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EVALUATION OF PAPAYA TYPES

By

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(2013-12-122)



THESIS

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KERALA, INDIA

2015

DECLARATION

I, hereby declare that this thesis entitled “Evaluation of Papaya Types” is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society

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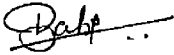
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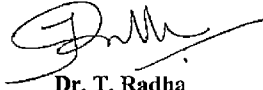
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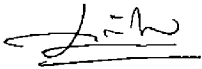
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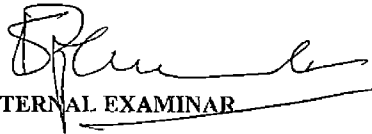
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DEDICATED TO MY

BELOVED FAMILY



INTRODUCTION

1. INTRODUCTION

India is the leading papaya producer in the world with an area of 1.33 lakh ha and production of 56.39 lakh tones (NHB, 2014). It is adaptable to diverse soil and climatic conditions, comes early in bearing than any other fruit crop, produces fruits in less than a year and production of fruits is quite high per unit area which gives quick and high returns.

Papaya (*Carica papaya* L.) is a native crop of Mexico, and was introduced to India in the 16th century. The popularity of this fruit is mainly due to its multifarious uses as fresh fruit, processed products, production of papain, pectin and carpaine alkaloid.

Ripe papaya is one of the best refreshing fruits, rich in vitamin A and a good source of Vitamin B and Vitamin C. It supplies appreciable amounts of minerals, consisting mainly of iron, calcium, phosphorous and also traces of protein. Papaya is rich in the enzyme papain, which helps in digestion of proteins. It is widely used in meat tenderization, clarification of beer, in tanning industry and in manufacture of chewing gum. Now papaya has emerged as a commercial fruit crop due to the recognition of its nutraceutical properties and industrial applications.

Papaya is cultivated on a large scale in different parts of India. Even though papaya is highly nutritious, it has not attained much popularity in our state as compared to other states. In Kerala it is mainly grown as a homestead crop. The area and production in the state are 16,000 ha and 98,600 mt respectively (NHB, 2015). The major limiting factor for commercial cultivation is the unavailability of high yielding varieties/ types adapted to climatic conditions in Kerala.

A wide range of natural variability in plant height, fruiting height, fruit size, and quality of the fruit can be seen in papaya grown in the homesteads of

Kerala. This variability is mainly due to seed propagation and cross pollinated nature of the crop. Some of the plants grown in the homesteads are highly adaptable to adverse soil and climatic conditions and free from pests and diseases.

Hence there is tremendous scope for selection of superior types from the heterogenic population available in Kerala. Practically very little attempt has been made under Kerala conditions to exploit this variability for the improvement of the crop. In this context the present investigation on 'Evaluation of papaya types' was undertaken with an objective of assessment of variability in papaya and to select promising types/ varieties suitable for Kerala.



REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Papaya (*Carica papaya* L.) is one of the major fruit crops commercially grown in tropical and subtropical areas. It is a polygamous species and shows considerable phenotypic variation in morphological and horticultural traits due to cross pollinated nature that can be utilized in genetic improvement. Large number of varieties of papaya has been released throughout the world. But knowledge regarding the performance of these varieties under Kerala condition is meager.

The papaya germplasm ranges from very primitive types to major commercial varieties. There are numerous local mixtures everywhere in all parts of papaya growing areas. Collection, conservation, documentation, evaluation and utilization of papaya germplasm and thereby to develop varieties are pre-requisite for future advancement (Ram, 1992).

2.1 VARIABILITY IN PAPAYA

Varying degrees of genetic diversity was reported in Caricaceae family. The high diversity was caused by the compatibility between several genera and species of the family which leads to the production of natural hybrids (Jimenez and Horovitz, 1957; Mekako and Nakasone, 1975). Such complex hybrid population is the reason for morphological and genetic variability. In addition to that seed propagation in papaya led to occurrence of undesirable genetic variation due to open pollination resulting in a mixture of genotypes.

In a correlation study Singh and Kumar (2010) observed wide range of variation for nodes at first fruiting, plant height, number of fruits/ plant, fruit weight, fruiting length and yield. They also reported that phenotypic coefficient of variation was higher than the genotype coefficient of variation for all the characters and the yield was significantly correlated with number of fruit, fruit weight, fruiting length

and leaf length of papaya plant.

2.1.1 Tree Characters

Papaya is a small normally unbranched quick-growing soft-wooded tree 'almost an herb' with latex vessels in all parts. Morphologically, the stem is hollow between the nodes, except in young plants, consisting mainly of wood parenchyma and bears large triangular scars. Hollow stems were light green to tan brown in colour with diameter of 8 inches (Aravind *et al.*, 2013).

Singh *et al.* (2006) reported variation in plant height (mean 2.09 m), collar girth (0.33 m) and canopy spread (1.81 m EW/ 1.83 m NS). Wide range of variability observed in plant height and plant girth, ranged from 138.4 to 240.6 cm and 28.02 to 36.8 cm respectively (Singh and Kumar, 2010).

2.1.2 Leaf Characters

The leaves are very large (up to 75 cm wide), palmately lobed or deeply incised with entire margins and petioles of 30 to 90 cm in length. The peltate leaves are arranged in a 2/5 spiral, having large long hollow petioles and large, deeply-lobed blades except in some cultivars (Samson, 1986). According to Ram (2005) petiole length was positively correlated with number of fruits.

According to Sompack *et al.* (2014) colours of mature leaf petioles could be divided into three groups, most of them had pale green leaf petioles, only 'Hinan' and 'Si Thong' had reddish-purple and pale yellow leaf petioles, respectively.

Nirujogi and Dinesh (2012) reported variation in number of leaves in papaya varieties. The number of leaves varied from 18 to 31 in Arka Surya and for Arka Prabath, number of leaves varied from 20 to 33. The difference among the progenies for various morphological characters was because of different sex types.

2.1.3 Flower Characters and Sex Expression

Papaya is also known as “trioecious plant” which means that separate plants bear male, female, or bisexual flowers. Female and bisexual flowers are waxy, ivory white and borne on short peduncles in leaf axils along the main stem. Female flowers of papaya were pear shaped when unopened whereas, bisexual flowers are cylindrical (Aravind *et al.*, 2013). Male papaya can be distinguished by the smaller flowers borne on long stalks.

IBPGR (1988) formulated descriptors for inflorescence and fruit characters which included type of tree hermaphroditism, type of flowering, colour of inflorescence stalk, corolla tube colour of male, female and hermaphrodite flowers and flower size.

Sex expression in papaya is greatly influenced by genetic and environmental factors. Female plant is stable and more productive than hermaphrodite and sex reversing male plants. The per cent of carpelloidic flowers was significantly correlated with minimum temperature and growth rate of the plants (Awada, 1958). The genetic make-up of sex reversing male was entirely different from pure male (Ram *et al.*, 1985). According to Ram *et al.* (1994) higher female fertility (8.17%) was observed in March when the maximum temperature was 29.5 °C whereas lowest fertility (0.22%) in December when the minimum temperature was 12.2 °C in sex reversing male. Papaya grew rapidly during the hot summer months but stopped fruit set during the cold winter months, with fruits maturing the following spring and summer. Poor performance of papaya was found with the minimum air temperatures below 11 °C and minimum soil temperatures below 19 °C (Allan, 2002).

2.1.4 Fruit Characters

Papaya fruits are berries since they resemble melon by having a central seed cavity and show high diversity in size, shape and colour. Fruit size can vary

extensively, ranging from less than 100 g in some wild accessions to over 10 kg in certain landraces. Samson (1986) reported that the weight of the fruit varied from 0.5 to 2.0 kg. Singh *et al.* (2006) reported significant variation in fruit length (26.19cm), width (42.28 cm) and fruit cavity (15.34 cm).

Fruits formed from female flowers are oblong to nearly spherical and from hermaphrodite flowers are usually elongated and vary from cylindrical to pear in shape. Papaya fruit shape was a sex-linked trait with the fruit of female trees ranging from spherical to ovoid while fruit from hermaphrodite trees were elongate, cylindrical to pear-shaped (Chan and Paull, 2008; Paull *et al.*, 2008). Plants begin to bearing fruits in 6-12 months. Depending on cultivar and temperature individual fruits mature within 5-9 months (Aravind *et al.*, 2013). The colour of ripe fruits and flesh varied from yellow to salmon red.

2.1.5 Seed Characters

The mature fruits contain numerous grey-black spherical seeds which are commercially used as propagating material. Mature seeds in fruit cavity were black, round and encased in a gelatinous-like substance (Uraiwong *et al.*, 2005).

Due to the presence of gelatinous substance sarco-testa, low germination percentage was reported in freshly extracted seeds of papaya (Ellis *et al.*, 1985). Sarcotesta should be removed from the seed to reduce the time taken for germination. Ellis *et al.* (1985) recommended that freshly extracted papaya seeds were rubbed to remove the sarcotesta then thoroughly washed in running water before being dried for storage. Various genotypes of papaya behave differently with regard to seed germination and seedling vigour.

2.1.6 Biochemical Characters

Papaya is a rich source of several natural compounds like vitamins, minerals

plant pigments, alkaloids, pectins, volatile compounds, proteolytic enzymes and growth inhibitors. The ripe fruits of papaya contains highest amount of bioactive compounds such as phenolic compounds, vitamin C and carotenoids than unripe fruits. Ferulic, p-coumaric, and caffeic acids are the most abundant acids in papaya skin. The major alkaloids are carpaine, choline, piperidine and caricacin. According to USDA (2014) the total dietary fibre content of ripe fruits varied from 11.9 to 21.5 g/ 100 g/ dry matter.

The carotenoids are responsible for the flesh colour of the fruit mesocarp. Carotenoids like β -cryptoxanthin and β -carotene were found in all types of papaya cultivars leading to orange and yellow flesh (Wall, 2006). Carotenoids integrated more quickly into the membranes during ripening mainly due to the increased content of esterified carotenoids in turn increased the colour intensity of the fruit and it accumulated in chromoplasts (Andersson *et al.*, 2008; Yahia and Ornelas-Paz, 2010).

Red-fleshed cultivars generally had excellent flavour but very poor outer shape and appearance, whereas yellow-fleshed cultivars had very good appearance and flavour (Drew, 2005). According to Schweiggert *et al.* (2011) total lycopene content of red fleshed papaya was significantly higher than that of yellow fleshed fruit. Papaya is considered as a good source of lycopene, with average values ranging from 0.36 to 3.4 mg/ 100 g fresh weight and the fruit was ranked number four after red guava, water melon and tomatoes (Schweiggert *et al.*, 2011; 2012; USDA, 2014).

Average vitamin C content for papaya fruit was 51.2 mg/ 100 g. The vitamin E content of papaya was undetectable or in low concentrations 0.3 mg/ 100 g fresh weight (Charoensiri *et al.*, 2009; USDA, 2014).

The total phenolic content in papaya pulp was ranging from 0.02 to 2.08 mg GAE/ 100 g fresh weight, determined by using the standard Folin Ciocalteu method (Faller and Fialho 2010; Isabelle *et al.*, 2010). The major polyphenols found in

papaya pulp of 'Maradol' cultivars were ferulic acid (187 to 277 mg/ 100 g dry weight (DW)), p-coumaric acid (136 to 230 mg/ 100 g DW), and caffeic acid (113 to 176 mg/ 100 g DW (Sancho *et al.*, 2011).

According to Williams *et al.* (2013) papaya plant contained both glucosinolates and cyanogenic glucosides. It was rich in benzyl isothiocyanate (BITC) which provided potential for use in chemoprevention of cancer. Nwofia *et al.* (2012) reported that the papaya seed contained 0.2 to 0.3, 0.05 to 0.07, 0.03 to 0.07 and 0.03 to 0.04 mg/ 100 g fresh weight of niacin, thiamine, riboflavin and β -carotene, respectively.

Nurul and Asmah (2010) compared total phenolic (TPC), total flavonoid (TFC), β -carotene, lycopene, ascorbic acid (AA) contents and antioxidant properties of fresh and pickled papaya. The results indicated that mean TPC (mg gallic acid equivalent/ 100 g dry samples), TFC (mg rutin equivalent/ 100 g dry samples), β -carotene ($\mu\text{g}/ 100$ g edible portions), lycopene ($\mu\text{g}/ 100$ g edible portions) and AA content (mg/ 100 g edible portions) were higher in fresh papaya (141.66 ± 11.71 ; 57.80 ± 2.11 ; 793.83 ± 5.47 ; 779.69 ± 5.55 ; 70.37 ± 0.65) as compared to pickled form.

Chemical composition of papaya fruit was greatly influenced by cultivar variation, growing location, sunlight exposure, agricultural practices, stage of ripeness and postharvest handling (Wall, 2006; Sancho *et al.*, 2011).

Vitamin C content was low (21.2 to 36.9 mg/ 100 ml) during 91 to 133 Days after anthesis, then increased and reached the peak at 161 DAA (77.8 mg/ 100 ml). Sunlight had no effect on Soluble Solids Content (SSC), dry matter and vitamin C contents whereas the lycopene and β -carotene contents of the shady side were higher than those of the light exposed side.

2.2 EVALUATION OF PAPAYA VARIETIES

Gynodioecious papaya lines were evaluated for yield and quality, the result showed that CP 30, CP 48, CP 56 and CP 33 yielded more than 50 kg of fruit/ tree (Auxcilia and Sathiamoorthy, 1996). Morphological and fruit traits of selfed progenies from gynodioecious papaya varieties Arka Surya and Arka Prabath were evaluated under Maharashtra conditions. Some variations for plant and fruit characters were found in the progenies due to different genetic constitution of female and hermaphrodite plants (Nirujogi and Dinesh, 2012). In a varietal evaluation study by Das (2013) with eight varieties and hybrids of papaya and it was found that Coorge Honeydew, Pusa Majesty and local types were performing excellent with respect to yield and quality parameters.

Das *et al.* (2014) compared the performance of papaya varieties Sunrise Solo and Washington. They found that the seed germination (63.33%) and fruit maturity (154 days) were early in the cultivar 'Sunrise Solo' compared to 'Washington'. The percentage of fruit set (76.09%) and germination percentage (63.33%) was more in the case of cultivar 'Sunrise Solo' compared to the cultivar 'Washington'.

Anther-derived papaya plants were evaluated to elucidate their usefulness in breeding and commercial fruit production (Rimberia *et al.*, 2009). They reported that the plants derived from microspore were all female and the majority of them were triploids (87.5 %). Out of the 30 triploid strains evaluated, three were dwarves (less than 100 cm), four were medium height (110 to 150 cm), and the rest were tall (more than 200 cm). The highest fruit yield per tree (27.4 kg) was reported in dwarf triploid while the lowest yield (7.0 kg) in tall triploids.

An experiment was conducted to develop an alternative method of conferring PRSV (Papaya ring spot virus) resistance from *Carica cauliflora* to *Carica Papaya* by asexual propagation using grafting and inarching (Valencia *et al.*, 2001). The

result showed that *C. cauliflora* when used as rootstock or when inarched with *C. papaya*, did not confer PRSV resistance to the scion but delayed expression of the disease symptoms.

An experiment was conducted to screen 16 papaya genotypes against the papaya ring spot and leaf curl virus diseases under field conditions at IARI, New Delhi (Prakash and Singh 2013). They found that the Genotypes P-7-9, Sinta, Pune selection-3, P-7-2 and RCTP-1 were shown tolerance to papaya ringspot and leaf curl virus diseases. According to Reddy *et al.* (2011) variety Red Lady has the minimum disease incidence of 8.33% with maximum (26) days for PRSV symptom expressions.

A study was conducted to determine host range, distribution patterns over time and space and spread of papaya mealy bug, *Paracoccus marginatus* (Gowda *et al.*, 2014). The population of mealy bug was visually estimated and rated and found to occur on 60 plant species belonging to 29 families in five districts of South Karnataka, among which the predominant families being Euphorbiaceae, Malvaceae followed by Solanaceae and Asteraceae. Highest number of host plants of *P. marginatus* was recorded under the family Euphorbiaceae.

An attempt was made to ripen the Papaya in different ripening media and to evaluate them for preparation of jam (Rodge and Yadlod, 2009). They found that fruits ripened in straw contain more sugar, total carotenoid and ascorbic acid. They further reported that jam prepared from Solo papaya had more organoleptic score as compared to the jam prepared from Washington papaya.

Maragatham and Panneerselvam (2011) conducted preliminary screening of seven papaya varieties (CO 1 to CO 7) for wine making. The all varieties of papaya was subjected to alcoholic fermentation using various strains of yeast and they found that wine made from CO 2 had given good yield using *Saccharomyces cerevisiae*

with an alcohol content of 8.00 to 12.00 per cent.

2.3 IMPROVEMENT IN PAPAYA

Breeding is the technique to improve plant type with desirable traits. Inbreeding and selection methods are adopted for varietal improvement in papaya. Since it is a cross pollinated crop, its flowering and fruiting habit varies as a result variation exist in shape, size, quality, taste, flavour, and colour of fruit. The controlled pollination method maintained maximum varietal purity but the quantity of seed produced by this method was limited. Ram and Majumder (1990) observed higher seed yield in dioecious lines than the gynodioecious lines under controlled pollination.

The sibmated progenies of papaya variety Coorg Honey Dew were studied for assessing the uniformity in fruit size and shape (Karunakaran *et al.*, 2010). They observed highest genotypic variation (GV) and phenotypic variation (PV) in S2 generation, while lowest in S4 variation. The PV and GV were observed to decline with the progress of the generation and the genotypic coefficient of variation was lesser than the phenotypic coefficient of variation implying the role of environment influencing the characters.

Papaya fruit shape was a sex-linked trait with the fruit of female trees ranging from spherical to ovoid while fruit from hermaphrodite trees are elongate, cylindrical to pear shaped (Chan and Paull, 2008; Paull *et al.*, 2008).

The hybrid vigour assessment study conducted at TNAU (Kamalkumar *et al.*, 2010) indicated the hybrids CO 2 × Pusa Giant, 9-1(D) × CO 5, Pusa Dwarf × 9-1(D), CO 3 × IIHR 39, CO 7 × IIHR 39, CO 7 × Exotica, IIHR 39 × Coorg Honey dew have high positive significant heterosis for number of fruits. Analysis of various genetic characters in papaya was done at Kerala Agricultural University

(Nair *et al.*, 2010) revealed that the hybrids, Coorg Honey Dew × Pusa Dwarf, Pusa Dwarf × Coorg Honey Dew recorded lower height of plants at different stages of growth and lowest height to first flower. The days taken to first flowering was less in Pusa Nanha × Pusa Dwarf and highest percentage of fruit set was observed in Pusa Nanha × Coorg Honey Dew.

Storey (1953) found that red pulp colour was recessive to yellow pulp in papaya. Among the yellow and red pulp, demand was more for the red pulped varieties for table purpose and for processing (Balamohan *et al.*, 2010). He also observed segregation of F1 progenies in the ratio 4:1 in fifth generation of backcrossing CO 2 and red anthered male (M1R).

Interspecific hybridization in papaya was conducted to study the performance of hybrid progeny against papaya ring spot virus (Iyer *et al.*, 1987). They reported that interspecific hybridization generated a hybrid progeny tolerant to 'PRSV' but on back-crossing tolerance was lost. Intergeneric hybridization was carried out by Dinesh *et al.* (2013) using the 'PRSV' resistant wild species *Vasconcellea cauliflora* as male parent, with the papaya variety 'Arka Surya' as female parent, they observed that F1 generation was segregated in the ratio of 3:1 for papaya to castor type plants but after about 7 generations of sibmating of hermaphrodite plants they were obtained the intergeneric hybrid line resistant to PRSV.

2.4 SEED GERMINATION AND GROWTH

Papaya is commercially propagated by seed. Quality seed is important for successful production and establishing papaya based industry. For getting high quality seeds freshly harvested papaya seeds should be dried under shade at room

temperature for five days (Venkattaraman, 1988). He also suggested that the fruit should be harvested at 126 and 133 days after anthesis in cvs. CO 6 and CO 2.

Germination of papaya seed was greatly influenced by cultivar, stage of harvesting, seed size and environmental factors. The large seeds recorded higher germination than small seeds in papaya cultivars which were graded into small and large size seeds. In fresh seeds, seedling emergence is slow and non-uniform (Chacko and Singh, 1971). The fresh papaya seeds exhibit dormancy up to a period of 35 days. According to Sasikala (2002) CO 4 exhibited 93% dormancy, followed by CO 5 (91 per cent), CO 7 (90 per cent), CO 2 (89 per cent), CO 1 (81 per cent), CO 6 (79 per cent) and CO 3 (72 per cent).

An experiment was conducted to explore the effect of growth media on seed germination and seedling growth in papaya cv. Red Lady (Bhardwaj, 2013). Highest germination rate (92.71), highest seed vigour (89.33), minimum time taken for germination (3.22 days) was observed when vermicompost, sand and pond soil (1:1:1) with 2 cm cocopeat, used as growth media.

Kumar *et al.* (2011) conducted an experiment to identify suitable priming treatments for freshly extracted and aged seeds. Priming treatments consisted of hydration, 500 ppm GA₃, 1000 ppm GA₃, 0.5 M KNO₃, 1 M KNO₃, 0.5 M thiourea, 1 M thiourea and untreated fresh seeds (control). Priming of fresh and aged seeds with GA₃ and KNO₃ significantly improved all the parameters like standard germination, viability percentage, seedling length, dry weight and vigour index. Priming with 1000 ppm GA₃ and 1M KNO₃ in fresh and aged seeds showed significant improvement in seed quality.

Single seedling grown in potting mixture treated with vermicompost shown the higher seedling height (28.50 cm), seedling diameter (0.639 cm), petiole length (6.410 cm), petiole diameter (0.186 cm), number of leaves (11.65), short dry weight (1.254 g), root length (29.715 cm) root dry weight (0.392 g) and root shoot ratio (0.340). In main field condition, three seedlings per polybag grown in potting mixture

and vermicompost was found to have early flowering (86.69 days) and first bearing height (96.695 cm) with minimum plant height of 90.930 cm (Rajamanickam *et al.*, 2010).

Drought and salt tolerance of papaya cultivars namely Ranchi Dwarf, Honey Dew, Farm Selection and Local were evaluated at cell level on different concentrations of NaCl 0.5, 1.0 and 1.5 % (Beniwal *et al.*, 2010). They found that the callus of cultivar 'Local' kept at 0.5 % NaCl concentration, expressed 90 % recovery followed by 64 % in cv. Honey Dew. The recovery percentage decreased with the increase in NaCl concentration.

2.5 SEX DETERMINATION

Plant sex in papaya is controlled by a single gene having at least three alleles; a dominant allele for male plants, a different dominant allele for hermaphrodite plants and a recessive allele for female plants (Hofmeyr, 1938; Storey, 1938; 1953; 1976; Sondur *et al.*, 1996).

Papaya is a polygamous species having 3 basic sex types such as staminate (male), hermaphrodite (bisexual) and pistillate (female), out of these only female is stable while the flowers of male and hermaphrodite vary in sex expression under different climatic conditions. Ram *et al.* (1994) observed that there are 32 heritable sex forms in papaya out of which 31 sex forms except female changing its sex were observed.

Since papaya is a polygamous species, sex identification at juvenile stage is of considerable importance to cultivation practices. But in papaya it is very difficult to identify male and female plant by morphological characters. Other methods like morphological tags, cytological evidences and isozyme markers are used to determine the hermaphrodite type of papaya at the seedling stage.

Several DNA based markers have been developed that detect the sex of papaya plants without having to wait until they flower (Deputy *et al.*, 2002; Hsu *et al.*, 2012). All individuals carrying the PSDM marker turned out to be hermaphrodites, and those without PSDM were shown to be females (Urasaki *et al.*, 2002). They also reported that the primer IBRC-RP07 (5'-TTGGCACGGG-3') that discriminates the sex of papaya.

About 18 RAPD primers were studied for the identification of molecular markers at seedling stage to determine the sex types especially for identification of hermaphrodite at seedling stage (Dwivedi *et al.*, 2014). Primer OPB16 amplified the female specific bands of 300 bp and 950 bp respectively and RAPD marker OPB 08 amplified specific bands of 300 bp only in female papaya. Thus the primer OPA16 and OPB 08 could be used for the development of SCAR markers for the detection of female and hermaphrodite sex in papaya at seedling stage.

Sondur *et al.* (1996) proposed a model of sex type, designated SEX1-M, encodes a trans-acting factor that induces male floral parts while inhibiting carpel development Hermaphrodite allele, SEX1-H, is intermediate having the ability to induce male structures but only reducing carpel size and female allele, sex1-f, is incapable of inducing male structures.



