits. In other words, cluster means of different clusters helps in identification of the character to be chosen for hybridization (Sardana *et al.*, 1997).

5.3.7 Principle component analysis:

Out of four major PC's, the first PC showed significant factor loadings for morphological traits *viz.*, nut weight (0.394), kernel weight (0.466), kernel per cent (0.337) and shell per cent (0.372) indicated 43.36 % of the total variance whereas, significant factor loadings for nut length (0.398), kernel length (0.335) and shell thickness (0.595) by PC2 and contributing 19.77 per cent of the total variance. These results are in conformity with the results of Hussain *et al.* (2016), who found that the first four PC's revealed maximum variation in walnut genotypes and PC1 and PC2 contributed total variance of 41.65 per cent and 23.42 per cent, respectively with total variance (65.05 per cent), showing maximum factor loadings by kernel ratio, shell per cent, kernel yield and nut width by the first two PC's. Arzani *et al.* (2008) also found similar results through correlation matrix analysis for variation, three principal components (with an Eigen value greater than 1) accounted for 81 per cent of the total variation of nut and kernel characteristics, 65.8 per cent of which was represented by the first two components.

Chapter-6

Summary and Conclusion

CHAPTER-VI

SUMMARY AND CONCLUSION

The present study entitled “**Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropic**” was carried out in three different region *viz.*, Jammu, Samba and Akhnoor during the year 2017-2018 and the main objective of the work was to quantification of diversity of seedling guava in Jammu province and to select the superior genotypes of seedling guava based on different characteristics. The results of the present studies are summarized as under:

Among different genotypes, the morphological parameters *viz.*, tree height was recorded maximum in genotype PSA-65 and PSA-68 as 5.98 m, whereas, minimum (3.16 m) was recorded in PSS-22. Maximum plant spread (3.97 m) was recorded in genotype PSA-65 and minimum was recorded in genotype PSS-22 as 2.37 m. There were wide range of variation in tree volume wherein maximum tree volume was recorded in genotype PSA-65 as 197.01 m³ and minimum tree volume as 20.02 m³ was in genotype PSS-22. The maximum trunk girth (27.27 cm) was recorded in PSA-65, whereas, minimum trunk girth was recorded in genotype PSS-22 as 20.02 cm. Among different genotypes, PSJ-1 and PSJ-18 had recorded maximum leaf length *i.e.* 15.92 cm, whereas, minimum leaf length was recorded in PSS-22 as 10.41 cm. Maximum value for the leaf width (6.48 cm) was recorded in PSJ-17, whereas, minimum value for leaf width (3.41cm) was recorded in genotype PSS-22. Genotype PSJ-19 was having highest leaf area as 102.52 cm², whereas, minimum leaf areas (43.67 cm²) was recorded in genotype PSJ-22. Maximum leaf length-width ratio was recorded in genotype PSS-40 as 3.79, whereas, minimum leaf-width ratio was recorded in PSJ-11 as 2.22.

The maximum fruit weight (177.17 gm) was observed in genotype PSJ-20 and minimum (86.70 gm) was noted in PSS-27. Maximum fruit length (6.98 cm) was observed in genotype PSA-25 and minimum (5.53 cm) in genotype PSJ-19. Maximum fruit diameter (6.70 cm) was observed in PSS-40 whereas, minimum fruit diameter genotype PSJ-9 and PSA-54 as 5.13 cm. Maximum fruit volume was 180.07 cm³ in PSA-65, whereas, minimum fruit diameter (92.48 cm³) was recorded in PSJ-8.

The maximum specific gravity was noticed under genotype PSJ-17 as 1.15 whereas, the minimum specific gravity was observed as 1.00 in genotypes PSS-23, PSS-25, PSS-26, PSS-27, PSS-28, PSS-29 and PSS-52. Maximum pulp percentage was recorded in the genotype PSJ-1 as 99.06 percent, whereas, minimum pulp percentage was recorded in genotype PSA-52 as 96.45 percent. Maximum seed weight per fruit was recorded in PSA-66 as 301.00, whereas, minimum seed weight per fruit was recorded in genotypes PSJ-1 as 135.66. Highest value for the number of seeds per fruit was recorded in genotype PSA-66 as 301.00, whereas, minimum value for the number of seeds per fruit was recorded in genotype PSJ-1 as 135.66. Genotype PSJ-20 had scored the maximum value (1.57 gm) for hundred seed weight, whereas, minimum value for hundred seed weight was recorded in genotype PSJ-1 and PSJ-2 as 1.01 gm.