MATERIALS AND
METHODS

3. MATERIALS AND METHODS

The present investigation on 'Evaluation of papaya types' was carried out in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, Kerala, during 2013 to 2015

The study was conducted in two different experiments

- 1 Assessment of variability
- 2 Evaluation of selected types/ varieties

3.1 EXPERIMENT I - ASSESSMENT OF VARIABILITY

The selection of promising types/ varieties was done based on the survey, collection and analysis. The details of the methodology and the analytical technique adopted are presented in this chapter.

Survey was conducted during the period of January to April 2014, in the homesteads of Thrissur, Palakkad and Ernakulam districts of Kerala to assess the variability in papaya (Plate 1). Seventy five plants were tagged in different locations consisting of twenty five plants in each district. The plants were located from Kodakara, Viyyur, Alathur, Mannarkad, Chittur, Muvattupuzha and Aluva. Forty plants were selected from the initial tagged ones based on the different biometric, fruiting and flowering characters such as plant height, collar girth, number of fully developed leaves, leaf area, length of petiole, time of flowering, sex expression of plant and fruit size. Tolerance to important pest and diseases was also considered for the selection. Descriptors (IBPGR) for papaya were adopted for collecting the data. Initial selection was done based on the following vegetative characters of the plant.

3.1.1 Morphological Characters

Observations on biometric characters were recorded during the survey.

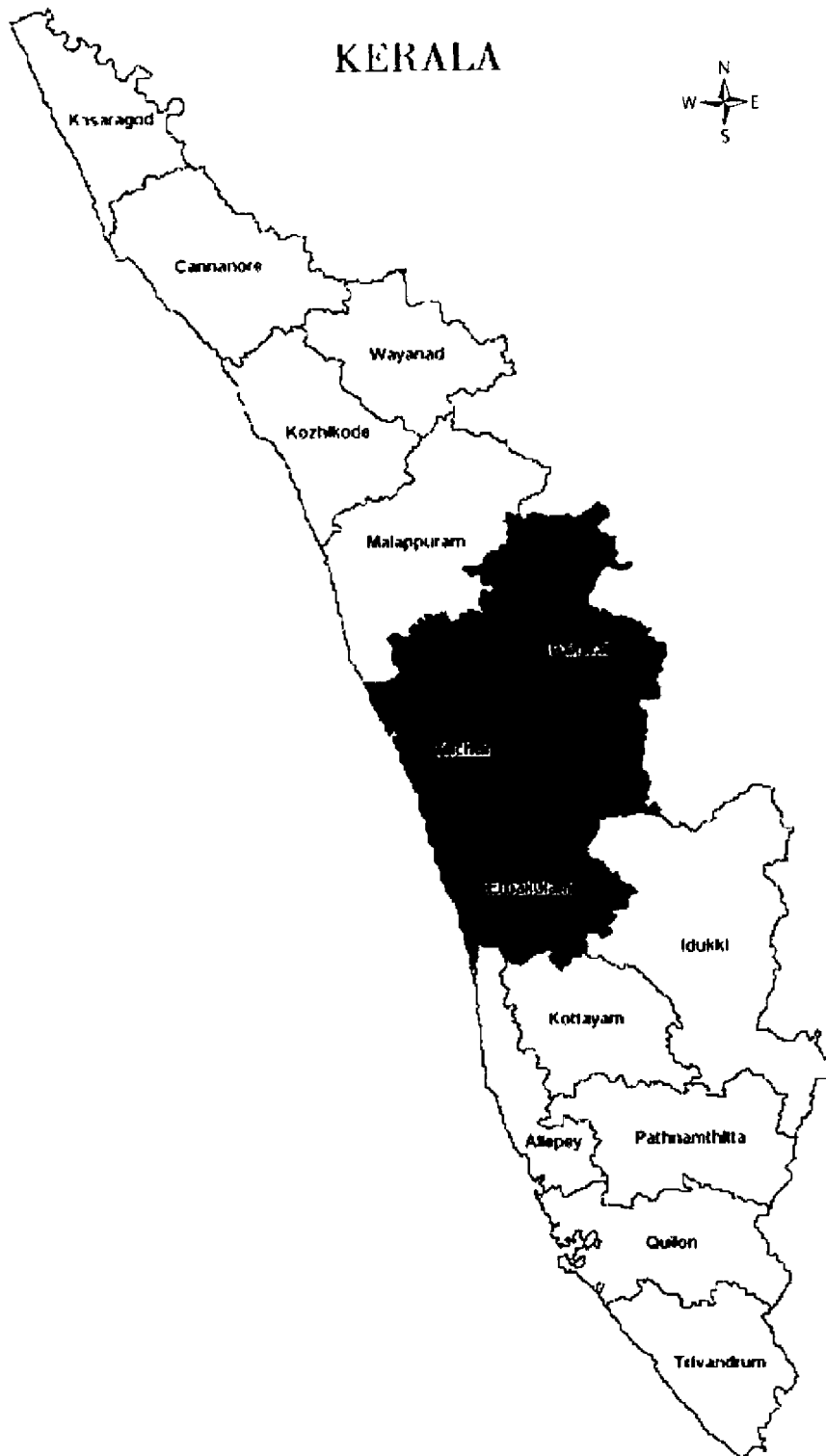


Plate 1 Survey locations in Kerala

3.1.1.1 Plant Height

Plant height was measured from the ground level up to the growing point using a graduated pole and expressed in m

3.1.1.2 Collar Girth

Collar girth was taken using a measuring tape at 10 cm above the ground level and expressed in cm

3.1.1.3 Number of Fully Developed Leaves

The total number of fully developed leaves was taken

3.1.1.4 Leaf Area

Leaf area was calculated using the equation described by Karıkarı (1973)

$$Y = 106 X - 2028$$

Where X represents the length of the median midrib of fifth leaf from the top and expressed in cm Y represents the leaf area of the plant and expressed in cm².

3.1.1.5 Length of Petiole

Petiole length of the fifth leaf from the top was measured and expressed in cm

3.1.1.6 Colour of Petiole

Colour of petiole was recorded

3.1 2 Flowering and Fruiting Characters

From the forty plants selected initially based on plant and fruit characters, physiologically matured fruits were harvested Further selection was based on the

flowering and fruiting characters, sensory evaluation and biochemical analysis of fruit. The following observations were recorded.

3.1.2.1 Time of Flowering

Time of flowering was noted.

3.1.2.2 Sex Expression of Plant

Sex expression of the individual plant (male, female and hermaphrodite) was noticed.

3.1.2.3 Weight of Fruit

Weight of individual fruit was recorded and expressed in g.

3.1.2.4 Length of Fruit

Length of fruit was taken by measuring the distance between the pedicel and apex and expressed in cm.

3.1.2.5 Volume of Fruit

The volume of fruit was estimated by water displacement method and expressed in ml.

3.1.2.6 Shape of Fruit

Shape of fruit was recorded.

3.1.2.7 Circumference of the Fruit

Circumference of the fruit was measured by running a twine around the midpoint of the fruit, recorded its length and expressed in cm.

3.1.2.8 Flesh Thickness

It was measured at central point of the fruit using a twine and expressed in cm.

3.1.2.9 *Flesh Colour*

Flesh colour was recorded

3.1.2.10 *Number of Seeds per Fruit*

Number of matured seeds per fruit was counted

3.1.2.11 *Weight of 100 seeds*

Weight of 100 matured seeds was taken and expressed in g

3.1.3 Sensory Evaluation

A score chart was prepared based on a nine point hedonic scale ranging from one to nine, one denotes poor and nine excellent quality. The organoleptic evaluation was done by a panel of 10 semi-trained persons. The parameters considered were appearance, taste and aroma. The details about the score chart used in sensory evaluation is given in the Appendix I.

3.1.4 Biochemical Analysis of Fruit

3.1.4.1 *Acidity*

Titration acidity was estimated as per A O A C method using 0.1 N NaOH. The solution (10 ml of fruit solution + 10 ml of distilled water) was titrated against 0.1 N NaOH using phenolphthalein as indicator.

3.1.4.2 *Total Soluble Solids (TSS)*

Total Soluble Solids was estimated directly by using an Erma hand refractometer (range 0 - 32 ° brix) and expressed in degree brix.

3.1.4.3 *Reducing, non-reducing and total sugars*

Sugars were determined as per the procedure described by Ranganna (1986). To 10 grams of papaya fruit pulp 100 ml of distilled water was added and clarified.

with neutral lead acetate, excess lead was removed by adding potassium oxalate solution. The volume was then made up to 250 ml. Filtered the solution by using Wattman no. 1 filter paper. Aliquot of this solution was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage on fresh weight basis.

The non-reducing sugars were estimated by subtracting the per cent of reducing sugars from the total sugars. To 50 ml of filtrate, 10 ml HCl was added and kept it for overnight, then neutralized with NaOH pellet solution and made up to 250 ml. An aliquot of this solution was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator. The total sugar was expressed as percentage of fresh weight basis.

3.2 EXPERIMENT II - EVALUATION OF SELECTED TYPES/ VARIETIES

Based on the survey and evaluation 25 desirable accessions were identified. Seeds were collected from the selected types and seedlings were raised as per the Package of Practices Recommendations of KAU. Simultaneously seeds of five varieties were collected from different research institutes in India.

The different types/ varieties were screened in the field for dwarf stature, high yield, quality and tolerance to pest and diseases. Thus 30 accessions of papaya including 25 accessions and 5 released varieties were used for the detailed study in the field. The details of accessions/ varieties are given in Table 1.

3.2.1 Experimental Site

The experiment was conducted in the college orchard of the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara.

Table 1 Accessions/ varieties used in the field experiment

Sl No	Code for accessions	Name of variety	Source of seed
1	Acc 1	Local type	Thrissur
2	Acc 2	Local type	Thrissur
3	Acc 3	Local type	Thrissur
4	Acc 4	Local type	Thrissur
5	Acc 5	Local type	Thrissur
6	Acc 6	Local type	Palakkad
7	Acc 7	Local type	Palakkad
8	Acc 8	Local type	Palakkad
9	Acc 9	Local type	Thrissur
10	Acc 10	Local type	Thrissur
11	Acc 11	Local type	Thrissur
12	Acc 12	Local type	Palakkad
13	Acc 13	Local type	Palakkad
14	Acc 14	Local type	Ernakulam
15	Acc 15	Local type	Thrissur
16	Acc 16	Local type	Palakkad
17	Acc 17	Local type	Ernakulam
18	Acc 18	Local type	Palakkad
19	Acc 19	Local type	Palakkad
20	Acc 20	Local type	Thrissur
21	Acc 21	Local type	Palakkad
22	Acc 22	Local type	Ernakulam
23	Acc 23	Local type	Ernakulam
24	Acc 24	Local type	Ernakulam
25	Acc 25	Local type	Ernakulam
26	Arka Prabath	Arka Prabath	IIHR, Bangalore
27	CO 8	CO 8	TNAU, Coimbatore
28	CO 7	CO 7	TNAU, Coimbatore
29	CO 2	CO 2	TNAU, Coimbatore
30	Pusa Nanha	Pusa Nanha	IARI, New Delhi

3.2.2 Soil and Climate

The area is located at an elevation of 22.5 m above mean sea level and between $10^{\circ} 32'$ N latitude and $76^{\circ} 16'$ E longitude and it enjoys a warm humid tropical climate

Soil sample was collected from the experimental plot to assess the nutrient status of the field before and after experiment. Then the soil sample was chemically analyzed to estimate the status of organic matter, major and minor nutrients. The soil of the experimental site is sandy loam in texture and acidic in reaction. Physico-chemical properties of the soil were given in the Appendix II. The area lies in a tropical climate receiving more than 80 per cent of rainfall distributed through South - West and North - East monsoon. Mean weather data during the cropping period were given in the Appendix III.

3.2.3 Cropping Period

The experiment was conducted during the period of May 2014 to July 2015.

3.2.4 Experimental Materials

- | | | |
|----|-----------------------------------|---|
| 1. | Types/ varieties | Papaya types from Thrissur, Palakkad and Ernakulam districts, released varieties namely Arka Prabath, CO 8, CO 7, CO 2 and Pusa Nanha |
| 2 | Manures and fertilizers | Farm yard manure 10 – 25 kg/ plant/ year
N P K – 40 40 80 g/ plant in bimonthly interval |
| 3 | Plant protection chemicals | Score, bavistin and bordeaux mixture |
| 4 | Biocontrol agent | Pseudomonas - 10 g formulation |

3.2.5 Seeds and Sowing

Polythene bags of 20 cm x 15 cm size and 150 gauge thickness were used for raising papaya seedlings. They were filled with a mixture of FYM, soil and sand in equal proportions. Two seeds were sown in each polythene bag during May 2014. Seeds were germinated within 2 weeks after sowing.

3.2.6 Layout

The experiment was laid out in RBD with 30 treatments and 3 replications.

Design	RBD
No. of Treatments (types / varieties)	30
No. of Replications	3
No. of plants/ plot	4
Spacing	2m x 2m

3.2.7 Planting and Aftercare

Two month old seedlings were transplanted to the main field during July 2014 at a spacing of 2 x 2m. Pits of size 50 cm x 50 cm x 50 cm are taken and filled with topsoil. Seedlings are shaded to protect them from excessive sunlight until they establish. FYM was applied at 10 to 25 kg / plant / year as basal dose in basins around the plant. Urea, Factomphos, Murate of Potash were used as inorganic source of manures according to Package of Practices recommendations of KAU (2011). The plants were irrigated during summer months and the field was kept free of weeds.

Male plants were removed as soon as they flower and the female and

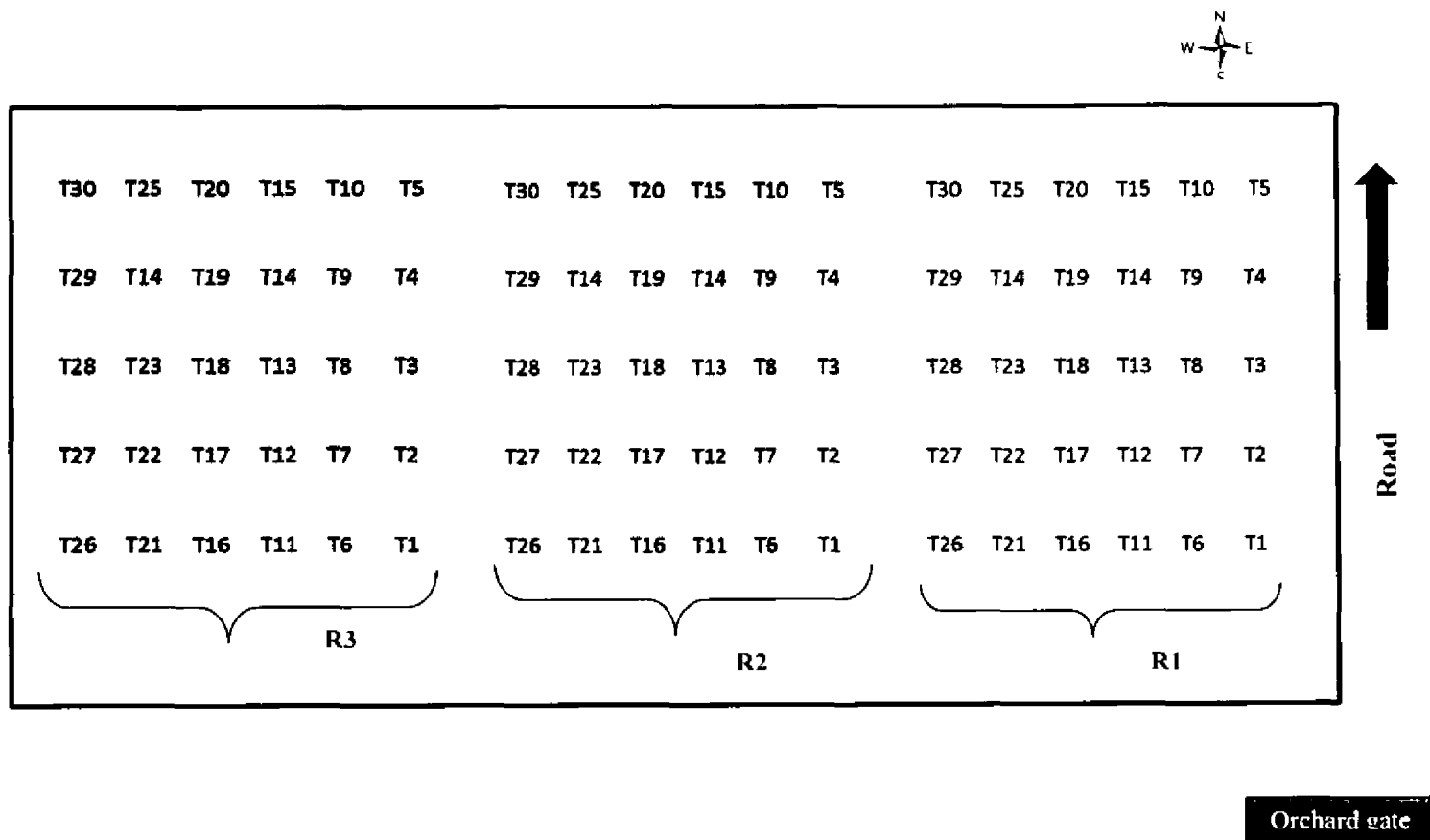


Plate 2 Lay out of the field

hermaphrodite plants are retained Fungicides like Score (systemic), Bavistin (0.1%) and Bordeaux mixture were used in the field to control the Cercospora leaf spot and damping off diseases Biocontrol agent Pseudomonas was applied in the basin at 10 g formulation (10^{10} cells per gram) mixed with 2 kg of well decomposed farmyard manure in the experimental plot at the time of transplanting to control collar rot

3.2.8 Observations

Observations were recorded up to one year after planting

3.2.8.1 Morphological Characters

Observations on biometric characters were recorded

3.2.8.1.1 Plant Height

Plant height was measured as in 3.1.1.1 and expressed in m

3.2.8.1.2 Collar Girth

Collar girth was taken as in 3.1.1.2 and expressed in cm

3.2.8.1.3 Number of Fully Developed Leaves

The numbers of fully opened functional leaves were taken at bimonthly interval

3.2.8.1.4 Leaf Area

Leaf area was measured as in 3.1.1.4 and expressed in cm^2

3.2.8.1.5 Length of Petiole

Petiole length was measured as in 3.1.1.5 and expressed in cm

3.2.8.1.6 Colour of Petiole

Colour of petiole was recorded

3.2.8.2 Flowering and Fruiting Characters

3.2.8.2.1 Days for First Flowering

Number of days from transplanting to opening of first flower was counted

3.2.8.2.2 Height at First Flowering

Height at first flowering was measured and expressed in cm

3.2.8.2.3 Sex Expression of Plant

Sex expression of the individual plant (male, female and hermaphrodite) was taken

3.2.8.2.4 Weight of Fruit

Weight of individual fruit was recorded and expressed in gram

3.2.8.2.5 Length of Fruit

Length of fruit was taken as in 3 1 2 4 and expressed in cm

3.2.8.2.6 Volume of Fruit

The volume of fruit was estimated as in 3 1 2 5 and expressed in ml

3.2.8.2.7 Shape of Fruit

Shape of fruit was recorded

3.2.8.2.8 Circumference of the Fruit

Circumference of the fruit was measured as in 3 1 2 7 and expressed in cm

3.2.8.2.9 Flesh Thickness

Flesh thickness was measured as in 3 1 2 8 and expressed in cm

3.2.8.2.10 Flesh Colour

Flesh colour of the fruit was recorded

3.2.8.2.11 Peel Pulp Ratio

Peel pulp ratio was calculated by dividing the weight of the peel by the weight of the pulp for each fruit.

3.2.8.2.12 Cavity Volume

Cavity volume was measured by estimating the volume of water that the fruit cavity can hold and expressed in ml

3.2.8.2.13 Cavity Index

Cavity index was calculated using the formula

$$\text{Cavity index} = \frac{\text{Cavity volume}}{\text{Fruit volume}} \times 100$$

3.2.8.2.14 Number of Seeds per Fruit

Number of matured seeds per fruit was counted

3.2.8.2.15 Weight of 100 Seeds

Weight of 100 matured seeds was taken and expressed in grams

3.2.8.2.16 Days to First Harvest

Number of days from transplanting to first harvest was noted

3.2.8.2.17 Days to Ripening

The days taken from fruit set to reach fruit ripening stage were counted

3.2.8.2.18 Fruit Yield

Average weight of fruit was calculated and multiplied with total number of fruits to get the fruit yield per plant and expressed in Kg/ plant

3.2.8.3. Sensory Evaluation

A score chart was prepared based on a nine point scale ranging from one to nine, one denotes poor and nine excellent quality The organoleptic evaluation was done by a panel of 10 semi trained persons The parameters considered were appearance, taste and aroma

3.2.8.4. Biochemical Analysis of Fruit

3.2.8.4.1 Acidity

Acidity was estimated as in 3 1 4 1

3.2.8.4.2 Total Soluble Solids (TSS)

TSS was estimated as in 3 1 4 2 and expressed in degree brix

3.2.8.4.3 Reducing, non - reducing and total sugars

Sugars were determined as in 3 1 4 3 and expressed as percentage on fresh weight basis

3.2.8.4.4 Beta Carotene

Beta carotene content of the fruit was estimated by using A O A C method (1995). Ten gram fruit was taken in 150 ml glass stoppered Erlenmeyer flask and 40 ml water saturated butanol (WSB) was added For complete extraction of beta carotene the contents of the flasks were mixed vigorously for one minute and kept for overnight (16-18 h) at room temperature under dark condition Next day, the contents were shaken again and filtered through Wattman no 1 filter paper Optical density of

clean filtrate was measured at 440 nm. Pure water saturated butanol (WSB) was used as blank.

Calibration curve was made from known amounts of pure beta carotene from 0.25 µg/ml to 1.5 µg/ml which are prepared after suitable dilutions of original stock with WSB in calibrated 10 ml volumetric flasks. Then the beta carotene content was calculated from calibration curve.

3.2.8.4.5 Vitamin C

Vitamin C content of the fruit was estimated as per the procedure described by Ranganna (1986). The procedure includes two different steps.

Standardization of dye

10 ml of 4 per cent oxalic acid was added into 5 ml of working standard solution and titrated against the dye (2,6-Dichloro phenol indophenol dye).

Sample preparation

Sample extraction was done by (0.5 to 5g) using 4 per cent oxalic acid and made up to known volume. Ten ml of 4 per cent oxalic acid then added into 5 ml of sample solution and titrated against the dye (2,6-Dichloro phenol indophenol dye).

3.3 STATISTICAL ANALYSIS

Hierarchical cluster analysis was done to study the extent of divergence. For that the selected 40 collections of papaya were scored as per the score given in the IBPGR descriptor and grouped into nine clusters based on the qualitative characters such as fruit shape, flesh colour, colour of petiole, time of flowering and sex expression of plant (Table 2). Organoleptic evaluation of fruit was done by applying the Kendall's coefficient of concordance.

The data recorded for the morphology, flowering, fruiting and quality attributes of papaya were subjected to statistical analysis by applying the techniques of ANOVA for Randomized Block Design (Pans and Sukhatms, 1976)

Table 2 Score as per IBPGR descriptor

Sl No	Character	Descriptor state	Description	
1	Colour of petiole	1	Pale green	
		2	Normal Green	
		3	Dark green	
		4	Green and Shades of red purple	
		5	Red Purple	
2	Time of flowering	1	Sep – Oct	
		2	Oct	
		3	Oct – Nov	
		4	Dec	
3	Sex expression of plant	1	Female	
		2	Hermaphrodite	
		3	Male	
4	Flesh colour	1	light yellow	
		2	Bright yellow	
		3	Deep yellow to orange	
		4	Reddish orange	
		5	Scarlet	
		6	Others	
5	Fruit shape		Fruits shape from hermaphrodite flowers	Fruits shape from female flowers
		1	Globular	Globular
		2	Round	Round
		3	High round	High round
		4	Elliptic	Elliptic
		5	Oval	Oval
		6	Oblong	Oblong
		7	Oblong ellipsoid	Oblong ellipsoid
		8	Oblong blocky	Oblong blocky
		9	Elongate	Elongate
		10	Lengthened cylindrical	Lengthened cylindrical
		11	Pear shaped (pyriform)	Pear shaped (pyriform)
		12	Club	Club
		13	Blossom end tapered	Blossom end tapered
		14	Acron (heart shaped)	Acron (heart shaped)
		15	Reniform	Reniform
		16	Turbinate inferior	Turbinate inferior
		17	Plum shaped	
18	Other			



RESULTS

4. RESULTS

The experiment on 'Evaluation of papaya types' was conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara, Thrissur, Kerala, during 2013 to 2015 with the objective of assessment of variability in papaya and to select promising types/ varieties suitable for Kerala. Results of the studies are presented in this chapter.