Total soluble solids in different guava genotypes ranged from 6.34 to 10.75°B. The maximum TSS content (10.75°B) was observed in genotypes PSA-65 and minimum (6.34°B) in PSS-37. The acidity content was noted lowest (0.25%) in genotype PSS-22, whereas, maximum in genotype PSS-40 as 0.64 per cent. T.S.S/acid ratio was found maximum in genotype PSS-36 as 36.08, whereas, minimum in genotype PSS-37 as 26.66.

Total sugars ranged between 6.19 per cent to 10.50 per cent. Genotype PSS-41 recorded maximum total sugar as 10.50 per cent whereas, minimum total sugar per cent was recorded in genotype PSS-21 and PSS-22 as 6.19 percent. Highest value for the reducing sugars was recorded in PSA-65 as 6.51 percent and minimum in genotype PSJ-1 as 3.22 percent. On the other hand, highest non-reducing sugar was recorded in genotype PSS-40 and PSS-41 as 4.45 percent and minimum non reducing percentage was recorded in PSJ-11 as 1.87 per cent. Vitamin C as ascorbic acid content also exhibited wide range of variation among guava genotypes. Maximum value for vitamin C was recorded in genotype PSA-65 as 215 and minimum in genotype PSJ-22 as 128.41 mg/100g . Highest dietary fibre was recorded in genotype PSA-53 as 14.74 percent and minimum in genotype PSS-21 as 9.59 percent. Highest yield was recorded in genotype PSA-65 as 24.80 kg/tree, whereas, minimum was recorded in genotype PSJ-3 as 16 kg/tree. Maximum yield efficiency was recorded in genotype PSS-36 as 0.53 kg/cm² and minimum was recorded in genotype PSA-62 as 0.34 kg/cm². Highest range was recorded as 165.34 for the character number of seeds

per fruit with the mean of 226.33 and minimum range was recorded for the character acidity as 0.07 with mean of 0.30. However, seed weight per fruit was found to have highest phenotypic coefficient of variation *i.e.* >30 per cent whereas, tree height had recorded moderate genotypic variation *i.e.* <10 per cent. Highest heritability of 76.60 per cent was recorded in hundred seed weight, whereas, lowest heritability *i.e.* < 10 was recorded for tree height. On the other hand, highest genetic advance was recorded as 54.40 per cent for the trait ascorbic acid and lowest for the acidity as 0.13 per cent. Similarly, highest genetic gain (40.84%) was recorded for hundred seed weight and lowest genetic gain (11.03%) was recorded for pulp percentage. Different physico-chemical characteristics like tree height, tree spread, tree volume, leaf area and total sugars showed a positive correlation with TCSA, leaf area, leaf length, leaf length-width ratio, fruit volume, fruit diameter, fruit weight and yield. Fruit volume was recorded to have maximum positive direct effect (0.0888) on yield while, specific gravity showed a maximum negative direct effect (-0.076) on yield. Cluster 1 had recorded maximum intra cluster distance (185.20) and maximum inter cluster distance (834.74) was recorded between cluster I and cluster IV. In principal component analysis first five principle components possessed Eigen value greater than 1.0, with per cent contribution toward total variance 51.62 per cent, 18.06 per cent, 6.70 per cent, 4.96 per cent and 4.70 per cent. However, the total contribution by first five principle components toward the variance was 86.07 per cent.

CONCLUSION

The diversity assessment study on seedling guava genotypes has revealed that huge variability exists with regard to different growth characters, yield characters, physical and chemical (quality) characters of fruits. From the investigation, it is concluded that PSA-65, PSA-68 were superior as compared to other genotypes with respect to different characteristics as well as yield parameters. The other genotypes *i.e.*, PSS-21, PSS-41 and PSJ-1 were also found superior with respect to some horticultural traits.

Table: 11 Comparison of superior selection with L-49 for important horticultural traits.