4.1 EXPERIMENT I - ASSESSMENT OF VARIABILITY

A detailed survey was conducted in the homesteads of Thrissur, Palakkad and Ernakulam districts of Kerala to assess the variability in papaya. Based on the general vigour of the plants, 75 plants were tagged in different locations namely Kodakara, Viyyur, Alathur, Mannarkad, Chittur, Muvattupuzha and Aluva.

Forty plants were selected from the initially tagged ones based on the different biometric, flowering and fruiting characters such as plant height, collar girth, number of fully developed leaves, leaf area, length and colour of petiole, time of flowering, sex expression and fruit size of plants. Fruits from these 40 plants were collected and subjected to quantitative and qualitative analysis and were designated as collections for further evaluation.

4.1.1 Clustering Based on Qualitative Characters

Based on the qualitative characters viz., fruit shape, flesh colour, sex expression of plant, petiole colour and time of flowering 40 collections were grouped into nine clusters by utilizing the scoring technique described in materials and methods. Agglomerative hierarchical clustering was performed with 5 characters. The dendrogram obtained was then constructed for 40 collections (Fig. 1). The nine clusters obtained along with the accessions included in each cluster are presented in Table 3.

Dendrogram using Average Linkage (Between Groups)

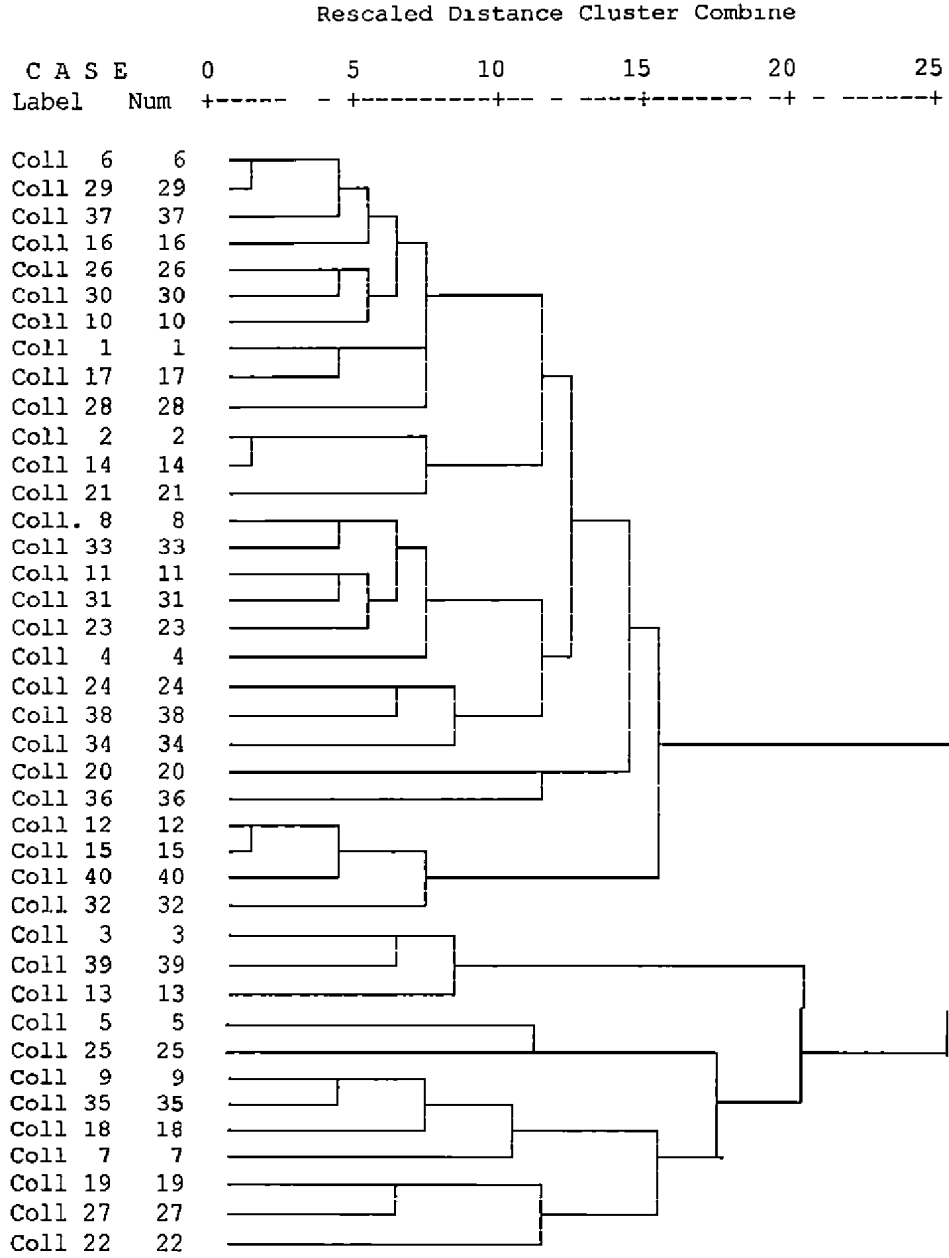


Fig 1 Heirarchialdendrogram showing relationship among forty collections of papaya

Table 3 Collections included in the clusters

Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX
Coll 1	Coll 24	Coll 20	Coll 12	Coll 3	Coll 5	Coll 25	Coll 7	Coll 19
Coll 2	Coll 38	Coll 26	Coll 15	Coll 39			Coll 9	Coll 22
Coll 4	Coll 34		Coll 40	Coll 13			Coll 18	Coll 27
Coll 6			Coll 32				Coll 35	
Coll 8								
Coll 10								
Coll 11								
Coll 14								
Coll 16								
Coll 17								
Coll 21								
Coll 23								
Coll 26								
Coll 28								
Coll 29								
Coll 30								
Coll 31								
Coll 33								
Coll 37								
19	3	2	4	3	1	1	4	3

Among the IX clusters, cluster I had maximum number of collections (19), cluster IV and VIII had 4 collections each Cluster II, V and IX had 3 collections each Cluster III had 2 collections, whereas the rest of the clusters consisted of 1 collection each Collection 5 and Coll 25 fell in a separate cluster viz , cluster VI and VII respectively were morphologically distinct from all other collections

4.1.2 Morphological Characters

The data on the morphological characters of 40 collections are presented in Table 4 The cluster wise data on the morphological characters of 40 collections are presented in Table 5

4.1.2.1 Plant Height

Wide variation was observed in plant height The plant height of the collections varied from 2.1 to 6.6 m Collection 17, Coll 19 and Coll 20 recorded the lowest plant height of 2.1 m each and the highest plant height was recorded by Coll 11

The cluster mean for plant height ranged from 3.00 to 5.50 m Cluster III recorded the lowest cluster mean value of 3.00 ± 1.27 m for plant height and cluster VI recorded the highest value of 5.50 m

4.1.2.2 Collar Girth

Collar girth of the plant ranged from 30.00 to 88.16 cm Collection 4 recorded the highest collar girth of 88.16 cm Lowest collar girth recorded in Coll 13, Coll 20 and Coll 38 (30.00 cm each)

The cluster mean for collar girth varied from 36.50 to 60.50 cm Cluster II recorded the lowest cluster mean value of 36.50 ± 6.26 cm for collar girth and cluster VI recorded the highest value of 60.50 cm

4.1.2.3 Number of Fully Developed Leaves

Number of fully developed leaves varied among the collections. Highest leaf number of 56 was recorded in Coll 3 and lowest leaf number of 12 recorded in Coll 30.

The cluster mean value ranged from 20.00 to 36.66. Cluster VII recorded the lowest cluster mean value of 20 and cluster IX recorded the highest value of 36.66 ± 4.16 .

4.1.2.4 Leaf Area

The highest leaf area was recorded in Coll 5 (6770.00 cm^2) and the lowest was recorded in Coll 31 (940.00 cm^2).

The cluster mean for leaf area varied from 2446.63 to 6770.00 cm^2 . Cluster I recorded the lowest cluster mean value of $2446.63 \pm 1143.78 \text{ cm}^2$ for leaf area and cluster VI recorded the highest value of 6770.00 cm^2 .

4.1.2.5 Petiole Length

Petiole length of the collections ranged from 42.00 to 120.00 cm. Collection 32 and Coll 34 recorded the highest petiole length of 120.00 cm each. The lowest petiole length was recorded by Coll 19 (42 cm).

The cluster mean value for petiole length ranged from 59.00 to 110.00 cm. Cluster VI recorded the highest cluster mean value of 110.00 cm for petiole length and cluster IX recorded the lowest value of 59 ± 15.71 cm.

4.1.2.6 Colour of Petiole

Five types of petiole colour (pale green, normal green, dark green, green and shades of red purple and red purple) were observed in the collections.

Table 4 Morphological characters of 40 collections

Collection No	Plant height (m)	Collar girth (cm)	No of fully developed leaves	Leaf area (cm ²)	Petiole length (cm)	Colour of petiole
Coll 1	3.5	40.00	25.00	2106.0	57.00	Normal Green
Coll 2	5.4	47.00	28.00	1158.0	70.00	Pale green
Coll 3	6.2	72.50	56.00	5604.0	99.00	Normal Green
Coll 4	5.3	88.16	53.00	5816.0	91.00	Green
Coll 5	5.5	60.50	24.00	6770.0	110.00	Purple
Coll 6	4.8	58.00	44.00	3272.0	64.00	Normal Green
Coll 7	4.6	57.00	42.00	5180.0	78.00	Pale green
Coll 8	3.9	43.00	23.00	3060.0	80.00	Normal Green
Coll 9	5.5	50.00	22.00	3272.0	92.00	Pale green
Coll 10	3.6	64.00	40.00	3060.0	62.00	Normal Green
Coll 11	6.6	61.00	22.00	2424.0	93.00	Normal Green
Coll 12	4.2	49.00	30.00	3484.0	70.00	Green and Shades of red purple
Coll 13	3.6	30.00	15.00	1576.0	65.00	Normal Green
Coll 14	5.1	52.00	29.00	2954.0	68.00	Pale green
Coll 15	3.8	67.00	43.00	3166.0	60.00	Green and Shades of red purple
Coll 16	4.5	73.00	39.00	4014.0	90.00	Normal Green
Coll 17	2.1	35.00	16.00	2212.0	60.00	Normal Green
Coll 18	4.5	68.50	38.00	4332.0	110.00	Pale green
Coll 19	2.1	44.00	38.00	6452.0	42.00	Normal Green
Coll 20	2.1	30.00	15.00	1682.0	60.00	Normal Green
Coll 21	4.3	31.00	26.00	2212.0	60.00	Normal Green
Coll 22	4.3	50.00	32.00	3802.0	73.00	Normal Green
Coll 23	4.5	35.00	16.00	1894.0	60.00	Normal Green
Coll 24	4.0	42.50	26.00	2530.0	75.00	Normal Green
Coll 25	3.7	40.00	20.00	2742.0	78.00	Purple
Coll 26	4.2	53.70	20.00	2530.0	75.00	Normal Green
Coll 27	4.4	54.00	40.00	3484.0	62.00	Normal Green
Coll 28	3.6	74.00	38.00	2212.0	70.00	Pale green
Coll 29	5.1	67.00	40.00	1152.0	63.00	Normal Green
Coll 30	3.0	48.00	12.00	2212.0	75.00	Normal Green
Coll 31	6.0	69.00	32.00	940.0	60.00	Normal Green
Coll 32	3.6	59.00	48.00	3590.0	120.00	Purple
Coll 33	2.7	40.00	18.00	2106.0	67.00	Normal Green
Coll 34	3.0	37.00	36.00	3802.0	120.00	Normal Green
Coll 35	4.1	44.00	29.00	3166.0	70.00	Pale green
Coll 36	3.9	45.50	28.00	3908.0	65.00	Normal Green
Coll 37	4.5	51.00	34.00	1152.0	85.00	Normal Green
Coll 38	3.6	30.00	16.00	3272.0	90.00	Pale green
Coll 39	4.5	52.00	32.00	3802.0	80.00	Normal Green
Coll 40	5.6	62.00	24.00	2636.0	85.00	Red Purple

Table 5 Cluster wise data for vegetative characters of 40 collections

Cluster No	Plant height (m)		Collar girth (cm)		No of fully developed leaves		Leaf area (cm ²)		Petiole length (cm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cluster I	4.35	1.13	54.20	15.54	29.21	11.05	2446.63	1143.78	71.05	11.68
Cluster II	3.53	0.50	36.50	6.26	26.00	10.00	3201.33	638.94	95.00	22.91
Cluster III	3.00	1.27	37.75	10.96	21.50	9.19	2795.00	1574.02	62.50	3.54
Cluster IV	4.30	0.90	59.25	7.58	36.25	11.14	3219.00	428.39	83.75	26.25
Cluster V	4.76	1.32	51.50	21.25	34.33	20.59	3660.66	2017.71	81.33	17.03
Cluster VI	5.50	-	60.50	-	24.00	-	6770.00		110.00	
Cluster VII	3.70	-	40.00	-	20.00	-	2742.00	-	78.00	
Cluster VIII	4.68	0.59	54.88	10.52	32.75	8.99	3987.50	953.50	87.50	17.54
Cluster IX	3.60	1.30	49.33	5.03	36.66	4.16	4579.33	1629.55	59.00	15.71

4.1.2.7 Pest and Diseases

Serious pests and diseases problem were not observed during the survey, except slight incidence of mealy bug. Only healthy plants were selected for the study.

4.1.3 Flowering and Fruiting Characters

Observations on flowering and fruiting characters of the collections are presented in Table 6 and cluster wise data for fruit characters are presented in Table 7.

4.1.3.1 Time of Flowering

The peak flowering season was from September to December.

4.1.3.2 Sex Expression of Plant

Either female or hermaphrodite plants were selected for the study.

4.1.3.3 Fruit Weight

Fruit weight of the collections varied from 380.00 to 3130.00 g. Highest fruit weight of 3130.00 g was recorded in Coll. 19 and the lowest was in Coll. 38 (380.00 g).

Mean fruit weight varied among different clusters. The highest cluster mean value recorded in cluster IX (1586.66 ± 1343.36 g) and lowest cluster mean value of 600 ± 242.49 g was recorded in cluster II.

4.1.3.4 Fruit Length

Length of the fruit ranged from 16.00 to 35.00 cm. Collection 19 recorded the highest fruit length of 35.00 cm. The lowest fruit length was recorded by Coll. 7 and Coll. 18 (16.00 cm).

Among the clusters, mean value for fruit length ranged from 17.88 to 27.50 cm.

The highest cluster mean value of 27 50 cm recorded in cluster VII and lowest cluster mean value of $17\ 88 \pm 2\ 17$ cm was recorded in cluster II.

4.1.3.5 Fruit Volume

Highest fruit volume of 3280 00 ml was recorded in Coll 19 and the lowest in Coll 38 (400 00 ml)

Mean fruit volume varied among different clusters This was the highest ($1706\ 66 \pm 1374\ 38$ ml) in cluster IX and lowest in cluster II ($666\ 67 \pm 260\ 26$ ml)

4.1.3.6 Fruit Shape

With respect to fruit shape, the fruits showed wide variation Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong to ellipsoid and club shapes were observed

4.1.3.7 Circumference of Fruit

Circumference of fruit varied among the collections The highest fruit circumference recorded by Coll 32 (52 00 cm) Lowest fruit circumference was recorded in Coll 6 (15 00 cm)

The cluster mean for circumference of fruit varied from 24 00 to 40 33 cm Cluster IX recorded the highest cluster mean value of $40\ 33 \pm 9\ 35$ cm for circumference of fruit and cluster VII recorded the lowest value of 24 00 cm

4.1.3.8 Flesh Thickness

Highest flesh thickness was recorded in Coll 10 (4 30 cm) and the lowest in Coll 7 and Coll 38 (1 90 cm each)

The cluster mean for flesh thickness ranged from 2 00 to 3 26 cm Cluster IX

Table 6 Flowering and fruiting characters of 40 collections

Collection No	Time of flowering	Sex expression of plant	Fruit weight (g)	Fruit length (cm)	Fruit volume (ml)	Fruit shape
Coll 1	Oct – Nov	Hermaphrodite	440 0	18 90	500 0	Pear shaped
Coll 2	Sep – Oct	Female	1275 0	25 50	1310 0	Acron
Coll 3	Oct – Nov	Hermaphrodite	955 0	21 20	1029 0	Oblong – ellipsoid
Coll 4	Sep – Oct	Female	1500 0	25 00	1720 0	Round
Coll 5	Sep – Oct	Hermaphrodite	1220 0	26 00	1300 0	Elongate
Coll 6	Oct – Nov	Hermaphrodite	640 0	20 00	700 0	Pear shaped
Coll 7	Sep – Oct	Hermaphrodite	985 0	16 00	1100 0	Elongate
Coll 8	Sep – Oct	Female	1340 0	24 50	1410 0	Oval
Coll 9	Oct	Hermaphrodite	765 0	19 50	800 0	Blossom end tapered
Coll 10	Oct	Hermaphrodite	1630 0	31 50	1720 0	Pear shaped
Coll 11	Sep – Oct	Female	595 0	19 00	630 0	Oval
Coll 12	Oct – Nov	Female	1150 0	23 00	1280 0	Acron
Coll 13	Oct – Nov	Female	1500 0	27 00	1740 0	High round
Coll 14	Sep – Oct	Female	740 0	24 00	830 0	Acron
Coll 15	Oct – Nov	Female	909 0	25 20	1012 0	Acron
Coll 16	Oct Nov	Hermaphrodite	1620 0	24 00	1800 0	Pear shaped
Coll 17	Dec	Hermaphrodite	1060 0	25 00	1180 0	Pear shaped
Coll 18	Sep – Oct	Hermaphrodite	985 0	16 00	1025 0	Lengthened cylindrical
Coll 19	Sep – Oct	Hermaphrodite	3130 0	35 00	3280 0	Lengthened cylindrical
Coll 20	Oct	Female	975 0	22 50	1010 0	Oval
Coll 21	Sep – Oct	Hermaphrodite	595 0	19 00	685 0	Acron
Coll 22	Oct – Nov	Female	680 0	19 00	740 0	Elliptic
Coll 23	Sep – Oct	Female	1500 0	27 00	1680 0	Round
Coll 24	Oct – Nov	Female	860 0	20 30	920 0	Round
Coll 25	Oct – Nov	Hermaphrodite	1380 0	27 50	1500 0	Oblong
Coll 26	Oct	Hermaphrodite	1465 0	27 50	1590 0	Acron
Coll 27	Sep – Oct	Hermaphrodite	950 0	23 70	1100 0	Oblong
Coll 28	Oct- Nov	Hermaphrodite	735 0	21 00	900 0	Acron
Coll 29	Oct Nov	Hermaphrodite	1020 0	25 60	1300 0	Pear shaped
Coll 30	Oct- Nov	Hermaphrodite	900 0	24 00	990 0	Acron
Coll 31	Sep – Oct	Hermaphrodite	440 0	18 90	570 0	Oval
Coll 32	Oct	Hermaphrodite	2105 0	27 50	2220 0	Acron
Coll 33	Oct	Female	1110 0	21 00	1180 0	Oval
Coll 34	Dec	Female	560 0	24 00	680 0	Round
Coll 35	Oct	Hermaphrodite	855 0	20 00	950 0	Blossom end tapered
Coll 36	Sep – Oct	Hermaphrodite	880 0	23 00	980 0	Acron
Coll 37	Oct – Nov	Hermaphrodite	640 0	29 00	720 0	Oval
Coll 38	Oct- Nov	Female	380 0	24 00	400 0	Round
Coll 39	Oct	Hermaphrodite	850 0	23 00	910 0	Club shaped
Coll 40	Oct – Nov	Female	820 0	22 00	880 0	Acron

Table 7 Cluster wise data for fruit characters of 40 collections

Cluster No	Fruit weight (g)		Fruit length (cm)		Fruit volume (ml)		Circumference of fruit (cm)		Flesh thickness (cm)		No of seeds/ fruit	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cluster I	1012.89	412.58	23.71	3.68	1127.11	439.56	33.44	8.89	2.69	0.52	645.53	265.37
Cluster II	600.00	242.49	22.77	2.14	666.67	260.26	31.17	5.58	2.50	0.66	218.00	138.17
Cluster III	927.50	67.18	22.75	0.35	995.00	21.21	36.70	2.40	2.70	0.14	616.00	220.62
Cluster IV	1246.00	589.39	24.43	2.44	1348.00	604.68	39.38	8.65	2.90	0.25	699.00	327.58
Cluster V	1101.66	348.93	23.73	2.96	1226.33	448.80	34.83	9.00	2.63	0.38	707.33	152.97
Cluster VI	1220.00		26.00	-	1300.00		38.00	-	3.00	-	362.00	-
Cluster VII	1380.00	-	27.50	-	1500.00	-	24.00	-	2.00		623.00	
Cluster VIII	897.50	107.51	17.88	2.17	968.75	128.08	36.73	1.79	2.70	0.88	495.00	157.16
Cluster IX	1586.66	1343.36	25.90	8.22	1706.66	1374.38	40.33	9.35	3.26	0.64	480.00	424.41

Table 6. Flowering and fruiting characters of 40 collections (continued)

Collection No.	Circumference of fruit (cm)	Flesh thickness (cm)	Flesh colour	No. of seeds/ fruit	100 seed weight (g)
Coll. 1	25.40	2.50	Deep yellow to orange	800.0	3.00
Coll. 2	38.70	3.00	Bright yellow	608.0	2.50
Coll. 3	39.00	2.20	Bright yellow	540.0	3.90
Coll. 4	50.00	3.00	Bright yellow	420.0	3.50
Coll. 5	38.00	3.00	Bright yellow	362.0	3.00
Coll. 6	15.00	2.50	Bright yellow	436.0	3.00
Coll. 7	36.00	1.90	Light yellow	637.0	3.47
Coll. 8	44.40	3.00	Bright yellow	878.0	3.50
Coll. 9	35.50	3.90	Deep yellow to orange	298.0	3.50
Coll. 10	37.50	4.30	Bright yellow	500.0	3.50
Coll. 11	30.50	2.30	Light yellow	230.0	2.04
Coll. 12	38.00	3.00	Bright yellow	653.0	3.00
Coll. 13	24.50	2.80	Bright yellow	742.0	3.92
Coll. 14	29.00	3.00	Bright yellow	754.0	3.50
Coll. 15	33.50	2.80	Bright yellow	279.0	3.50
Coll. 16	46.00	2.40	Light yellow	597.0	3.96
Coll. 17	34.50	3.00	Deep yellow to orange	459.0	3.50
Coll. 18	36.00	2.20	Deep yellow to orange	440.0	3.20
Coll. 19	51.00	4.00	Scarlet	938.0	3.50
Coll. 20	38.40	2.60	Reddish orange	772.0	3.00
Coll. 21	30.50	2.50	Light yellow	482.0	2.95
Coll. 22	33.50	2.80	Scarlet	100.0	3.00
Coll. 23	24.50	2.50	Light yellow	940.0	4.01
Coll. 24	37.50	3.20	Deep yellow to orange	100.0	3.00
Coll. 25	24.00	2.00	Deep yellow to orange	623.0	3.50
Coll. 26	36.00	2.90	Bright yellow	1100.0	5.90
Coll. 27	36.50	3.00	Reddish orange	402.0	3.00
Coll. 28	26.00	2.50	Deep yellow to orange	768.0	3.94
Coll. 29	39.50	2.70	Bright yellow	930.0	4.10
Coll. 30	39.00	2.00	Bright yellow	926.0	3.00
Coll. 31	25.40	2.00	Light yellow	328.0	2.32
Coll. 32	52.00	3.20	Bright yellow	1064.0	3.00
Coll. 33	39.00	3.00	Bright yellow	900.0	3.50
Coll. 34	29.00	2.40	Light yellow	370.0	2.98
Coll. 35	39.40	2.80	Bright yellow	605.0	3.00
Coll. 36	35.00	2.80	Scarlet	460.0	3.00
Coll. 37	24.50	2.10	Bright yellow	209.0	2.00
Coll. 38	27.00	1.90	Bright yellow	184.0	1.98
Coll. 39	41.00	2.90	Bright yellow	840.0	3.90
Coll. 40	34.00	2.60	Bright yellow	800.0	3.20

Table 7. Cluster wise data for fruit characters of 40 collections

Cluster No.	Fruit weight (g)		Fruit length (cm)		Fruit volume (ml)		Circumference of fruit (cm)		Flesh thickness (cm)		No. of seeds/ fruit	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cluster I	1012.89	412.58	23.71	3.68	1127.11	439.56	33.44	8.89	2.69	0.52	645.53	265.37
Cluster II	600.00	242.49	22.77	2.14	666.67	260.26	31.17	5.58	2.50	0.66	218.00	138.17
Cluster III	927.50	67.18	22.75	0.35	995.00	21.21	36.70	2.40	2.70	0.14	616.00	220.62
Cluster IV	1246.00	589.39	24.43	2.44	1348.00	604.68	39.38	8.65	2.90	0.25	699.00	327.58
Cluster V	1101.66	348.93	23.73	2.96	1226.33	448.80	34.83	9.00	2.63	0.38	707.33	152.97
Cluster VI	1220.00	-	26.00	-	1300.00	-	38.00	-	3.00	-	362.00	-
Cluster VII	1380.00	-	27.50	-	1500.00	-	24.00	-	2.00	-	623.00	-
Cluster VIII	897.50	107.51	17.88	2.17	968.75	128.08	36.73	1.79	2.70	0.88	495.00	157.16
Cluster IX	1586.66	1343.36	25.90	8.22	1706.66	1374.38	40.33	9.35	3.26	0.64	480.00	424.41

recorded the highest cluster mean value of 3.26 ± 0.64 cm for flesh thickness and cluster VII recorded the lowest value of 2.00 cm.

4.1.3.9 Flesh Colour

Fruits of different collections showed variation in flesh colour, ranging from light yellow to scarlet.

4.1.3.10 No. of Seeds/ Fruit

Collection 26 recorded highest number of seeds per fruit (1100). The lowest number of seeds per fruit was recorded in Coll. 22 and Coll. 24 (100 each).

Number of seeds per fruit varied among different clusters. This was the highest (707 ± 152.97) in cluster V and lowest (218 ± 138.37) in cluster II.

4.1.3.11 Weight of 100 Seeds

Weight of 100 matured well developed seeds was highest in Coll. 26 (5.90 g) and lowest in Coll. 38 (1.98 g).

The highest (3.91 ± 0.01 g) mean value for 100 seed weight recorded in cluster V and lowest (3g) in cluster III and cluster VI.

4.1.4 Sensory Evaluation

Organoleptic characters, viz., appearance, colour, taste, sweetness, aroma and texture of the fruits among the different collections/ varieties were evaluated and presented in Table 8.

The mean rank obtained for appearance ranged from 5.60 to 37.25. Collection 19 recorded highest mean rank (37.25) followed by Coll. 22 (36.35) and Coll. 1

(34.4). Collection 13 recorded the lowest mean rank (5.60) followed by Coll. 21 (6.55).

The mean rank obtained for colour ranged from 3.44 to 42.94. Collection 19 recorded highest mean rank (42.94) followed by Coll. 22 (41.50) and Coll. 39 (36.44). Collection 31 recorded the lowest mean rank (3.44) followed by Coll. 23 (5.56).

The mean rank obtained for taste ranged from 4.80 to 36.85. Collection 10 recorded highest mean rank (36.85) followed by Coll. 22 (35.25) and Coll. 18 (19.55). Collection 31 recorded the lowest mean rank (4.80) followed by Coll. 7 (6.9).

The mean rank obtained for sweetness ranged from 6.00 to 37.15. Collection 10 recorded highest mean rank (37.15) followed by Coll. 27 (35.1) and Coll. 15 (34.2). Collection 11 recorded the lowest mean rank (6.00) followed by Coll. 21 (6.50).

The mean rank obtained for aroma ranged from 6.05 to 34.70. Collection 40 recorded highest mean rank (34.7) followed by Coll. 14 (33.9) and Coll. 22 (33.2). Collection 3 recorded the lowest mean rank (6.00) followed by Coll. 29 (6.45).

The mean rank obtained for texture ranged from 3.95 to 33.55. Collection 17 recorded highest means rank (33.55) followed by Coll. 1 (33.4) and Coll. 39 (32.75). Collection 23 recorded the lowest mean rank (3.95) followed by Coll. 29 (4.50).

4.1.5 Biochemical Characters

Observations on biochemical characters of the collections are presented in Table 9 and the cluster wise data are presented in Table 10.

Table 8. Sensory evaluation of fruits of 40 collections

Collection No.	Appearance (Mean rank)	Colour (Mean rank)	Taste (Mean rank)	Sweetness (Mean rank)	Aroma (Mean rank)	Texture (Mean rank)
Coll. 1	34.40	34.67	33.35	30.80	30.85	33.40
Coll. 2	29.95	30.50	29.95	27.35	30.95	28.45
Coll. 3	12.20	15.72	15.80	7.80	6.05	9.95
Coll. 4	27.35	33.06	26.50	27.85	27.55	20.20
Coll. 5	22.75	31.89	29.20	30.45	26.85	19.40
Coll. 6	23.25	23.00	21.35	22.05	20.80	25.05
Coll. 7	8.15	13.33	6.90	8.95	11.15	11.30
Coll. 8	28.90	23.72	23.55	20.35	23.75	29.10
Coll. 9	27.05	26.67	31.65	29.95	32.30	29.75
Coll. 10	16.10	23.61	36.85	37.15	14.90	25.70
Coll. 11	8.85	6.22	7.40	6.00	8.25	10.45
Coll. 12	28.05	28.00	25.45	25.35	23.65	27.05
Coll. 13	5.60	9.56	8.85	8.65	7.30	7.35
Coll. 14	12.55	27.39	15.40	16.40	33.90	31.60
Coll. 15	24.60	24.11	31.50	34.20	16.90	27.85
Coll. 16	8.55	8.06	7.35	8.60	10.55	7.55
Coll. 17	26.00	33.22	26.60	28.05	32.75	33.55
Coll. 18	11.15	9.61	11.80	8.60	15.35	10.90
Coll. 19	37.25	42.94	30.75	23.45	19.85	17.70
Coll. 20	33.75	32.67	33.45	33.20	31.20	27.75
Coll. 21	6.55	13.78	9.25	6.50	11.75	11.50
Coll. 22	36.35	41.50	35.25	32.30	33.20	32.50
Coll. 23	8.40	5.56	7.15	7.90	10.30	3.95
Coll. 24	27.00	20.28	25.60	28.10	31.15	31.75
Coll. 25	31.70	29.61	20.50	32.55	19.95	24.95
Coll. 26	10.70	7.94	7.30	9.45	9.75	7.65
Coll. 27	25.60	23.28	29.85	35.10	30.00	29.65
Coll. 28	7.10	11.06	7.40	8.45	12.20	7.10
Coll. 29	8.75	7.89	9.35	6.55	6.45	4.50
Coll. 30	30.80	23.39	28.90	31.80	31.70	28.75
Coll. 31	10.25	3.44	4.80	10.95	9.15	5.90
Coll. 32	28.05	29.56	17.30	20.55	26.90	29.40
Coll. 33	26.10	28.22	28.40	21.00	22.35	15.15
Coll. 34	9.75	12.50	9.00	10.80	12.30	11.65
Coll. 35	26.15	28.22	30.15	27.20	21.90	27.65
Coll. 36	29.10	15.89	28.60	31.20	32.30	28.95
Coll. 37	12.55	8.61	9.55	12.70	7.70	10.30
Coll. 38	11.45	13.83	14.20	10.70	11.45	10.05
Coll. 39	21.45	36.44	15.90	18.20	19.95	32.75
Coll. 40	25.75	33.11	27.90	22.80	34.70	31.85
KW	0.759	0.752	0.804	0.806	0.717	0.803

4.1.5.1 Total Soluble Solids (TSS)

Total soluble solids (TSS) of the fruit ranged from 3.80 to 14 °Brix. Highest TSS was recorded in Coll.1 and Coll. 4 (14 °Brix each) followed by Coll. 2 and Coll. 30 (13 °Brix each), Coll. 27 (12.40 °Brix), Coll. 5 and Coll. 6 (12.20 °Brix each). The lowest TSS was recorded by Coll. 3 and Coll. 38 (3.80 °Brix each).

Total soluble solids (TSS) was the highest in cluster VI (12.20 °Brix) followed by cluster III (11.30 ± 0.71 °Brix), cluster IX (10.93 ± 1.29 °Brix), cluster IV (10.80 ± 0.78 °Brix) and cluster VII (10.00 °Brix). Cluster II recorded the lowest TSS (6.67 ± 3.97 °Brix) followed by cluster V (7.00 ± 4.39 °Brix).

4.1.5.2 Sugars

Collection 4 recorded the highest reducing (10.32 %) and total sugar (12.12 %) were as the Coll. 37 recorded the lowest reducing (3.10 %) and total sugar (3.90 %). Cluster VI recorded the highest mean value for reducing sugar (10.06 %) and total sugar (10.91 %) were as the cluster II recorded the lowest value of 5.37 ± 1.84 per cent and 6.26 ± 2.31 per cent respectively.

Collection 8 and Coll. 9 were recorded the highest non - reducing sugar (2.81 %). Collection 6 recorded the lowest non - reducing sugar of 0.13 per cent. Among the clusters, mean value for non - reducing sugars ranged from 0.31 to 1.59 per cent.

4.1.5.3 Acidity

Acidity of the collections ranged from 0.051 to 0.153 per cent. The cluster mean for acidity ranged from 0.07 to 0.15 per cent. Cluster IV recorded the lowest cluster mean value of 0.07 ± 0.02 per cent for acidity and cluster VII recorded the highest value of 0.15 per cent

Table 9. Biochemical characters of 40 collections

Collection No.	TSS (° Brix)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Acidity (%)
Coll. 1	14.00	9.82	1.22	11.04	0.102
Coll. 2	13.00	8.33	0.27	8.60	0.051
Coll. 3	3.80	3.50	1.90	5.40	0.076
Coll. 4	14.00	10.32	1.80	12.12	0.051
Coll. 5	12.20	10.06	0.85	10.91	0.102
Coll. 6	12.20	7.60	0.40	8.00	0.153
Coll. 7	4.60	4.10	0.87	4.97	0.076
Coll. 8	11.20	8.00	2.81	10.81	0.076
Coll. 9	11.00	8.00	2.81	10.81	0.076
Coll. 10	11.00	8.69	1.06	9.75	0.076
Coll. 11	4.90	5.82	0.17	5.99	0.051
Coll. 12	11.00	7.60	1.38	8.90	0.051
Coll. 13	5.20	5.71	0.79	6.50	0.102
Coll. 14	11.20	6.60	0.80	7.40	0.076
Coll. 15	10.40	7.69	0.15	7.84	0.102
Coll. 16	6.00	4.92	0.13	5.05	0.102
Coll. 17	10.00	6.50	1.04	7.54	0.076
Coll. 18	6.00	5.09	1.33	6.42	0.076
Coll. 19	10.00	5.34	1.10	6.44	0.051
Coll. 20	10.80	5.12	2.42	7.54	0.102
Coll. 21	5.80	4.24	1.06	5.30	0.051
Coll. 22	10.40	6.66	0.29	6.95	0.102
Coll. 23	6.00	5.23	1.17	6.40	0.076
Coll. 24	11.20	7.40	1.48	8.88	0.102
Coll. 25	10.00	7.69	0.31	8.00	0.153
Coll. 26	4.40	5.71	0.49	6.20	0.076
Coll. 27	12.40	8.33	1.08	9.41	0.076
Coll. 28	6.00	4.60	1.30	5.90	0.051
Coll. 29	7.00	5.40	0.50	5.90	0.102
Coll. 30	13.00	9.30	0.50	9.80	0.051
Coll. 31	6.00	4.70	0.70	5.40	0.051
Coll. 32	10.00	7.69	0.15	7.84	0.076
Coll. 33	9.40	7.40	0.29	7.69	0.076
Coll. 34	5.00	3.80	0.70	4.50	0.102
Coll. 35	9.80	6.76	1.10	7.86	0.128
Coll. 36	11.80	7.23	0.75	7.98	0.076
Coll. 37	4.40	3.10	0.80	3.90	0.102
Coll. 38	3.80	4.90	0.50	5.40	0.153
Coll. 39	12.00	7.90	0.30	8.20	0.076
Coll. 40	11.80	7.78	1.14	8.92	0.051

Table 10. Cluster wise data for biochemical characters of 40 collections

Cluster No.	100 seed weight (g)		TSS (°Brix)		Reducing sugar (%)		Non-reducing sugar (%)		Total sugar (%)		Acidity (%)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cluster I	3.35	0.89	8.92	3.47	6.65	2.05	0.87	0.65	7.52	2.30	0.08	0.03
Cluster II	2.65	0.58	6.67	3.97	5.37	1.84	0.89	0.52	6.26	2.31	0.12	0.03
Cluster III	3.00	0.00	11.30	0.71	6.18	1.49	1.59	1.18	7.76	0.31	0.09	0.02
Cluster IV	3.18	0.23	10.80	0.78	7.69	0.07	0.71	0.65	8.38	0.62	0.07	0.02
Cluster V	3.91	0.01	7.00	4.39	5.70	2.20	1.00	0.82	6.70	1.41	0.08	0.02
Cluster VI	3.00	-	12.20	-	10.06	-	0.85	-	10.91	-	0.10	-
Cluster VII	3.50	-	10.00	-	7.69	-	0.31	-	8.00	-	0.15	-
Cluster VIII	3.29	0.24	7.85	3.03	5.99	1.73	1.53	0.88	7.52	2.49	0.09	0.03
Cluster IX	3.16	0.29	10.93	1.29	6.78	1.49	0.82	0.46	7.60	1.58	0.08	0.03

Table 11. Plant and fruit characters of selected 25 accessions

Collection No.	Accession No.	Plant height (m)	Fruit weight (g)	TSS (°brix)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
Coll. 1	Acc. 1	3.5	440.0	14.00	9.82	1.22	11.04
Coll. 2	Acc. 2	5.4	1275.0	13.00	8.33	0.27	8.60
Coll. 4	Acc. 3	5.3	1500.0	14.00	10.32	1.80	12.12
Coll. 5	Acc. 4	5.5	1220.0	12.20	10.06	0.85	10.91
Coll. 6	Acc. 5	4.8	640.0	12.20	7.60	0.40	8.00
Coll. 8	Acc. 6	3.9	1340.0	11.20	8.00	2.81	10.81
Coll. 9	Acc. 7	5.5	765.0	11.00	8.00	2.81	10.81
Coll. 10	Acc. 8	3.6	1630.0	11.00	8.69	1.06	9.75
Coll. 12	Acc. 9	4.2	1150.0	11.00	7.60	1.38	8.90
Coll. 14	Acc. 10	5.1	740.0	11.20	6.60	0.80	7.40
Coll. 15	Acc. 11	3.8	909.0	10.40	7.69	0.15	7.84
Coll. 17	Acc. 12	2.1	1060.0	10.00	6.50	1.04	7.54
Coll. 19	Acc. 13	2.1	3130.0	10.00	5.34	1.10	6.44
Coll. 20	Acc. 14	2.1	975.0	10.80	5.12	2.42	7.54
Coll. 22	Acc. 15	4.3	680.0	10.40	6.66	0.29	6.95
Coll. 24	Acc. 16	4.0	860.0	11.20	7.40	1.48	8.88
Coll. 25	Acc. 17	3.7	1380.0	10.00	7.69	0.31	8.00
Coll. 27	Acc. 18	4.4	950.0	12.40	8.33	1.08	9.41
Coll. 30	Acc. 19	3.0	900.0	13.00	9.30	0.50	9.80
Coll. 32	Acc. 20	3.6	2105.0	10.00	7.69	0.15	7.84
Coll. 33	Acc. 21	2.7	1110.0	9.40	7.40	0.29	7.69
Coll. 35	Acc. 22	4.1	855.0	9.80	6.76	1.10	7.86
Coll. 36	Acc. 23	3.9	880.0	11.80	7.23	0.75	7.98
Coll. 39	Acc. 24	4.5	850.0	12.00	7.90	0.30	8.20
Coll. 40	Acc. 25	5.6	820.0	11.80	7.78	1.14	8.92

Selection of Collections

Further selection of collection was done with special reference to plant height, fruit weight, TSS, sugars and organoleptic characters. Twenty five collections were evenly selected from the 40 collections for detailed evaluation in the field. The selected 25 collections were distributed in all the nine clusters. The details of the selected collections are given in the Table 11. The selected collections were again numbered from Acc. 1 to Acc. 25 for further study. Plant height of these selected 25 accessions ranged from 2.1 to 5.6 m. Fruit weight ranged from 440.0 to 3130.0 g. The TSS of selected 25 collections ranged from 9.40 to 14 °Brix and total sugars ranged from 6.44 to 12.12 per cent.

4.2 EXPERIMENT II - SELECTION OF PROMISING TYPES/ VARIETIES

The selected 25 accessions along with five released varieties were subjected to detailed studies.

4.2.1 Morphological Characters

Morphological characters such as plant height, collar girth, number of fully developed leaves, leaf area and length of petiole were recorded at bimonthly interval for 12 months and presented in Table 12 to 16.

4.2.1.1 Plant Height

Height of papaya plant at 2 MAP (Months after planting), 4 MAP, 6 MAP, 8 MAP, 10 MAP and 12 MAP are shown in Table 12.

At 2 MAP, the lowest plant height of 0.43 m was recorded by Pusa Nanha which was significantly superior to all other treatments. This was followed by Acc. 15 (0.56 m) which was on par with CO 8 (0.62 m), Arka Prabath (0.64), Acc. 23 (0.64 m), Acc. 13 (0.66 m), Acc. 24 and CO 2 (0.68 m each). Accession 19 recorded

the highest plant height (0.95 m) followed by Acc. 10 and Acc. 25 (0.94 m each).

At 4 MAP, also Pusa Nanha recorded the lowest plant height (0.85 m) followed by Arka Prabath (1.03 m) which was on par with Acc. 13 and Acc.14 (1.16 m each), Acc. 15 (1.17m), CO 2 (1.17 m) and Acc. 23 (1.18 m). Accession 17 recorded the highest plant height of 1.65 m followed by Acc. 11 (1.55 m), Acc. 10 (1.53 m), Acc. 19 (1.51 m), Acc. 9 (1.50 m), Acc. 28 (1.50 m) and were on par.

At 6 MAP, Pusa Nanha recorded the lowest plant height (1.04 m) followed by Acc. 15 (1.30 m) which was on par with Acc. 13 (1.33 m), Acc. 12 (1.35 m), Acc. 23 and Arka Prabath (1.42 m each), CO 2 (1.44 m) and Acc. 22 (1.46 m). Accession 7, Acc.18 and CO 7 recorded the highest plant height of (1.82 m each) followed by Acc. 17 (1.81 m), Acc. 16 (1.80 m), Acc. 11 (1.79 m) and Acc. 1 (1.78 m):

At 8 MAP, the lowest plant height of 1.26 m was recorded in Pusa Nanha (1.26 m) followed by Acc. 15 (1.47 m) which was on par with Acc. 13 (1.54 m) and CO 2 (1.57 m). Accession 18 recorded the highest plant height of 2.35 m followed by CO 7 (2.32 m) and Acc. 7 (2.30 m) and these were on par.

At 10 MAP, also lowest plant height was recorded by Pusa Nanha (1.51 m) which was on par with Acc. 15 (1.67 m), Acc. 13 (1.68 m). Accession 18 and CO 7 recorded the highest plant height of 2.87 m each followed by Acc. 7 (2.84 m) and these were on par.

At 12 MAP, also lowest plant height was recorded by Pusa Nanha (1.79 m) which was on par with Acc. 15 (1.87 m) and Acc. 13 (1.95 m). This was followed by CO 2 (2.14 m), Acc. 12 (2.24 m) and Acc. 4 (2.25 m). Accession 18 recorded the highest plant height (3.18 m) followed by CO 7 (3.15 m), Acc. 7 (3.12m) and these were on par.



Table 12. Plant height of papaya accessions/ varieties, m

Accession/ varieties	Plant height (m)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
Acc. 1	0.90	1.47	1.78	2.14	2.50	2.78
Acc. 2	0.81	1.46	1.68	2.01	2.32	2.63
Acc. 3	0.84	1.49	1.70	1.94	2.16	2.43
Acc. 4	0.76	1.31	1.49	1.72	1.94	2.25
Acc. 5	0.71	1.41	1.63	1.95	2.27	2.48
Acc. 6	0.78	1.30	1.59	2.07	2.55	2.76
Acc. 7	0.82	1.45	1.82	2.30	2.84	3.12
Acc. 8	0.93	1.38	1.71	2.15	2.60	2.73
Acc. 9	0.90	1.50	1.76	2.10	2.50	2.87
Acc. 10	0.94	1.53	1.77	2.10	2.49	2.70
Acc. 11	0.92	1.55	1.79	2.14	2.52	2.76
Acc. 12	0.71	1.23	1.35	1.66	2.02	2.24
Acc. 13	0.66	1.16	1.33	1.54	1.68	1.95
Acc. 14	0.80	1.16	1.59	1.91	2.28	2.53
Acc. 15	0.56	1.17	1.30	1.47	1.67	1.87
Acc. 16	0.81	1.48	1.80	2.07	2.37	2.72
Acc. 17	0.85	1.65	1.81	2.16	2.52	2.81
Acc. 18	0.79	1.31	1.82	2.35	2.87	3.18
Acc. 19	0.95	1.51	1.75	2.14	2.58	2.85
Acc. 20	0.91	1.39	1.61	1.92	2.24	2.59
Acc. 21	0.78	1.38	1.60	1.91	2.21	2.53
Acc. 22	0.80	1.23	1.46	1.86	2.27	2.61
Acc. 23	0.64	1.18	1.42	1.71	2.02	2.28
Acc. 24	0.68	1.39	1.50	1.84	2.17	2.49
Acc. 25	0.94	1.47	1.76	2.08	2.45	2.74
Arka Prabath	0.64	1.03	1.42	1.77	2.12	2.40
CO 8	0.62	1.39	1.60	1.83	2.01	2.32
CO 7	0.77	1.50	1.82	2.32	2.87	3.15
CO 2	0.68	1.17	1.44	1.57	1.74	2.14
Pusa Nanha	0.43	0.85	1.04	1.26	1.51	1.79
CD (0.05)	0.126	0.154	0.163	0.143	0.171	0.212

MAP – Months after planting

4.2.1.2 Collar Girth

Collar girth of papaya plant at 2 MAP, 4 MAP, 6 MAP, 8 MAP, 10 MAP and 12 MAP are shown in Table 13.

At 2 MAP, Acc. 11 recorded the highest collar girth of 13.58 cm followed by CO 7 (13.51 cm), Acc. 1 (12.81 cm), Acc. 19 (12.53 cm), Acc. 25 (12.05 cm), Acc. 3 (11.55 cm), Acc. 17 (11.47 cm), Acc. 20 (11.33 cm) and Acc. 2 (11.14 cm).

Lowest collar girth was recorded by Pusa Nanha (7.33 cm) followed by Acc. 7 (7.66 cm), Acc. 15 (7.83 cm), Acc. 5 (8.05 cm), Acc. 23 (8.45 cm) and Arka Prabath (8.71 cm).

At 4 MAP, Acc. 11 recorded the highest collar girth of 25.95 cm followed by Acc. 7 (25.33 cm), Acc. 17 (24.18 cm), Acc. 14 (23.97 cm), Acc. 1 (23.66 cm) and Acc. 2 (23.39 cm). Lowest collar girth was recorded by CO 8 (13.12 cm) which was on par with Acc. 15 (16.80 cm), Acc. 5 (17.30 cm), Arka Prabath (17.33 cm) and Pusa Nanha (17.50 cm).

At 6 MAP, highest collar girth of 33.78 cm was recorded in Acc. 2 followed by Acc. 18 (32.17 cm), Acc. 7 (31.64 cm) and Acc. 1 (30.44 cm) and these were on par. Lowest collar girth was recorded by CO 2 (23.27 cm) followed by Pusa Nanha (23.58 cm), Acc. 15 (23.74 cm), CO 8 (23.82 cm), Acc. 23 (23.94 cm) and Acc. 5 (24.77 cm).

At 8 MAP, highest collar girth of 56.17 cm was recorded in CO 8 followed by Acc. 12 (52.95 cm), Acc. 22 (48.57 cm), CO 2 (47.87 cm) , Acc. 18 (45.40 cm) and these were on par. Lowest collar girth was recorded by Acc. 21 (28.21 cm) followed by Acc. 5 (28.47 cm), Acc. 4 (28.79 cm), Acc. 13 (28.90 cm) and Acc. 23 (30.15 cm).