	Fruit length(cm)	Fruit breadth(cm)	Fruit weight(g)	T.S.S(°B)	Yield(kg /ht)
PSJ-19	6.73	6.40	175.72	10.41	20.11
PSJ-20	6.90	6.63	177.17	9.25	20.24
PSJ-37	6.91	6.53	173.38	6.34	18.23
PSJ-38	6.95	6.65	168.84	8.69	18.57
PSJ-65	6.98	6.63	177.17	10.75	24.80
PSJ-69	6.77	6.48	177.88	10.07	22.48
L-49	6.22	6.45	182.3	11.6	25-150



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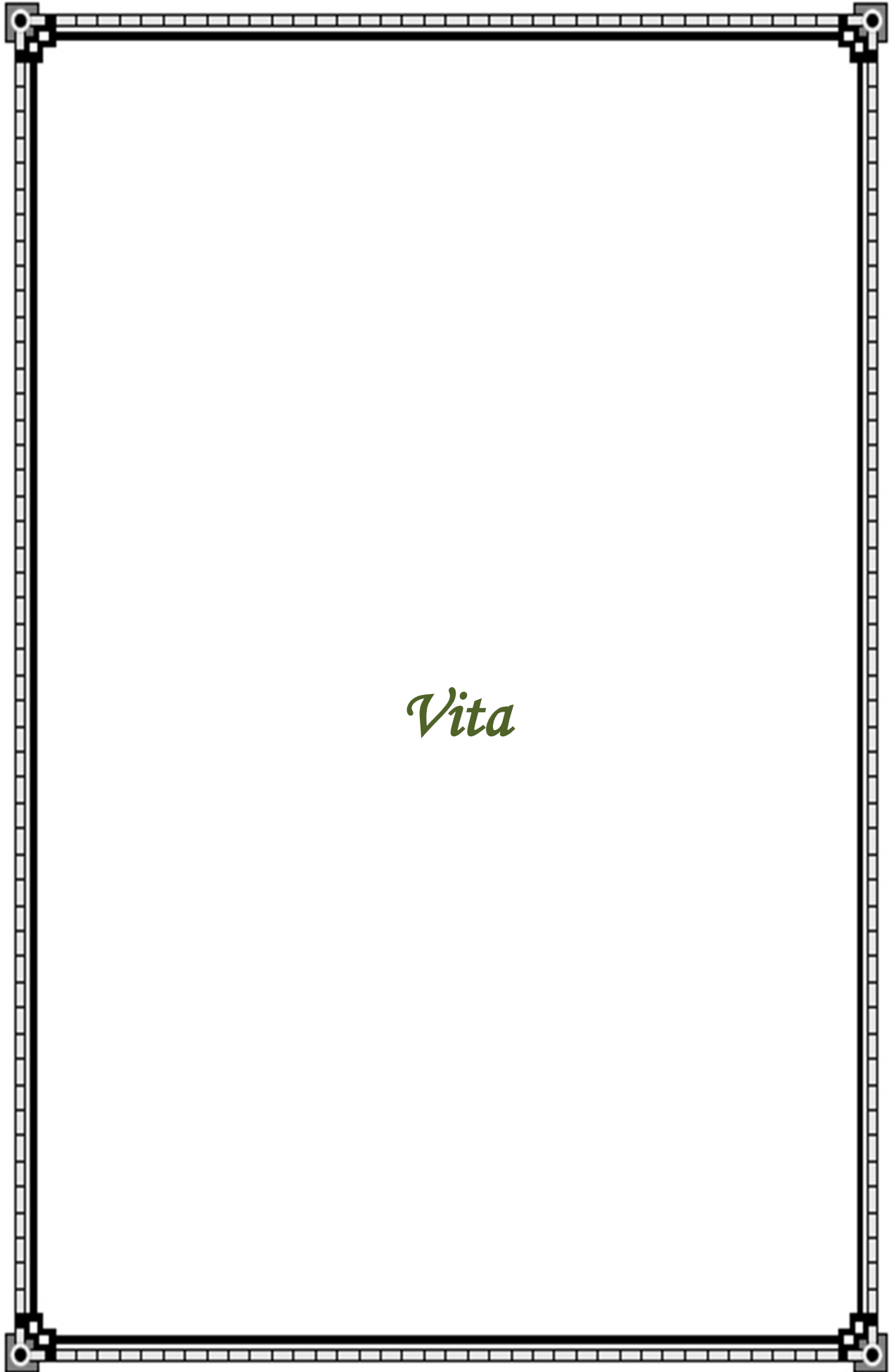
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CERTIFICATE-IV

Certified that all necessary corrections as suggested by external examiner and the advisory committee have been duly incorporated in the thesis entitled “**Diversity Assessment of Seedling Guava (*Psidium guajava* L.) in Jammu Sub-tropics**” submitted by **Miss Isha Sharma**, Registration No. **J-16-M-446**.

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