At 10 MAP, highest collar girth of 88.83 was recorded in CO 8 followed by

Table 13. Collar girth of papaya accessions/ varieties, cm

Accessions/ varieties	Collar girth (cm)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
Acc. 1	12.81	23.66	30.44	35.15	41.33	46.33
Acc. 2	11.14	23.39	33.78	35.55	38.00	44.40
Acc. 3	11.55	21.86	28.61	31.74	36.43	41.45
Acc. 4	9.69	20.53	25.83	28.79	32.23	37.22
Acc. 5	8.05	17.30	24.77	28.47	31.45	36.75
Acc. 6	8.95	21.03	27.61	37.48	45.85	50.67
Acc. 7	7.66	25.33	31.64	42.42	61.58	66.58
Acc. 8	10.83	21.53	28.72	33.40	39.98	45.65
Acc. 9	9.94	21.50	27.44	30.70	35.08	40.25
Acc. 10	9.50	21.82	29.16	32.81	35.75	40.96
Acc. 11	13.58	25.95	28.99	31.91	35.29	40.49
Acc. 12	9.22	20.02	26.92	52.95	79.67	84.67
Acc. 13	10.72	22.49	26.39	28.90	31.33	37.21
Acc. 14	9.00	23.97	29.29	33.84	36.65	42.31
Acc. 15	7.83	16.80	23.74	33.16	46.62	52.12
Acc. 16	9.98	21.61	28.55	32.30	36.70	41.39
Acc. 17	11.47	24.18	28.09	41.96	54.25	59.60
Acc. 18	8.83	22.33	32.17	45.40	62.16	68.53
Acc. 19	12.53	22.60	29.47	35.83	41.99	46.99
Acc. 20	11.33	20.05	29.39	31.70	35.99	41.78
Acc. 21	10.25	20.02	25.15	28.21	31.65	36.21
Acc. 22	9.94	19.92	29.25	48.57	74.65	78.81
Acc. 23	8.45	18.33	23.94	30.15	34.67	39.67
Acc. 24	9.14	21.31	27.91	32.52	37.09	42.52
Acc. 25	12.05	20.17	26.22	42.25	61.38	65.71
Arka Prabath	8.71	17.33	26.11	31.17	37.33	42.93
CO 8	9.07	13.12	23.82	56.17	88.83	94.62
CO 7	13.51	19.83	24.89	38.11	53.92	59.78
CO 2	9.04	18.64	23.27	47.87	68.36	73.80
Pusa Nanha	7.33	17.50	23.58	38.79	58.66	64.29
CD (0.05)	2.98	4.95	4.28	12.15	24.40	24.15

MAP – Months after planting

Acc. 12 (79.67 cm), Acc. 22 (74.65 cm), CO 2 (68.36 cm) and these were on par. Lowest collar girth was recorded by Acc. 13 (31.33 cm) followed by Acc. 5 (31.45 cm), Acc. 21 (31.65 cm), Acc. 4 (32.23 cm) and Acc. 23 (34.67 cm).

At 12 MAP, highest collar girth of 94.62 cm was recorded in CO 8 followed by Acc. 12 (84.67 cm), Acc. 22 (78.81 cm), CO 2 (73.80 cm) and these were on par. Lowest collar girth was recorded by Acc. 21 (36.21 cm) followed by Acc. 5 (36.75 cm), Acc. 13 (37.21 cm), Acc. 4 (37.22 cm) and Acc. 23 (39.67 cm).

4.2.1.3 Leaf Area

The data on leaf area are given in Table 14. At 2 MAP, highest leaf area was recorded in Acc. 1 (1930.51 cm²) followed by Acc. 11 (1681.99 cm²), Acc. 25 (1572.47 cm²), CO 7 (1561.63 cm²) and Acc. 8 (1522.99 cm²). Lowest leaf area was reported in Acc. 10 (503.04 cm²) followed by Acc. 26 (505.40 cm²), Acc. 5 (518.35 cm²), Acc. 15 (627.89 cm²), Pusa Nanha (656.58 cm²) and Acc. 27 (663.22 cm²). There was no significant difference among the treatments at 4 MAP.

At 6 MAP, the highest leaf area of 3056.47 cm² was recorded in CO 2 followed by Acc. 24 (3024.62 cm²), Acc. 18 (2697.83 cm²), Acc. 10 (2636.00 cm²) and Acc. 19 (2632.47 cm²). The lowest leaf area was reported in CO 8 (1046.00 cm²) which was on par with Acc. 21 (1477.77 cm²) and Acc. 22 (1500.03 cm²).

At 8 MAP, Acc. 24 recorded the highest leaf area of 3453.97 cm² followed by Acc. 7 (3362.81 cm²), Acc. 18 (3312.63 cm²), Acc. 16 (3310.16 cm²), Acc. 2 (3252.21 cm²), Acc. 15 (3246.56 cm²), Acc. 1 (3233.13 cm²) and Acc. 25 (3220.77 cm²). The lowest leaf area was reported in CO 8 (1736.41 cm²) which was on par with Pusa Nanha (2030.39 cm²).

Table 14. Leaf area of papaya accessions/ varieties, cm²

Accessions/ varieties	Leaf area (cm ²)					
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
Acc. 1	1930.51	2100.11	2499.37	3233.13	3854.65	2913.79
Acc. 2	934.11	2429.89	2400.44	3252.21	4101.27	4643.99
Acc. 3	1480.60	2074.20	2300.33	2976.26	3378.35	4180.42
Acc. 4	1046.00	1991.75	2162.53	2424.35	2785.46	3324.65
Acc. 5	518.35	1640.19	2348.62	2750.48	3546.89	4134.49
Acc. 6	945.06	1693.77	2285.61	3003.47	3475.17	4038.38
Acc. 7	1054.83	1967.61	2612.44	3362.81	4010.47	4295.96
Acc. 8	1522.99	2223.78	2147.22	2633.88	3185.79	3882.21
Acc. 9	1176.73	1952.89	2146.04	2717.62	3254.69	3798.82
Acc. 10	503.04	2096.58	2636.00	2747.65	2887.93	3560.32
Acc. 11	1681.99	2274.42	2076.55	2875.91	3641.94	3864.54
Acc. 12	895.83	2030.39	1982.33	2361.46	2690.77	3486.83
Acc. 13	1110.78	1699.66	2064.78	2450.15	2851.53	3265.64
Acc. 14	1140.22	1724.40	2602.19	3203.45	3758.54	4082.90
Acc. 15	627.89	1664.33	2587.71	3246.56	4055.34	4540.82
Acc. 16	1154.35	1975.26	2459.33	3310.16	4237.31	4744.69
Acc. 17	1517.11	1887.64	2151.93	2939.16	3728.15	4444.01
Acc. 18	816.33	1964.67	2697.83	3312.63	3987.85	4423.16
Acc. 19	1463.29	1789.17	2632.47	3024.67	3468.81	4089.61
Acc. 20	1319.24	2011.77	2364.87	2844.47	3347.61	3837.69
Acc. 21	1117.61	1861.61	1477.77	2240.62	2969.19	4387.12
Acc. 22	1146.70	1470.00	1500.03	2881.57	3685.75	3980.79
Acc. 23	1222.67	1335.73	2194.33	2634.94	2902.41	3622.86
Acc. 24	957.67	2366.29	3024.67	3453.97	3806.24	4106.93
Acc. 25	1572.47	2371.00	2459.33	3220.77	3899.87	4709.36
Arka Prabath	505.40	1849.24	2526.46	2677.69	3007.00	3610.14
CO 8	663.22	1629.00	1046.00	1736.41	2377.36	3194.97
CO 7	1561.63	1750.31	1693.78	2316.94	2891.46	3251.51
CO 2	1041.84	1961.13	3056.47	2980.85	2906.30	3508.73
Pusa Nanha	656.58	1655.50	1867.50	2030.39	2202.11	3014.77
CD (0.05)	636.18	NS	493.93	355.81	341.97	1088.72

MAP – Months after planting

At 10 MAP, Acc. 16 recorded the highest leaf area of 4237.31 cm² followed by Acc. 2 (4101.27 cm²), Acc. 7 (4010.47 cm²), Acc. 15 (4055.34 cm²), Acc. 18 (3987.85 cm²), Acc. 25 (3899.87 cm²) and these were on par. The lowest leaf area was reported in Pusa Nanha (2202.11 cm²) followed by CO 8 (2377.36 cm²) and Acc. 12 (2690.77 cm²).

At 12 MAP, Acc. 16 recorded the highest leaf area of 4744.69 cm² followed by Acc. 25 (4709.36 cm²), Acc. 2 (4643.99 cm²) and Acc. 15 (4540.82 cm²). The lowest leaf area was reported in Acc. 1 (2913.79 cm²), followed by Pusa Nanha (3014.77 cm²), CO 8 (3194.97 cm²), CO 7 (3251.51 cm²) and Acc. 13 (3265.64 cm²).

4.2.1.4 Length of Petiole

Petiole length of papaya leaf at 2 MAP (Months after planting), 4 MAP, 6 MAP, 8 MAP, 10 MAP and 12 MAP are shown in Table 15.

At 2 MAP, Acc. 11 recorded the highest petiole length of 35.77 cm followed by Acc. 17 (34.40 cm), Acc. 25 (33.11 cm), Acc. 14 (32.27 cm) and Acc. 1 (32.19 cm). The lowest petiole length of 20.55 cm was recorded in Pusa Nanha followed by Arka Prabath (22.55 cm), Acc. 5 (22.61 cm), CO 8 (23.67 cm) and Acc. 15 (24.22 cm), CO 2 (24.62 cm).

At 4 MAP, highest petiole length of 43.79 cm was recorded in Acc. 24 followed by Acc. 2 (42.05 cm), Acc. 25 (41.50 cm), CO 2 (41.47 cm) and Acc. 11 (40.59 cm). Lowest petiole length was recorded by Acc. 23 (31.73 cm) which was on par with Acc. 22 (33.00 cm), Acc. 5 (34.60 cm), Pusa Nanha (34.75 cm), Acc. 15 (34.83 cm), CO 8 (36.50 cm), Arka Prabath (36.58 cm), Acc. 13 (36.67 cm) and Acc. 14 (36.93 cm).

At 6 MAP, Acc. 24 recorded the highest petiole length of 58.00 cm followed by Acc. 14 (57.89 cm), Acc. 7 (57.83 cm), Acc. 3 (57.50 cm), Acc. 20 (56.77 cm) and

Acc. 18 (56.17 cm). Lowest petiole length was recorded by CO 8 (37.80 cm) which was on par with Acc. 21 (42.59 cm).

At 8 MAP, Acc. 18 recorded the highest petiole length of 81.03 cm followed by Acc. 25 (77.36 cm) and these were on par. Lowest petiole length was recorded by CO 8 (51.12 cm) which was on par with Acc. 15 (52.96 cm), Pusa Nanha (53.71 cm), Acc. 8 (53.75 cm), Arka Prabath (55.10 cm), Acc. 12 (55.76 cm), Acc. 22 (56.12 cm) and Acc. 13 (56.68 cm).

At 10 MAP Acc. 18 recorded the highest petiole length of 110.45 cm followed by Acc. 25 (94.91 cm) and Acc. 17 (90.69 cm). Lowest petiole length was recorded by Arka Prabath (56.54 cm) which was on par with Acc.15 (57.75 cm) and Acc. 8 (58.87 cm).

At 12 MAP, Acc. 18 recorded the highest petiole length of 120.30 cm followed by Acc. 25 (106.68 cm) and Acc. 17 (101.35 cm). Lowest petiole length was recorded by Arka Prabath (66.59 cm) which was on par with Acc. 12 (68.59 cm), Acc. 15 (69.15 cm), Acc. 8 (70.32 cm), Pusa Nanha (72.76 cm), CO 8 (73.23 cm) and Acc. 4 (74.88 cm).

4.2.1.5 Colour of Petiole

With respect to petiole colour, the plants showed variations. Five types of petiole colour viz., pale green, normal green, dark green, green and shades of red purple, red purple were observed in the accessions.

4.2.1.6 Number of Fully Developed Leaves

The data on number of leaves of different accessions/ varieties at bimonthly interval are given in Table 16. At 2 MAP, CO 7 recorded the highest number of fully developed leaves of 17.11 followed by Acc. 19 (16.11), Acc. 11 (15.66) and Acc. 8 (15.11). The lowest number of fully developed leaves was recorded in Acc. 5 and

Table 15. Petiole length and colour of papaya accessions/ varieties

Accessions/ varieties	Length of petiole (cm)						Colour of petiole
	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP	
Acc. 1	32.19	38.94	50.55	66.27	89.50	99.47	Normal green
Acc. 2	29.94	42.05	53.17	64.87	86.85	97.82	Normal green
Acc. 3	32.05	38.70	57.50	68.76	80.26	93.44	Normal green
Acc. 4	26.44	37.92	52.16	57.52	63.55	74.88	Normal green
Acc. 5	22.61	34.60	52.50	60.94	70.04	80.56	Red purple
Acc. 6	27.30	38.44	54.39	58.28	65.50	75.33	Normal green
Acc. 7	26.89	37.69	57.83	71.57	86.20	98.89	Normal green
Acc. 8	30.69	40.11	52.11	53.75	58.87	70.32	Normal green
Acc. 9	29.81	37.55	54.28	65.85	76.84	86.74	Red purple
Acc. 10	28.00	38.91	54.22	62.32	69.34	81.14	Normal green
Acc. 11	35.77	40.59	52.39	61.54	75.45	85.11	Red purple
Acc. 12	28.67	40.48	51.83	55.76	59.04	68.59	Normal green
Acc. 13	26.83	36.67	49.00	56.68	64.47	75.92	Normal green
Acc. 14	32.27	36.93	57.89	68.97	83.74	95.81	Normal green
Acc. 15	24.22	34.83	49.10	52.96	57.75	69.15	Normal green
Acc. 16	26.39	37.76	55.05	63.94	73.96	78.16	Normal green
Acc. 17	34.40	38.67	53.80	73.92	90.69	101.35	Red purple
Acc. 18	26.83	37.67	56.17	81.03	110.45	120.30	Normal green
Acc. 19	31.96	38.74	55.39	65.25	74.08	87.66	Normal green
Acc. 20	30.56	38.11	56.77	60.68	68.26	79.39	Normal green
Acc. 21	26.18	40.36	42.59	60.01	81.40	80.81	Green and shades of red purple
Acc. 22	29.67	33.00	46.42	56.12	69.13	79.49	Normal green
Acc. 23	26.29	31.73	49.44	57.25	68.31	80.89	Normal green
Acc. 24	29.07	43.79	58.00	67.10	74.61	85.83	Red purple
Acc. 25	33.11	41.50	54.11	77.36	94.91	106.68	Red purple
Arka Prabath	22.55	36.58	54.93	55.10	56.54	66.59	Normal green
CO 8	23.67	36.50	37.80	51.12	61.78	73.23	Normal green
CO 7	32.16	35.64	51.72	65.01	77.31	86.22	Normal green
CO 2	24.62	41.47	53.00	61.96	71.06	83.86	Normal green
Pusa Nanha	20.55	34.75	45.50	53.71	62.32	72.76	Normal green
CD (0.05)	5.96	5.72	6.74	5.94	2.39	8.60	

MAP – Months after planting

Acc. 15 (10.77 each) followed by Acc. 18 (11.00), Pusa Nanha (11.33), Acc. 6 (11.50) and Acc. 24 (11.54).

At 4 MAP, Acc. 22 recorded the highest number of fully developed leaves of 21.50 followed by Acc. 18 (21.18), Acc. 11 and Acc. 1 (19.99 each), Acc. 8 (18.98), Acc. 20 (18.66), Acc. 19 (18.65), Acc. 7 (18.33) and Acc. 12 (18.18). The lowest number of fully developed leaves was recorded by CO 8 (12.65) followed by Acc. 25 (13.35), Acc. 15 (13.88) and Pusa Nanha.

At 6 MAP, Acc. 1 recorded the highest number of fully developed leaves of 26.87 followed by Acc. 22 (25.55), Acc. 11 (25.25), Acc. 18 (23.32), Arka Prabath (22.90) and Acc.7 (22.68) were on par with Acc. 1. The lowest number of fully developed leaves was recorded by CO 8 (15.89) followed by Acc. 4 (17.50), Acc. 15 (15.55), Acc. 23 (17.66) and Acc. 24 (18.20).

At 8 MAP, Acc. 11 recorded the highest number of fully developed leaves of 31.44 followed by Acc. 22 (29.67), Acc. 7 (28.66), Acc. 18 (28.17) and these were on par. The lowest number of fully developed leaves was recorded by CO 8 (18.33) which was on par with Acc. 4 (20.00), Acc. 15 (20.72), Acc. 24 (20.81), Acc. 21 (21.33), Acc. 23 (21.66) and Acc. 13 (22.00).

At 10 MAP, Acc. 11 recorded the highest number of fully developed leaves of 30.72 followed by Acc. 1 (28.22), Acc. 12 (27.50), Acc. 17 (26.24), and Arka Prabath (25.22). The lowest number of fully developed leaves was recorded in Acc. 5 (17.83) followed by Acc. 25 (18.33), Acc. 15 (18.50), and Acc. 24.

At 12 MAP, Acc. 11 recorded the highest number of fully developed leaves of 33.15 followed by Acc. 12 (32.35), Acc. 1 (31.42), Acc. 17 (29.93), Acc. 8 (29.45), Acc. 2 (29.31) and Acc. 3 (29.1). Lowest number of fully developed leaves was

Table 16. Number of fully developed leaves of selected accessions/ varieties

Accessions/ varieties	Number of fully developed leaves					
	2MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
Acc. 1	14.44	19.19	26.87	27.22	28.22	31.42
Acc. 2	14.22	16.16	20.56	26.11	24.44	29.31
Acc. 3	14.66	17.00	18.97	23.39	25.11	29.10
Acc. 4	13.33	15.52	17.50	20.00	20.33	24.15
Acc. 5	10.78	15.66	18.46	22.44	17.83	23.04
Acc. 6	11.50	15.99	19.26	22.89	21.52	24.89
Acc. 7	13.11	18.33	22.68	28.66	23.05	27.21
Acc. 8	15.11	18.98	20.93	23.66	24.78	29.45
Acc. 9	14.33	16.99	20.41	24.39	23.44	27.73
Acc. 10	12.66	16.33	20.97	27.22	21.78	26.05
Acc. 11	15.66	19.99	25.25	31.44	30.72	33.15
Acc. 12	12.07	18.18	20.91	25.17	27.50	32.35
Acc. 13	12.00	14.84	18.42	22.00	21.66	24.06
Acc. 14	13.83	17.00	20.12	25.33	20.33	23.93
Acc. 15	10.78	13.88	17.55	20.72	18.50	21.83
Acc. 16	13.11	15.99	18.76	22.22	22.89	26.27
Acc. 17	13.14	14.25	19.42	25.23	26.24	29.93
Acc. 18	11.00	21.18	23.32	28.17	22.67	27.61
Acc. 19	16.11	18.65	21.36	24.16	22.71	26.47
Acc. 20	14.11	18.66	21.76	26.22	20.77	24.97
Acc. 21	12.33	16.08	18.58	21.33	24.22	28.70
Acc. 22	14.17	21.50	25.55	29.67	23.00	26.99
Acc. 23	12.61	14.06	17.66	21.66	21.39	24.99
Acc. 24	11.54	15.49	18.20	20.81	19.89	23.71
Acc. 25	11.89	13.35	19.37	24.67	18.33	22.81
Arka Prabath	11.99	17.50	22.90	27.44	25.22	28.06
CO 8	12.22	12.65	15.89	18.33	20.17	24.64
CO 7	17.11	16.38	19.76	25.39	21.83	26.33
CO 2	12.89	16.19	18.41	23.03	21.23	24.84
Pusa Nanha	11.33	14.05	19.20	23.83	20.67	25.03
CD (0.05)	3.28	2.90	3.41	5.03	4.25	4.29

MAP - Months after planting

recorded by Acc. 15 (21.83) followed by Acc. 25 (22.81), Acc. 5 (23.04), Acc. 24 (23.71), Acc. 14 (23.93) and Acc. 13 (24.06).

4.2.2 Flowering and Fruiting Characters

The data on flowering and fruiting of papaya accessions/ varieties are given in Table 17.

4.2.2.1 Days to First Flowering

Lowest time taken for first flowering was observed in Acc. 4 (88.87 days) which was on par with Acc.2 (89 days), Acc. 17 (95.41 days) and Acc. 12 (97.67 days).

Acc. 16 took maximum number of days to first flowering (132.26 days) followed by Acc. 9 (129.12 days), CO 2 (128.33 days), Acc. 25 (125.05), Arka Prabath (125.02 days), Acc. 6 (124.15 days), Acc.18 (123.63 days), Acc. 8 (123.60 days) and these were on par.

4.2.2.2 Height at First flowering

Lowest flowering height was recorded by CO 8 (61.00 cm) which was on par with Pusa Nanha (62.73 cm) followed by Acc. 23 (81.04 cm), CO 2 (84.14 cm), Acc. 15 (85.49 cm) and Acc. 1 (87.67 cm). Highest flowering height of 152.27 cm was recorded in CO 7 which was on par with Acc.17 (150.40 cm) followed by Acc.19 (138.49 cm).

4.2.2.3 Sex Expression of Plant

The data on sex expression are given in Table 16. The accessions were dioecious and gynodioecious in nature.

4.2.2.4 Fruit Weight

Highest fruit weight of 1830 g was recorded in Acc. 15 followed by CO 8



Acc. 1



Acc. 2



Acc. 3



Acc. 4



Acc. 5



Acc. 6



Acc. 7



Acc. 8



Acc. 9



Acc. 10



Acc. 11



Acc. 12

Plate 3: Papaya accessions/ varieties in fruiting stage



Acc. 13



Acc. 14



Acc. 15



Acc. 16



Acc. 17



Acc. 18



Acc. 19



Acc. 20



Acc. 21



Acc. 22



Acc. 23



Acc. 24

Plate 3: Papaya accessions/ varieties in fruiting stage



Acc. 25



Arka Prabath



CO 8



CO 9



CO 2



Pusa Nanha

Plate 3: Papaya accessions/ varieties in fruiting stage

(1770 g), Pusa Nanha (1621.67 g) and was on par with Acc. 15. Next best treatment with reference to fruit weight was CO 2 (1316.67 g), followed by Acc. 4 (1261.33 g), Arka Prabath (1153.33), Acc. 2 (1030.00), Acc. 9 (1020.67 g).

Lowest fruit weight was recorded by Acc. 22 (406.67 g) which was on par with Acc. 5 (416.67 g), Acc. 20 (626.67 g), CO 7 (653.33 g), Acc. 16 (713.33 g), Acc. 14 (748.89 g), Acc. 19 (763.33 g), Acc. 8 (766.67 g) and Acc. 10 (803.33 g).

4.2.2.5 Fruit Length

Highest fruit length of 29.00 cm was recorded in Acc. 15 followed by Acc. 23 (28.58 cm), CO 8 (27.50 cm), Pusa Nanha (25.67 cm), Acc. 4 (25.58 cm) and CO 2 (25.50 cm) and these were on par. Lowest fruit length was recorded by Acc. 22 (16.50 cm) which was on par with CO 7 (18.33 cm) and Acc. 5 (18.50 cm) followed by Acc. 14 (20.80 cm).

4.2.2.6 Circumference of Fruit

Highest circumference of fruit was recorded in CO 8 (48.00 cm) followed by Pusa Nanha (47.58 cm), Acc. 15 (45.60 cm), Acc. 4 (44.91 cm), Acc. 3 (41.50 cm) and CO 2 (41.50 cm) and these were on par. Lowest circumference of fruit was recorded in Acc. 5 (23.75 cm) which was on par with Acc. 22 (25.67 cm), Acc. 20 (29 cm), Acc. 8 and Acc. 11 (31.58 cm each).

4.2.2.7 Fruit Shape

With respect to fruit shape, the fruits showed wide variation. Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong to ellipsoid and club shapes were observed.

4.2.2.8 Fruit Volume

Highest fruit volume of 2060 ml was recorded by Acc. 15 followed by CO 8

Table 17. Flowering and fruiting characters of papaya accessions/ varieties

Accessions/ varieties	Days to first flowering	Height at first flowering	Sex expression of plant	Fruit weight (g)	Fruit length (cm)	Circumference of fruit (cm)
Acc. 1	104.33	87.67	Gynodioecious	810.00	21.75	33.50
Acc. 2	89.00	103.29	Dioecious	1030.00	24.25	37.17
Acc. 3	107.33	108.14	Gynodioecious	973.33	22.00	41.50
Acc. 4	88.87	110.81	Gynodioecious	1261.33	25.58	44.91
Acc. 5	122.30	119.00	Gynodioecious	416.67	18.50	23.75
Acc. 6	124.15	129.59	Dioecious	920.00	21.42	38.42
Acc. 7	117.13	121.71	Gynodioecious	856.67	23.42	32.25
Acc. 8	123.60	111.33	Dioecious	766.67	22.67	31.58
Acc. 9	129.12	114.33	Dioecious	1020.67	24.50	36.75
Acc. 10	107.54	122.46	Dioecious	803.33	23.00	38.50
Acc. 11	116.50	103.16	Dioecious	866.67	23.58	31.58
Acc. 12	97.67	129.50	Gynodioecious	953.33	21.67	35.75
Acc. 13	116.72	95.00	Dioecious	991.11	21.55	39.08
Acc. 14	117.66	98.04	Gynodioecious	748.89	20.80	32.50
Acc. 15	112.00	85.49	Dioecious	1830.00	29.00	45.60
Acc. 16	132.26	135.92	Gynodioecious	713.33	21.67	37.52
Acc. 17	95.41	150.40	Dioecious	896.67	21.67	37.83
Acc. 18	123.63	129.31	Gynodioecious	860.00	22.42	33.83
Acc. 19	115.83	138.49	Gynodioecious	763.33	22.08	36.00
Acc. 20	106.45	108.56	Gynodioecious	626.67	20.92	29.00
Acc. 21	120.01	113.67	Dioecious	993.33	23.92	38.42
Acc. 22	120.50	102.76	Dioecious	406.67	16.50	25.67
Acc. 23	120.00	81.04	Gynodioecious	926.67	28.58	35.10
Acc. 24	122.29	101.63	Gynodioecious	917.78	22.50	39.39
Acc. 25	125.05	113.36	Dioecious	901.67	22.20	38.22
Arka Prabath	125.02	108.53	Gynodioecious	1153.33	23.33	35.00
CO 8	116.24	61.00	Dioecious	1770.00	27.50	48.00
CO 7	118.25	152.27	Gynodioecious	653.33	18.33	35.08
CO 2	128.33	84.14	Dioecious	1316.67	25.50	41.50
Pusa Nanha	118.73	62.73	Dioecious	1621.67	25.67	47.58
CD (0.05)	9.68	11.40		401.03	4.02	8.06

(2020 ml), Pusa Nanha (1823.33 ml) and these were on par. Lowest fruit volume was recorded by Acc. 22 (366.67 ml) which was on par with Acc. 5 (460 ml), CO 7 (776.67 ml), Acc. 20 (778.33 ml) and Acc. 16 (790 ml).

4.2.2.9 Flesh Thickness

Highest flesh thickness of 2.98 cm was recorded in Pusa Nanha followed by CO 2 (2.70 cm), Acc. 6 (2.68 cm), Acc. 11 (2.67 cm), Acc. 4 (2.62 cm) and Acc. 23 (2.60 cm). Lowest flesh thickness was recorded by Acc. 5 (1.42 cm) which was on par with Acc. 22 (1.83 cm) and Acc. 8 (1.90 cm).

4.2.2.10 Flesh Colour

Fruits of different accessions showed variation in flesh colour, ranging from light yellow to scarlet.

4.2.2.11 Peel Pulp Ratio

Lowest peel pulp ratio was recorded by Acc. 8 (0.093) followed by Acc. 5 (0.104), CO 2 (0.105), Acc. 6 and Pusa Nanha (0.115 each). Highest peel pulp ratio of 0.246 was recorded in CO 7 followed by Acc. 25 (0.208) and these were on par.

4.2.2.12 Cavity Volume

Lowest cavity volume was recorded by Acc. 22 (25 ml) followed by Acc. 5 (66.66 ml), Acc. 23 (90 ml), Acc. 12 (95.64 ml), Arka Prabath (113.14 ml), Acc. 20 (119.89 ml) and Acc. 25 (120.20 ml). Highest cavity volume of 443.49 ml was recorded in CO 8 followed by Acc. 4 (313.49 ml) and these were on par.

4.2.2.13 Cavity Index

Lowest cavity index was recorded by Acc. 22 (6.11) followed by Acc. 15 (7.79), Acc. 23 (8.58), Acc. 12 (10.25) and Acc. 25 (11.00). Highest cavity index of

Table 17. Flowering and fruiting characters of papaya accessions/ varieties (continued)

Accessions/ varieties	Fruit shape	Fruit volume (ml)	Flesh thickness (cm)	Flesh colour	Peel pulp ratio	Cavity volume (ml)	Cavity index
Acc. 1	Elongate	888.33	2.45	Scarlet	0.174	253.33	28.90
Acc. 2	Oblong- ellipsoid	1202.22	2.48	Bright yellow	0.134	244.44	20.39
Acc. 3	High round	1170.00	2.40	Bright yellow	0.136	187.20	16.41
Acc. 4	Round	1434.13	2.62	Deep yellow to orange	0.154	313.49	21.53
Acc. 5	Pear shaped	460.00	1.42	Light yellow	0.104	66.66	11.70
Acc. 6	Acron	1107.50	2.68	Light yellow	0.115	189.55	17.33
Acc. 7	Blossom end tapered	940.00	2.43	Bright yellow	0.169	174.00	19.36
Acc. 8	Elongate	843.33	1.90	Light yellow	0.093	158.66	19.68
Acc. 9	Club shaped	1083.33	2.38	Bright yellow	0.138	287.11	26.24
Acc. 10	Elongate	900.00	2.30	Light yellow	0.152	205.78	22.57
Acc. 11	Elongate	923.33	2.67	Light yellow	0.121	148.55	16.38
Acc. 12	Oval	1043.33	2.57	Bright yellow	0.15	95.64	10.25
Acc. 13	Globular	1078.89	2.49	Scarlet	0.186	248.89	20.67
Acc. 14	Lengthend cylindrical	803.33	2.25	Reddish orange	0.163	178.04	22.68
Acc. 15	Round	2060.00	2.47	Reddish orange	0.124	171.51	7.97
Acc. 16	High round	790.00	2.30	Light yellow	0.136	159.53	19.87
Acc. 17	Plum shaped	1060.00	2.13	Bright yellow	0.119	204.44	18.12
Acc. 18	Eliptic	933.33	2.23	Light yellow	0.122	139.29	14.73
Acc. 19	Oval	906.67	2.32	Bright yellow	0.14	160.49	18.22
Acc. 20	Elongate	778.33	2.15	Bright yellow	0.176	119.89	15.26
Acc. 21	Acron	1186.67	2.17	Bright yellow	0.162	214.04	17.78
Acc. 22	Oval	366.67	1.83	Bright yellow	0.151	25.00	6.11
Acc. 23	Round	1080.00	2.60	Light yellow	0.169	90.00	8.58
Acc. 24	Pear shaped	1195.55	2.53	Bright yellow	0.131	177.32	14.32
Acc. 25	Oval	1078.00	2.57	Bright yellow	0.208	120.20	11.00
Arka Prabath	Lengthened cylindrical	1090.00	2.43	Light yellow	0.116	113.14	11.49
CO 8	elongate	2020.00	2.55	Bright yellow	0.126	443.49	22.67
CO 7	Pear shaped	776.67	2.20	Scarlet	0.246	123.01	15.60
CO 2	Oval	1576.67	2.70	Light yellow	0.105	210.44	12.90
PusaNanha	Globular	1823.33	2.98	Deep yellow to orange	0.115	247.33	14.17
CD (0.05)		436.61	0.58		0.051	148.82	11.95

28.90 was recorded in Acc. 1 followed by Acc. 9 (26.24), Acc. 14 (22.68), CO 8 (22.67), Acc. 10 (22.57) and Acc. 4 (21.53).

4.2.2.14 Number of Fruits/ Plant

Accession 25 produced highest number of fruits per plant (35.11) followed by Acc. 1 (32.66), Acc. 5 (32.33), Acc. 6 (30.11) and these three were on par. The next best treatments with reference to number of fruits were Acc. 9 (25.44), Acc. 11 (23.38) and Acc. 19 (21.67).

Lowest number of fruits was recorded in Acc. 22 (6.67) followed by Arka Prabath (7.93), Acc. 12 (9.50), Acc. 15 (9.67), Acc. 13 (9.89), Acc. 24 (10.44), CO 8 (10.48), Acc. 23 (11.33), Acc. 17 (12.80) and CO 7 (13.50).

4.2.2.15 Yield (kg/ plant)

The highest per plant yield of 31.50 kg was recorded in Acc. 25 followed by Acc. 6 (27.63 kg/ plant), Acc. 1 (26.57 kg/ plant), Acc. 9 (25.77 kg/ plant) and Pusa Nanha (25.12 kg/ plant) and these were on par. The next best treatments with reference to per plant yield were CO 2 (22.33 kg/ plant), Acc. 4 (20.46 kg/ plant) and Acc. 11 (20.28 kg/ plant).

Lowest yield was recorded by Acc. 22 (2.47 kg/ plant) which was on par with CO 7 (8.65 kg/ plant), Acc. 12 (9.32 kg/ plant), Acc. 24 (9.34 kg/ plant) and Arka Prabath (9.40 kg/ plant).

4.2.2.16 Days to Ripening

Lowest time taken for fruit ripening was recorded by Acc. 14 (103.77 days) followed by Acc. 4 (117.27 days) which was on par with Acc. 22 (118.43 days).

Maximum days for fruit ripening were recorded in Acc. 12 (165 days)

followed by Acc. 17 (163.53 days), Pusa Nanha (160.80 days), Acc. 19 (158.65 days) and CO 7 (157.81 days).

4.2.2.17 Days to First Harvest

Minimum days for first harvest was recorded by Acc. 14 (228.75 days) followed by Acc. 2 (246.06 days) and Acc. 15 (246.63 days). Maximum days for first harvest was recorded in Arka Prabath (304.73 days) followed by Acc. 8 (288.97 days).

4.2.2.18 Number of Seeds/ Fruit

Highest number of seeds per fruit was recorded in CO 8 (687.23) followed by CO 7 (634.28) and was on par with CO 8. Next higher number of seeds per fruit was obtained in Acc. 20 (600.12) which was on par with Acc. 23 (547.77). Lowest number of seeds per fruit was recorded by Acc. 16 (215.50) which was on par with Acc. 24 (253.93), Acc. 8 (263.28), Acc. 25 (269.08) and Acc. 12 (271.49).

4.2.2.19 Weight of 100 Seeds

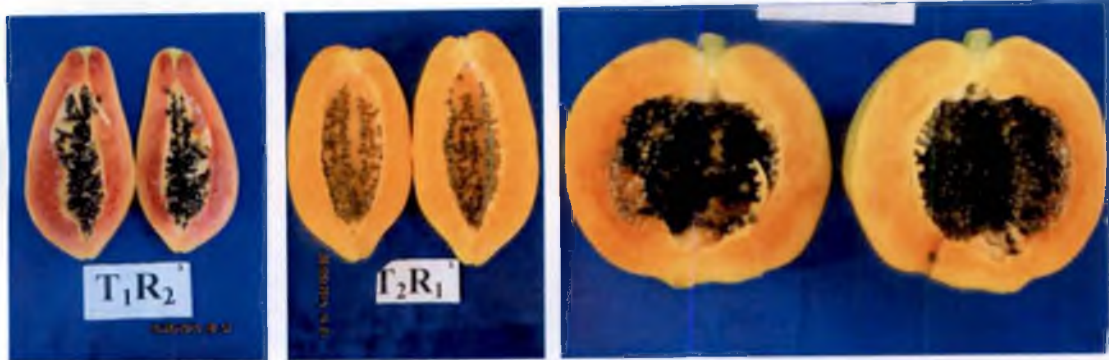
The highest seed weight for 100 seeds was recorded in Acc. 12 (3.42 g) followed by Acc. 1 (3.31 g), Acc. 8 (3.28 g), Acc. 14 (3.24 g), Acc. 6 (3.20 g) and these were on par. Lowest seed weight for 100 seeds was recorded by Arka Prabath (2.60 g) which was on par with Acc. 11 (2.68 g), Acc. 25 (2.79 g) and Acc. 22 (2.87 g).

4.2.3 Sensory Evaluation

The data on organoleptic characters, viz., appearance, colour, taste, sweetness, aroma and texture of the fruits among the different accessions/ varieties are presented in Table 18. The mean rank obtained for appearance ranged from 2.95 to 25.26. Pusa Nanha recorded highest mean rank (25.26) followed by Acc. 13 (22.31) and Acc. 15.

Table 17. Flowering and fruiting characters of papaya accessions/ varieties (continued)

Accession / varieties	No. of fruits/ plant	Yield(kg/ plant)	Days to ripening	Days to first harvest	No. of seeds/ fruit	100 seed weight (g)
Acc. 1	32.66	26.57	142.83	259.83	428.95	3.31
Acc. 2	18.27	18.52	146.06	246.06	443.36	3.07
Acc. 3	19.55	19.39	134.79	254.45	521.17	2.89
Acc. 4	16.33	20.46	117.27	249.88	305.89	2.93
Acc. 5	32.33	13.63	153.58	282.51	286.27	2.89
Acc. 6	30.11	27.63	151.62	283.59	373.90	3.20
Acc. 7	14.78	12.60	130.57	256.16	321.17	2.96
Acc. 8	15.28	11.63	155.70	288.97	263.28	3.28
Acc. 9	25.44	25.77	137.42	275.59	413.82	2.99
Acc. 10	19.17	15.46	155.19	275.19	394.55	3.10
Acc. 11	23.38	20.28	152.06	271.73	428.19	2.68
Acc. 12	9.50	9.32	165.00	278.33	271.49	3.42
Acc. 13	9.89	9.53	138.88	258.77	330.40	2.98
Acc. 14	15.89	11.59	103.77	228.75	506.95	3.24
Acc. 15	9.67	17.57	126.30	246.63	344.59	2.91
Acc. 16	15.72	11.39	145.22	254.11	215.40	2.93
Acc. 17	12.80	11.59	163.53	272.35	399.01	2.91
Acc. 18	14.50	12.44	134.00	269.27	445.60	3.05
Acc. 19	21.67	16.48	158.65	283.65	310.37	2.97
Acc. 20	15.89	9.68	150.50	267.46	600.12	3.00
Acc. 21	17.83	17.44	152.37	281.59	412.19	3.09
Acc. 22	6.67	2.47	118.43	248.76	541.27	2.87
Acc. 23	11.33	10.54	147.41	273.00	547.77	2.97
Acc. 24	10.44	9.34	135.40	266.19	253.93	3.13
Acc. 25	35.11	31.50	150.52	282.95	269.08	2.79
Arka Prabath	7.93	9.40	153.71	304.73	481.13	2.60
CO 8	10.48	18.55	140.30	254.83	687.23	2.96
CO7	13.50	8.65	157.81	266.81	634.26	2.96
CO2	16.77	22.33	150.53	275.76	477.19	3.04
Pusa Nanha	16.17	25.12	160.80	282.95	442.63	2.89
CD (0.05)	8.87	8.68	8.01	6.91	61.39	0.292



Acc. 1

Acc. 2

Acc. 3



Acc. 4

Acc. 5



Acc. 6



Acc. 7



Acc. 8



Acc. 9



Acc. 10

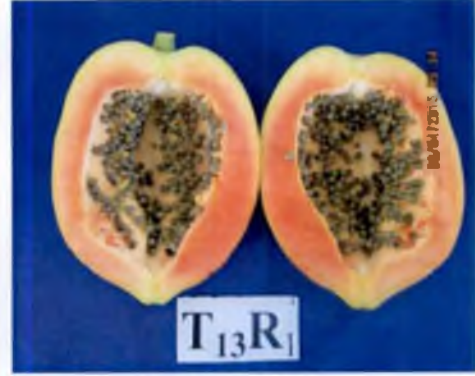
Plate 4: Longitudinal section of papaya accessions/ varieties



Acc. 11



Acc. 12



Acc. 13



Acc. 14



Acc. 15



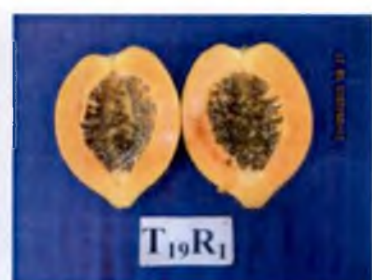
Acc. 16



Acc. 17



Acc. 18



Acc. 19

Plate 4: Longitudinal section of papaya accessions/ varieties



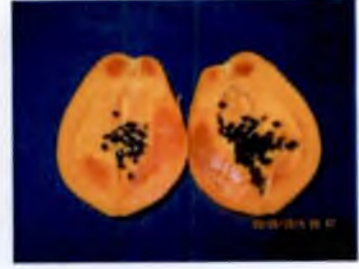
Acc. 20



Acc. 21



Acc. 22



Acc. 23



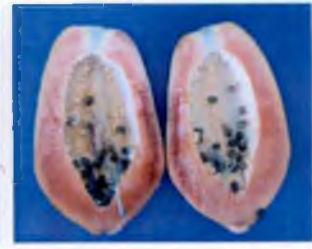
Acc. 24



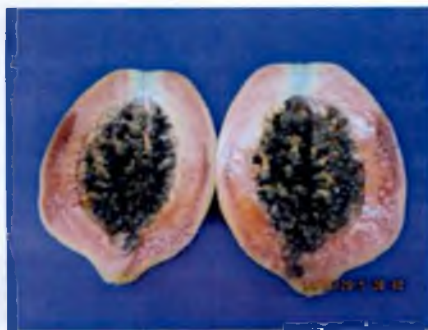
Acc. 25



Arka Prabath



CO 8



CO 7



CO 2



Pusa Nanha

Plate 4: Longitudinal section of papaya accessions/ varieties

(22.19). Accession 10 recorded the lowest mean rank (2.95) followed by Acc. 8 (7.98).

The mean rank obtained for colour ranged from 4.38 to 23.12. Accession 15 recorded highest mean rank (23.87) followed by Acc. 13 (23.12) and Acc. 25 (21.53). Accession 23 recorded the lowest mean rank (4.38) followed by Acc. 16 (8.42).

The mean rank obtained for sweetness ranged from 4.76 to 25.4. Accession 8 recorded highest mean rank (25.4) followed by Acc. 18 (24.2) and Acc. 11 (22.47). Accession 10 recorded the lowest mean rank (4.76) followed by Acc. 24 (5.36).

The mean rank obtained for taste ranged from 3.87 to 24.78. Accession 8 recorded highest mean rank (24.78) followed by CO 7 (23.12) and Acc. 18 (19.55). Accession 10 recorded the lowest mean rank (3.87) followed by Acc. 24 (4.45).

The mean rank obtained for aroma ranged from 6.28 to 22.68. Accession 25 recorded highest mean rank (22.68) followed by CO 8 (22) and Acc. 12 (21.67). Accession 8 recorded the lowest mean rank (6) followed by Acc. 11 (6.28)

The mean rank obtained for texture ranged from 4.38 to 22.33. Arka Prabath recorded highest mean rank (22.33) followed by CO 7 (21.93) and Acc. 24 (20.18). Accession 21 recorded the lowest mean rank (4.38) followed by Acc. 3 (8.12).

4.2.4 Biochemical Analysis of Fruit

The data on biochemical analysis of fruits are presented in Table 19.

4.2.4.1 Total Soluble Solids (TSS)

Total soluble solids (TSS) of the fruit showed significant variation among treatments. The highest TSS of 15.17 °Brix was recorded by Acc.21 followed by Acc. 11 (14.68 °Brix), Acc. 22 (14.47 °Brix), Acc. 8 (14.43 °Brix) and these were on par.

Table 18. Sensory evaluation of papaya accessions/ varieties

Accession/ varieties	Appearance (mean rank)	Colour (mean rank)	Taste (mean rank)	Sweetness (mean rank)	Aroma (mean rank)	Texture (mean rank)
Acc. 1	18.66	19.05	18.20	18.43	17.65	17.37
Acc. 2	19.09	16.78	21.67	15.60	21.35	16.35
Acc. 3	12.86	15.77	19.18	18.36	16.47	8.12
Acc. 4	13.52	19.03	16.37	18.53	14.63	9.42
Acc. 5	13.21	11.02	10.67	8.91	7.73	10.97
Acc. 6	16.93	8.88	12.02	6.91	14.30	16.17
Acc. 7	14.14	15.68	17.62	15.45	20.78	18.30
Acc. 8	7.98	9.20	24.78	25.40	6.00	13.48
Acc. 9	17.53	15.23	13.12	11.97	6.98	15.52
Acc. 10	2.95	12.47	3.87	4.76	19.85	20.18
Acc. 11	15.81	11.80	20.28	22.47	6.28	14.47
Acc. 12	15.00	19.10	13.05	15.07	21.67	18.42
Acc. 13	22.31	23.12	17.10	12.71	13.32	11.57
Acc. 14	20.97	19.65	21.58	22.25	18.72	13.12
Acc. 15	22.19	23.87	18.78	14.33	13.98	13.00
Acc. 16	15.02	8.42	13.07	16.45	16.58	18.23
Acc. 17	19.09	17.97	8.88	22.22	9.48	12.03
Acc. 18	13.31	8.73	19.55	24.12	17.17	18.32
Acc. 19	15.41	12.05	17.72	22.02	20.72	16.37
Acc. 20	15.14	17.33	5.20	6.95	13.72	17.62
Acc. 21	12.91	13.45	19.88	20.29	11.08	4.38
Acc. 22	10.21	15.93	12.08	13.76	10.28	16.57
Acc. 23	14.38	4.38	17.25	11.53	19.35	19.28
Acc. 24	12.66	18.40	4.45	5.36	7.03	20.18
Acc. 25	13.55	21.53	14.13	9.79	22.68	17.45
Arka Prabath	13.14	5.87	15.52	18.34	21.18	22.33
CO 8	14.66	21.87	16.58	19.47	22.00	15.93
CO 7	17.19	26.25	20.60	22.28	20.38	21.93
CO 2	19.95	11.88	16.57	15.31	19.18	14.43
Pusa Nanha	25.26	20.28	15.98	11.05	14.43	13.50
KW	0.293	0.448	0.405	0.476	0.415	0.261

The next best treatments with reference to TSS were Acc. 17 (13.97 °Brix), Acc. 18 (13.33 °Brix), Acc. 19 (13.27 °Brix), Acc. 6 (13.13 °Brix) and Acc. 2 (13.12 °Brix).

The lowest TSS was recorded by Acc. 10 (9.90 °Brix) followed by Acc. 24 (11.15 °Brix), CO 2 (11.63 °Brix), Pusa Nanha (11.70 °Brix) and Acc. 9 (11.73 °Brix).

4.2.4.2 Sugars

Highest per cent of reducing sugar was recorded by Acc. 11 (10.49 %) followed by Acc. 14 (10.36 %), Acc. 22 (9.92 %), Acc. 3 (9.92 %), Acc. 13 (9.90 %) and Acc. 29 (9.86 %).

Next best treatments with reference to reducing sugar were Acc. 18 (9.72 %), Acc. 4 (9.66 %), Acc. 8 (9.63 %), Acc. 17 (9.53 %) and Acc. 1 (9.48 %); all these treatments were statistically on par. Pusa Nanha recorded the lowest per cent of reducing sugar (7.75 %) followed by Acc. 10 (8.05 %) and Acc. 15 (8.00 %).

Accession 3 recorded the highest per cent of total sugar (10.89 %), followed by Acc. 11 (10.65 %), Acc. 14 (10.63 %), Acc. 4 (10.51 %), Acc. 13 (10.40) and these were on par. Pusa Nanha recorded the lowest per cent of total sugar (8.09 %) followed by Acc. 15 (8.46 %) and Acc.10 (8.48 %).

With respect to non- reducing sugar there was no significant difference among the treatments.

4.2.4.3 Vitamin C

Vitamin C exhibited significant difference among the treatments. It was highest in CO 7 (164.3 mg/ 100 g) and significantly superior to all other treatments. Next best treatments with reference to Vitamin C were Acc. 20 (120 mg/ 100 g),

Acc. 6 (117.6 mg/ 100 g), Acc. 8 (114.67 mg/100 g) and Acc. 11 (114.40 mg/ 100 g); all these treatments were statistically on par.

Lowest vitamin C content was reported in Pusa Nanha (34.67 mg/ 100 g), followed by Acc. 3 (47.12 mg/ 100 g), Acc. 29 (48.33 mg/ 100 g), Acc. 15 (51.19 mg/ 100 g), Acc. 14 (51.27 mg/ 100 g) and these were on par.

4.2.4.4 Beta Carotene

The highest beta carotene content was observed in Acc. 22 (42.67 mg/ 100 g), Acc. 13 (40.43 mg/ 100 g) and these two were on par. This was followed by Acc. 25 (28.80 mg/ 100 g), Acc. 9 (27.30 mg/100 g) and Acc. 19 (27.19 mg/ 100 g). Accession 16 recorded the lowest beta carotene content (8.54 mg/ 100 g) followed by Acc. 18 (9.58 mg/ 100 g).

4.2.5 Incidence of Pest and Diseases

No serious pest and diseases were noticed during the observation period except slight incidence of viral disease in Arka Prabath and fruit rot in Acc. 4, Acc. 10, Acc. 18, Acc. 20 and Pusa Nanha.

Table 19. Biochemical analysis of papaya accessions/ varieties

Accessions/ varieties	TSS (°Brix)	Acidity (%)	Reducing sugar (%)	Total sugar (%)	Non reducing sugar (%)	Vitamin C (mg/ 100 g)	Beta carotene (mg/ 100 g)
Acc. 1	12.77	0.203	9.48	9.93	0.45	104.27	16.19
Acc. 2	13.12	0.155	8.42	9.15	0.73	79.11	12.42
Acc. 3	14.13	0.261	9.92	10.89	0.97	47.12	15.00
Acc. 4	12.83	0.285	9.66	10.51	0.85	73.98	26.99
Acc. 5	12.80	0.139	8.80	9.16	0.37	98.20	13.24
Acc. 6	13.13	0.181	9.37	10.03	0.66	117.60	15.77
Acc. 7	12.40	0.181	8.69	9.29	0.59	93.60	18.08
Acc. 8	14.43	0.192	9.63	9.94	0.30	114.67	10.24
Acc. 9	11.73	0.163	8.84	9.16	0.32	80.60	27.30
Acc. 10	9.90	0.144	8.05	8.48	0.43	60.60	10.36
Acc. 11	14.68	0.203	10.49	10.65	0.16	114.40	10.89
Acc. 12	12.93	0.181	9.11	9.69	0.58	65.87	21.94
Acc. 13	12.48	0.284	9.90	10.40	0.50	74.84	40.43
Acc. 14	12.92	0.176	10.36	10.63	0.27	51.27	26.02
Acc. 15	11.80	0.203	8.09	8.46	0.37	51.19	15.63
Acc. 16	12.40	0.181	8.87	9.48	0.60	72.80	8.54
Acc. 17	13.97	0.133	9.53	9.84	0.30	92.80	12.63
Acc. 18	13.33	0.192	9.72	9.92	0.20	81.67	9.58
Acc. 19	13.27	0.160	9.18	10.10	0.93	67.72	27.19
Acc. 20	11.90	0.192	8.34	8.53	0.19	120.00	22.87
Acc. 21	15.17	0.139	9.45	9.98	0.53	72.20	25.59
Acc. 22	14.47	0.160	9.92	10.36	0.44	101.60	42.67
Acc. 23	13.73	0.192	8.81	9.56	0.75	107.60	13.40
Acc. 24	11.15	0.178	9.07	9.18	0.11	74.71	13.12
Acc. 25	12.47	0.176	8.16	8.72	0.56	58.33	28.80
Arka Prabath	12.73	0.171	8.70	8.97	0.28	95.67	14.19
CO 8	12.35	0.136	8.91	9.29	0.39	61.60	24.48
CO 7	12.37	0.167	9.19	9.78	0.69	164.27	13.05
CO 2	11.63	0.235	9.86	10.28	0.42	48.33	12.82
Pusa Nanha	11.70	0.173	7.57	8.09	0.52	34.67	21.48
CD (0.05)	2.93	NS	1.33	1.24	NS	32.30	7.56



DISCUSSION

5. DISCUSSION

Papaya (*Carica papaya* L.) is regarded as a highly nutritive and important fruit crop. It is easier to grow and produce fruits within a short period. Recently papaya has emerged as an important, industrial and medicinal fruit crop. The experiment on 'Evaluation of papaya types' was conducted with the objective of assessment of variability in papaya and to select promising types/ varieties suitable for Kerala. The results of the study are discussed in this chapter.

5.1 EXPERIMENT I - ASSESSMENT OF VARIABILITY IN PAPAYA

Variations manifested in papaya is due to its cross pollinated, heterozygous nature. Seed propagation also leads to variations in subsequent generations.

Survey was conducted in the homesteads of Thrissur, Palakkad and Ernakulam districts of Kerala to explore the variability in papaya. Initial selection of plants was done based on the general vigour of the plant. Based on the general appearance and vegetative vigour, 75 plants were tagged in these districts. Vegetative characters of a plant were identified as the attribute determining the plant vigour and yield potential (Chadha *et al.*, 1992).

Forty plants were again selected from the initially tagged ones based on different biometric, flowering and fruiting characters such as plant height, collar girth, number of fully developed leaves, leaf area, length of petiole, time of flowering, sex expression and fruit size of plant and were designated as collections for further evaluation.

Clustering into distinct groups revealed the existence of variation among the collections. The dendrogram analysis based on the qualitative characters viz., fruit

shape, flesh colour, time of flowering, sex expression and colour of petiole showed significant variation among the collections.

5.1.1 Morphological Characters

Variations in the morphological characters such as plant height, collar girth, number of leaves, leaf area and petiole length were noticed in the 40 collections.

The plant height of collections varied from 2.10 to 6.60 m. The lowest plant height of 2.10 m was recorded in Coll. 17, Coll. 19 and Coll. 20. The highest plant height was recorded by Coll. 11 (Fig. 2). The cluster mean for plant height ranged from 3.00 to 5.50 m. Cluster III recorded the lowest cluster mean value of 3.00 ± 1.27 m for plant height and cluster VI recorded the highest value of 5.5m.

Collar girth of the plants ranged from 30.00 to 88.16 cm. Collection 4 recorded the highest collar girth of 88.16 cm. Lowest collar girth of 30 cm was recorded in Coll. 13, Coll. 20 and Coll. 38. The cluster mean for collar girth varied from 36.50 to 60.50 cm. Cluster VI recorded the highest value of 60.50 cm and cluster II recorded the lowest mean value of 36.50 ± 6.26 cm. Singh and Kumar (2010) reported wide range of variability in papaya cultivars for plant height (138.4 to 240.6 cm), fruiting height (46.4 to 142.4 cm) and plant girth (28.02 to 36.8 cm). According to Singh *et al.* (2006) traits that varied significantly were plant height (mean 2.09 m) and collar girth (mean 0.33 m) in papaya types.

Number of fully developed leaves varied among the collections. Collection 3 recorded the highest number of 56 leaves and lowest number of 12 leaves was recorded in Coll. 30. The cluster mean value for number of leaves ranged from 20.00 to 36.66. Cluster IX recorded the highest value of 36.66 ± 4.16 and cluster VII recorded the lowest cluster mean value of 20 for number of leaves Nirujogi and Dinesh (2012) reported variation in number of leaves in papaya varieties. The number

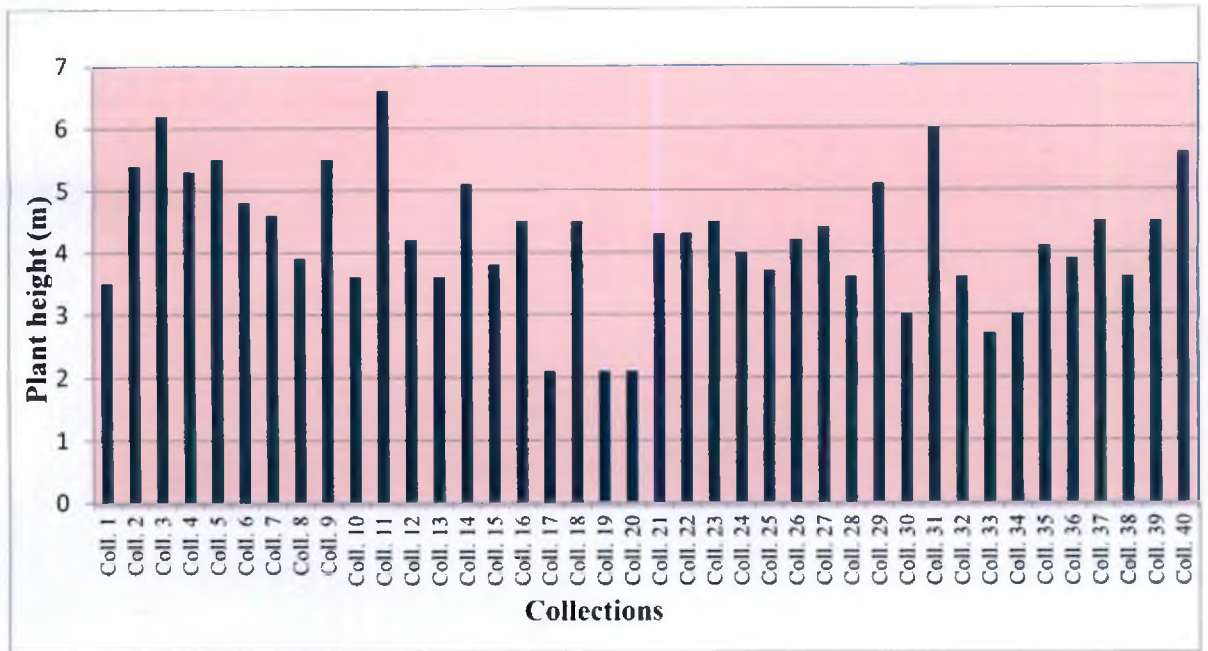


Fig. 2. Plant height of 40 papaya collections

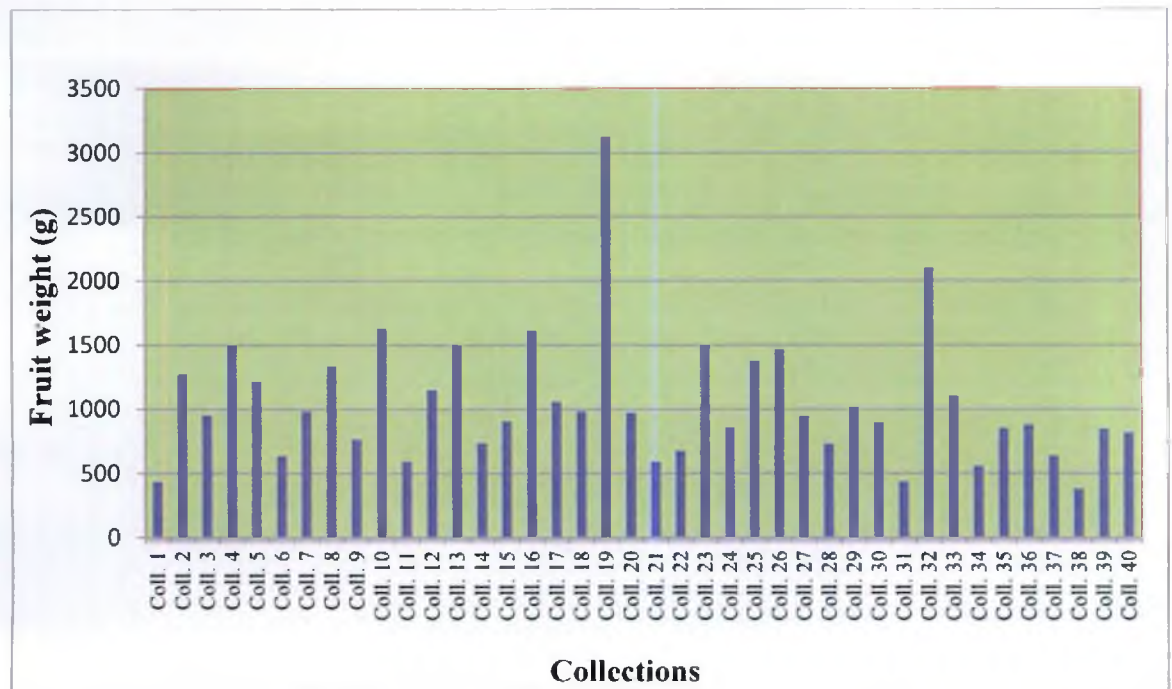


Fig. 3. Fruit weight of 40 papaya collections

of leaves varied from 18 to 31 in Arka Surya and for Arka Prabath the value ranged from 20 to 33.

The highest leaf area was recorded in Coll. 5 (6770 cm²) and the lowest was recorded in Coll. 31 (940 cm²). The cluster mean for leaf area varied from 2446.63 to 6770.00 cm². Cluster VI recorded the highest value of 6770.00 cm² and cluster I recorded the lowest cluster mean value of 2446.63 cm² for leaf area.

Petiole length of the collections ranged from 42 to 120 cm. Collection 32 and Coll. 34 recorded the highest petiole length of 120 cm each. The lowest petiole length was recorded by Coll. 19 (42 cm). The cluster mean value for petiole length ranged from 59 to 110 cm. Cluster VI recorded the highest value of 110 cm and cluster IX recorded the lowest cluster mean value of 59 ± 15.71 cm for petiole length. With respect to petiole colour, the plants showed variations. Five types of petiole colour viz., pale green, normal green, dark green, green and shades of red purple and red purple were observed in the collections. Sompack *et al.* (2014) studied the colour of mature leaf petiole in papaya. According to them colours of mature leaf petioles can be divided into three groups, most of them had pale green leaf petioles, only 'Hinan' and 'Si Thong' had reddish-purple and pale yellow leaf petioles, respectively.

5.1.2 Flowering and fruiting characters

The peak flowering season of these collections was from September to December. During the survey, it was interesting to notice that different sex forms including female, hermaphrodite, male and sex reversing male plants existed in papaya. Female and hermaphrodite plants were selected for the study.

Fruit weight of the collections ranged from 440 to 3130 g. Highest fruit weight of 3130 g was recorded in Coll. 19 and the lowest fruit weight of 440 g was recorded in Coll. 1 and Coll. 31 (Fig. 3). Mean fruit weight varied among different

clusters. This was the highest in cluster IX (1586.66 ± 1343.36 g) and lowest in cluster II (600 ± 242). It was similar to the findings of Singh and Kumar (2010). They reported that fruit weight of papaya plants ranged from 0.48 to 2.20 kg. Length of the fruit ranged from 16.00 to 35.00 cm. Collection 19 recorded the highest fruit length of 35.00 cm. The lowest fruit length of 16.00 cm was recorded by Coll. 7 and Coll. 18. Mean fruit length varied from 17.88 ± 2.17 to 27.50 cm. This was the highest in Cluster VII (27.50 cm) and the lowest in Cluster VIII (17.88 ± 2.17 cm). Highest fruit volume of 3280.00 ml was recorded in Coll. 19 and the lowest fruit volume of 400.00 ml was recorded in Coll. 38. Mean fruit volume varied among different clusters. This was the highest in cluster IX (1706.66 ± 1374.38 ml) and the lowest in cluster II (666.67 ± 260.26 ml). It was also found that the highest fruit weight and fruit volume was recorded by Coll. 19.

Fruits showed wide variation with respect to shape also. Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong to ellipsoid and club shapes were observed during the survey. Singh and Kumar (2010) reported that elongate fruits are preferred for commercial cultivation, while round fruits are preferred for table purpose. Circumference of fruit varied among the collections. The highest fruit circumference recorded by Coll. 32 (52.00 cm). Lowest fruit circumference of 15.00 cm was recorded in Coll. 6. The cluster mean for circumference of fruit varied from 24.00 to 40.33 cm. Cluster IX recorded the highest circumference of fruit (40.33 ± 9.35 cm) and cluster VII recorded the lowest value of 24.00 cm.

Highest flesh thickness was recorded in Coll. 10 (4.3 cm) and the lowest in Coll. 7 (1.9 cm). The cluster mean for flesh thickness ranged from 2 to 3.26 cm. Cluster IX recorded the highest cluster mean value of 3.26 ± 0.64 cm for flesh thickness and cluster VII recorded the lowest value of 2.00 cm. Fruits showed variation in flesh colour, ranging from light yellow to scarlet. The variation in fruit

diameter, flesh thickness, fruit length, number of fruits per plant and fruit weight might be due to various physiological phenomenon which take place in the plant body and genetic make-up of plant variety (Meena *et al.*, 2010).

Collection 26 recorded highest number of seeds per fruit (1100). The lowest number of seeds per fruit was recorded in Coll. 22 and Coll. 24 (100 each). Number of seeds per fruit varied among different clusters. This was the highest in Cluster V (707 ± 152.92) and lowest in Cluster II (218 ± 138.37). Weight of 100 seeds was highest in Coll. 26 (5.90 g) and lowest in Coll. 38 (1.98 g). The highest mean value for 100 seed weight recorded in Cluster V (3.91 ± 0.01 g) lowest in Cluster III and VI (3 g each).

5.1.3 Sensory Evaluation

Evaluation of organoleptic characters viz., appearance, colour, taste, sweetness, aroma and texture showed significant variation among the collections.

Among the 40 collections evaluated the highest rank for appearance was given for Coll. 19 (37.25) followed by Coll. 22 (36.35) and Coll. 1 (34.4). For colour highest rank was given for Coll. 19 (42.94) followed by Coll. 22 (41.5) and Coll. 39 (36.44). Collection 10 recorded highest mean rank (36.85) for taste followed by Coll. 22 (35.25) and Coll. 18 (19.55). Collection 10 also recorded highest rank for sweetness (37.5) followed by Coll. 27 (35.1) and Coll. 15 (34.2). From the sensory evaluation, Coll. 19 was found to be promising type with respect to appearance and colour. With regard to the taste and sweetness Coll. 10 was found to be promising type.

5.1.4 Biochemical Characters

Wide variation was noticed among the collections in terms of total soluble solids (TSS), reducing sugar and total sugar. The TSS was found to vary from 3.80 °Brix to 14 °Brix. Highest TSS of 14 °Brix was reported by Coll. 1 and Coll. 4.

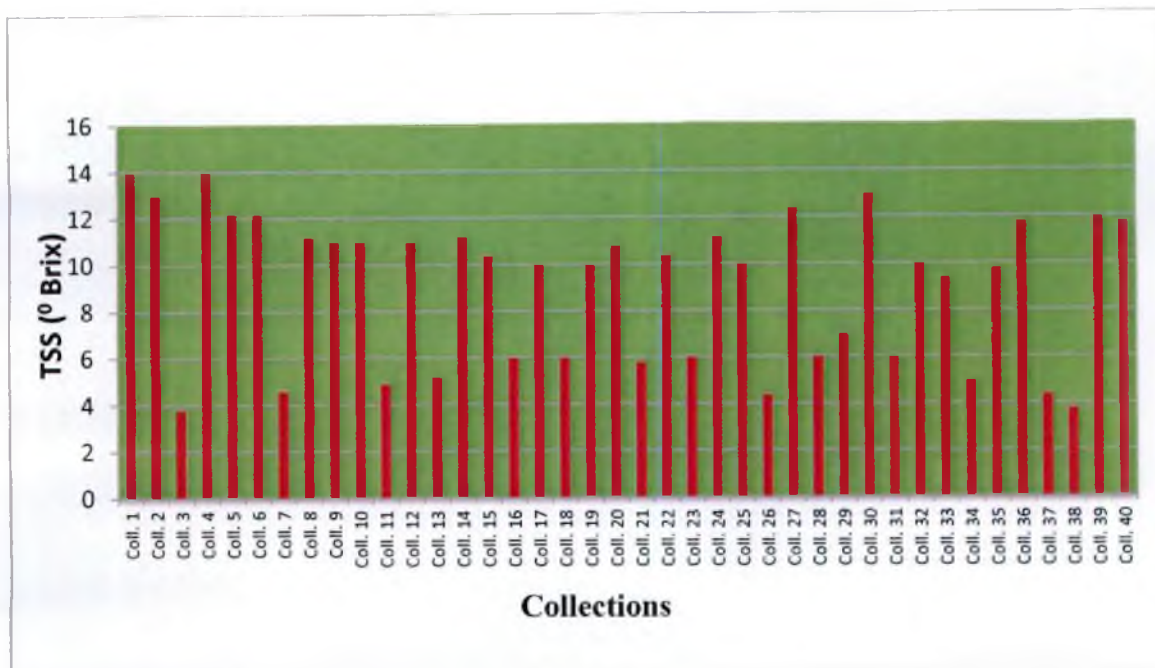


Fig. 4. Total soluble solids of 40 papaya collections

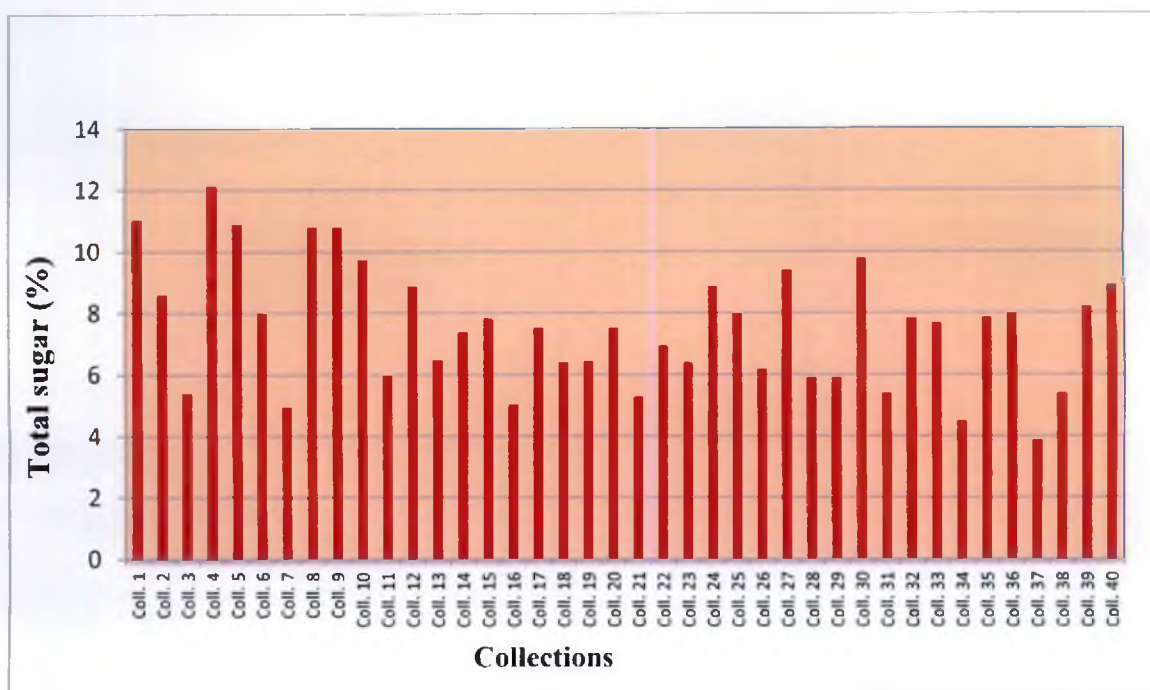


Fig. 5. Total sugar of 40 papaya collections

Lowest TSS of 3.80 °Brix was recorded in Coll. 3 and Coll.38 (Fig. 8). Total soluble solids was the highest in Cluster VI (12.20 °Brix) and the lowest was recorded by Cluster V (7.00 ± 4.39 °Brix). Acc. 4 recorded the highest reducing (10.32 %) and total sugar (12.12 %) whereas the Acc. 37 recorded the lowest reducing (3.10 %) and total sugar (3.90 %) (Fig. 5). Cluster VI recorded the highest mean value for reducing sugar (10.06 %) and total sugar (10.91 %) whereas the cluster II recorded the lowest value of 5.37 ± 1.84 per cent and 6.26 ± 2.31 per cent respectively. Collection 8 and Coll. 9 recorded the highest non - reducing sugar (2.81 %). Collection 6 recorded the lowest non – reducing sugar of 0.13 per cent. Among the clusters, mean value for non - reducing sugars ranged from 0.31 to 1.59 ± 1.18 per cent. The variation in TSS content in different varieties might be due to their genetic make-up and nature of variety which govern the chemical composition of the fruits (Meena *et al.*, 2010). Similar result was also reported by Singh *et al.* (2006).

Acidity of the accessions ranged from 0.051 to 0.153 per cent. The cluster mean for acidity ranged from 0.07 to 0.15 per cent. Cluster IV recorded the lowest cluster mean value of 0.07 ± 0.02 per cent for acidity and cluster VII recorded the highest value of 0.15 per cent. Chemical composition of papaya fruit was greatly influenced by cultivar variation, growing location, sunlight exposure, agricultural practices, stage of ripeness and postharvest handling. Similar results were also reported by Wall (2006) and Sancho *et al.* (2011).

In the present study biochemical characters and sensory qualities were taken as important parameters and plants producing fruits having TSS of 9.40 ° Brix and total sugar of 6.44 per cent or more alone were considered in the further selection procedure. From the 40 collections 25 accessions were selected for the field evaluation based on plant height, fruit weight, TSS, sugars and sensory qualities. These accessions were distributed in all the nine clusters. Similar procedure of variability assessment has already been reported by Sompak (2014).

5.2 EXPERIMENT II - EVALUATION OF SELECTED TYPES/ VARIETIES

Study on growth and development of papaya accessions/ varieties revealed significant differences in biometric, flowering, fruiting and biochemical characters.

5.2.1 Morphological Characters

In this experiment, the plant growth was assessed in terms of plant height, collar girth, number of fully developed leaves, leaf area and petiole length.

The data presented in Table 12 to 16 depicts that there was significant difference among the treatments at all stages of growth from second month onwards with respect to plant height, collar girth, number of leaves, leaf area, length and colour of petiole. In Papaya, dwarf stature is desirable as it facilitate easy harvesting of the fruits and it can also be recommended for HDP (High Density Planting). Since the plant stem is hollow, chances for braking the plant is more with an increases in plant height. In the present investigation Pusa Nanha recorded the lowest plant height (1.79 m) followed by Acc. 15 (1.87 m) and Acc. 13 (1.95 m) which were on par. It was also observed that Pusa Nanha recorded the lowest plant height throughout the growth period (Fig. 6). Ram (2005) reported that Pusa Nanha is a dwarf mutant, growing to a height of 106 cm approximately. The dwarf stature of Pusa Nanha was retained under Kerala condition also.

Collar girth is also an important character which determines the vigour of the plant. Highest collar girth of 94.62 cm was recorded in CO 8 towards the end of the observation period. It was found that the increase in plant height and collar girth was maximum during the early stages of growth and towards later period the increment was less. Higher growth rate was observed during the initial period and the growth rate was declined with the advancement of age.

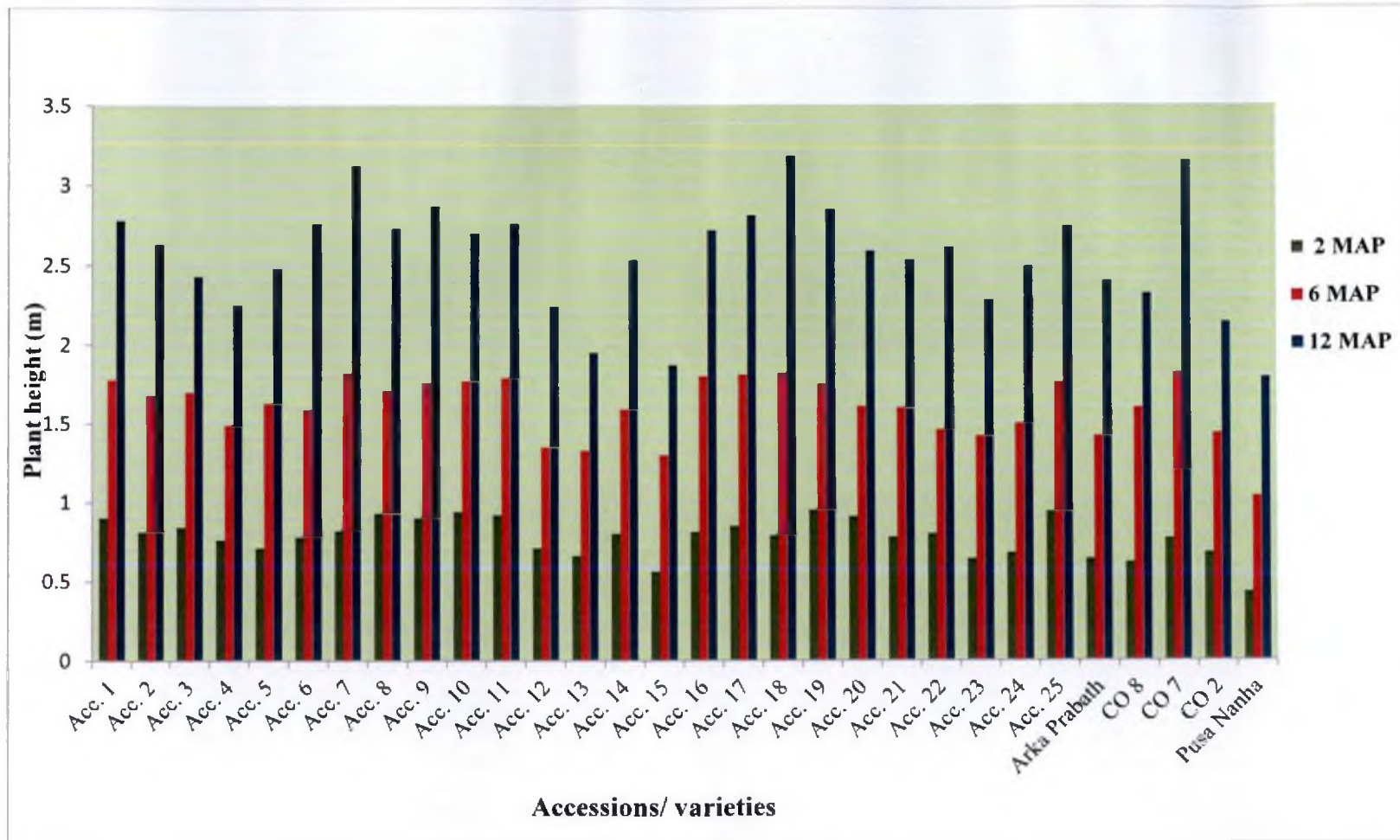


Fig.6. Plant height of papaya accessions/ varieties

Number of leaves and leaf area are the most important vegetative parameters which measure the photosynthetic ability and they determine the fruit yield of the plant. In the present study number of fully developed leaves and leaf area did not show a steady increase, instead the trend was found different among the accessions/ varieties. However, Dwivedi *et al.* (1999) found that fruit production was significantly and positively correlated with collar girth and the number of leaves per plant at flowering. Petiole length was increased with the advancement of growth in different accessions. Accession 25 recorded the highest yield and number of fruits per plant in the present study. The highest petiole length was also recorded by Acc. 25 next to Acc. 18. According to Ram (2005) petiole length was positively correlated with number of fruits.

With respect to petiole colour, the plants showed variations. Five types of petiole colour viz., pale green, normal green, dark green, green and shades of red purple, red purple were observed in the accessions/ varieties.

5.2.2 Flowering and Fruiting Characters

Significant difference was observed with respect to flowering and fruiting characters of papaya.

Early flowering and low height of first flowering are the most desirable traits in papaya. Accession 4, Acc. 2, Acc. 17 and Acc. 12 were earlier in flowering. Among the accessions/ varieties evaluated the plant height at first flowering varied from 61.00 to 152.27 cm. Lowest flowering height was recorded by CO 8 (61.00 cm) followed by Pusa Nanha (62.73 cm), Acc. 23 (81.04 cm), CO 2 (84.14 cm), Acc. 15 (85.49 cm) and Acc. 1 (87.67 cm). Flowering at lower height will facilitate easy harvesting and the total fruit yield is directly correlated with height (Ghanta *et al.*, 1995).

The prime objective of any breeding programme in fruit crops is ultimately

concerned with the improvement in fruit quality and yield parameters. In papaya, fruit size, shape and per plant yield are the most important characters for consideration.

Highest fruit weight (1830 g), fruit length (29.00 cm) and fruit volume (2060 ml) was recorded in Acc. 15 (Fig. 7). Highest fruit length of 29.00 cm was recorded in Acc. 15 followed by Acc. 23 (28.58 cm), CO 8 (27.50 cm), Pusa Nanha (25.67 cm), Acc. 4 (25.58 cm) and CO 2 (25.50 cm) and these were on par. Highest fruit circumference of 48.00 cm was recorded in CO 8. With respect to fruit shape, the fruits showed wide variation. Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong to ellipsoid and club shapes were observed.

With regard to the yield attributes also significant differences were noticed among the accessions/ varieties. Accession 25 produced higher number of 35.11 fruits per plant followed by Acc. 1, Acc. 5 and Acc. 6 (32.66, 32.33, and 30.11 respectively) and these were on par (Fig. 8). Significantly highest per plant yield of 31.50 kg was recorded in Acc. 25 followed by Acc. 6 (27.63 kg/ plant), Acc. 1 (26.57 kg/ plant), Acc. 9 (25.77 kg/ plant) and Pusa Nanha (25.12 kg/ plant) were on par (Fig. 9). It was also observed that as the number of fruits increases fruit yield also increases. According to Singh and Kumar (2010) number of fruits per plant varied from 32.6 to 62.4 and fruit yield per plant varied from 20.8 to 38.4 Kg/ plant. Meena *et al.* (2010) reported maximum diameter of fruit (11.67 cm), length of fruit (19.21 cm) and yield (23.67 kg/ plant) in Pusa Nanha.

Flesh thickness, peel pulp ratio, cavity volume and cavity index were ultimately determine the edible portion of the fruit. Highest flesh thickness of 2.98 cm was recorded in Pusa Nanha followed by CO 2 (2.70 cm), Acc. 6 (2.68 cm), Acc. 11 (2.67 cm), Acc. 4 (2.62 cm) and Acc. 23 (2.60 cm). Meena *et al.* (2010) also reported maximum flesh thickness and yield for Pusa Nanha.

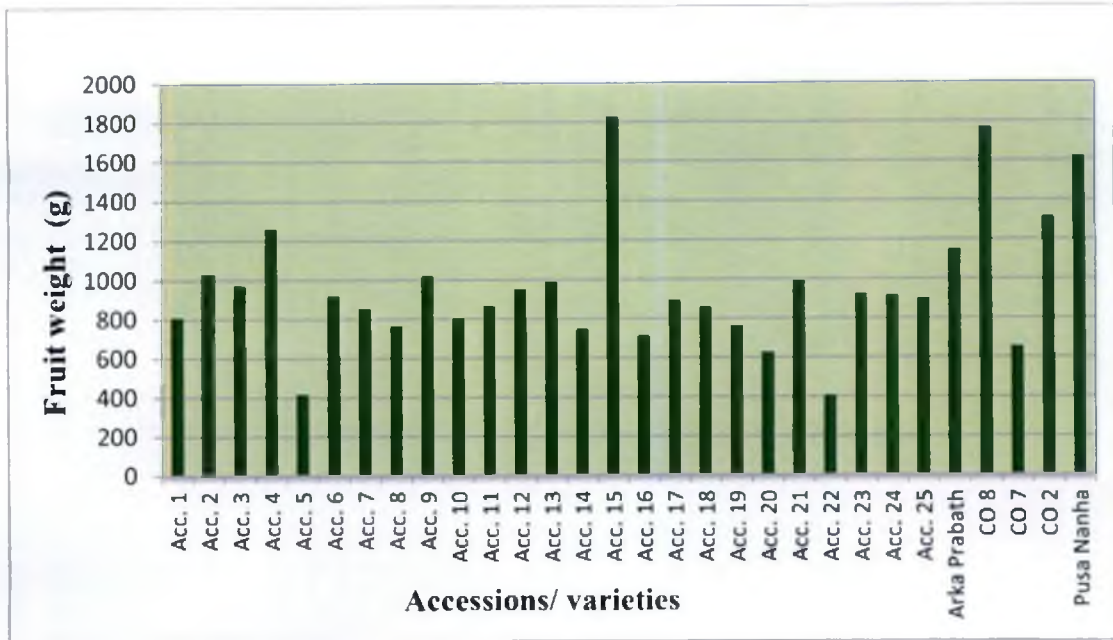


Fig. 7. Fruit weight of papaya accessions/ varieties

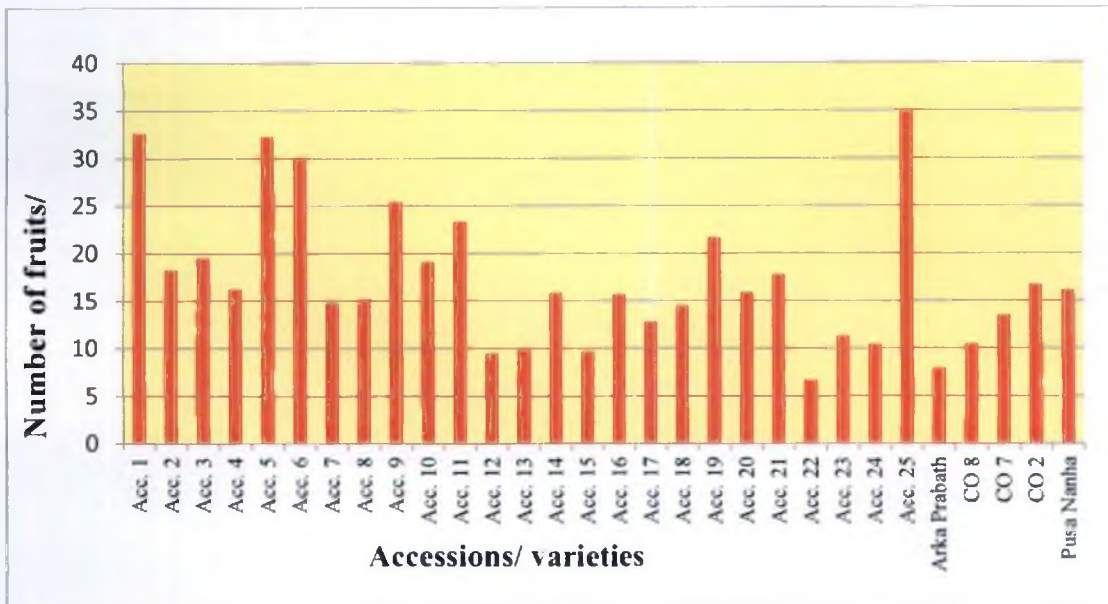


Fig. 8. Number of fruits/ plant of papaya accessions/ varieties

Lowest peel pulp ratio was recorded by Acc. 8 (0.093). Lowest cavity volume (25 ml) and cavity index (6.11) was recorded by Acc. 22. In papaya minimum values for cavity volume and cavity index are preferred on account of high pulp recovery. Fruits of different accessions showed variation in flesh colour which includes light yellow, bright yellow, deep yellow to orange, reddish orange and scarlet. Generally, the dioecious lines produce yellow fleshed fruits while gynodioecious lines bear both yellow and red fleshed fruits (Balamohan *et al.*, 2010). Pink or red pulped fruits are mostly preferred in international market rather than the yellow pulped in view of their appearance and taste.

Since papaya is commercially grown by seeds, quality and number of seeds per fruit are the most important aspect for successful production. Highest number of seeds per fruit was recorded in CO 8 (687.23) followed by CO 7 (634.28), Acc. 20 (600.12) and Acc. 23 (547.77). The highest seed weight for 100 seeds was recorded in Acc. 12 (3.42 g). Rathinavel (1986) reported that large seeds of papaya variety CO 3 and CO 4 showed highest per cent of seed germination, speed of germination, root and shoot length, vigour index and dry matter production of seedling.

The number of days from flowering to fruit maturity should be less so that the total crop duration is not extended unduly. Lowest time taken for fruit ripening was recorded by Acc. 14 (103.77 days) followed by Acc. 4 (117.27 days) and Acc. 22 (118.43 days). Minimum days for first harvest was recorded by Acc. 14 (228.75 days) followed by Acc. 2 (246.06 days) and Acc. 15 (246.63 days).

5.2.3 Sensory Evaluation

Evaluation of organoleptic characters *viz.*, appearance, colour, taste, sweetness, aroma and texture showed significant variation among the accessions/ varieties.

Among the twenty five accessions and five varieties evaluated the highest rank for appearance was given for Pusa Nanha (25.26) followed by Acc. 13 (22.31) and Acc. 15 (22.19). For colour highest rank was given for Acc. 15 (23.87) followed by Acc. 13 (23.12) and Acc. 25 (21.53). Accession 8 recorded highest mean rank (24.78) for taste followed by Acc. 2 (21.67), Acc. 14 (21.58), CO 7 (20.60) and Acc. 11 (20.28). Accession 8 also recorded highest rank for sweetness (25.4) followed by Acc. 18 (24.2) and Acc. 11 (22.47), CO 7 (22.28) and Acc. 14 (22.25). From the sensory evaluation, Acc. 8 was found to be promising type with respect to taste and sweetness.

5.2.4 Biochemical Analysis of Fruit

Significant differences were observed with regard to quality attributes (TSS, sugars and acidity). The highest TSS of 15.17 °Brix was recorded by Acc. 21, followed by Acc. 11 (14.68 °Brix) Acc. 22 (14.47 °Brix) and Acc. 8 (14.43 °Brix) were on par (Fig. 10). Highest per cent of reducing sugar was recorded by Acc. 11 (10.49 %) followed by Acc. 14 (10.36 %), Acc. 22 (9.92 %), Acc. 3 (9.92 %), Acc. 13 (9.90 %) and Acc.29 (9.86 %). Acc. 3 recorded the highest per cent of total sugar (10.89 %), followed by Acc. 11 (10.65 %), Acc. 14 (10.63 %), Acc. 4 (10.51 %) and Acc. 13 (10.40 %). Vitamin C exhibited significant difference among the accessions/ varieties. It was highest in CO 7 (164.3 mg/ 100 g) followed by Acc. 20 (120 mg/ 100 g), Acc. 6 (117.6 mg/ 100 g), Acc. 8 (114.67 mg/100 g) and Acc. 11 (114.40 mg/ 100 g). Beta carotene is the precursor molecule of vitamin A hence it is known as pro vitamin A. The highest beta carotene content was observed in Acc. 22 (42.67 mg/ 100 g) followed by Acc. 13 (40.43 mg/ 100 g).

5.3 Promising types/ varieties

Survey was conducted in the homesteads of Thrissur, Palakkad and Ernakulam districts of Kerala. Significant variability was observed during the survey

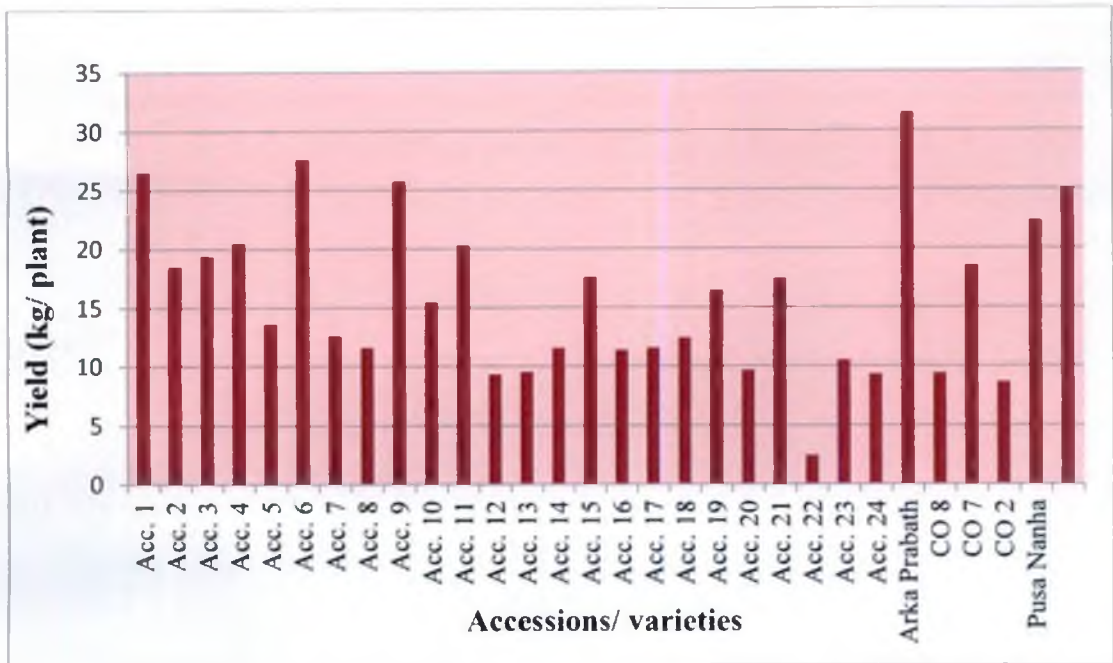


Fig. 9. Yield of papaya accessions/ varieties

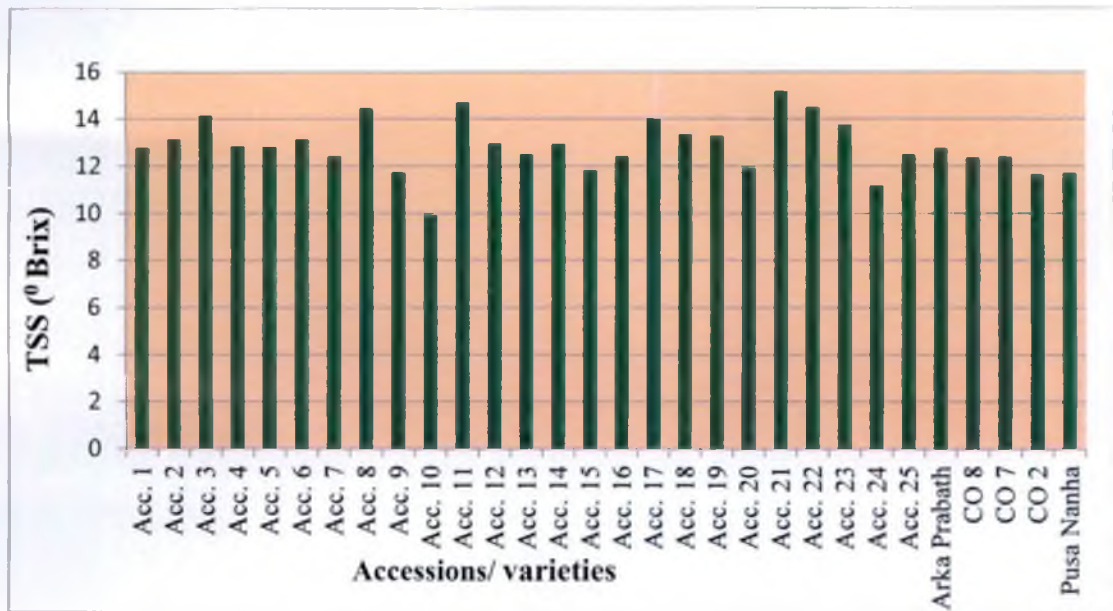
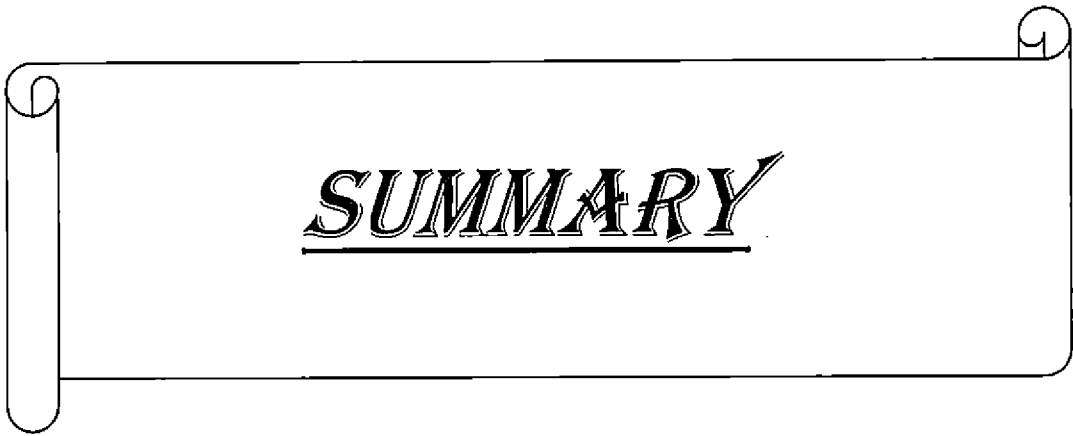


Fig. 10. Total Soluble Solids (TSS) of papaya accessions/ varieties

and 25 accessions were selected through a selection procedure for detailed study in the field. As a result of field evaluation eight accessions viz., Acc. 1, Acc. 6, Acc. 8, Acc. 11, Acc. 13, Acc. 14, Acc. 15, Acc. 25 and Pusa Nanha were found to be promising. The plant height of these promising types/ varieties ranged from 1.79 to 2.78 m. The yield per plant was highest for Acc. 25 (31.50 kg) and TSS was varied from 7.57 to 14.43 °Brix for selected accessions. All these selected accessions have reasonably higher sensory qualities. However further evaluation of accessions is necessary to get confirmatory results.



SUMMARY

SUMMARY

The study entitled 'Evaluation of papaya types' was carried out at College of Horticulture, Vellanikkara, during 2013 to 2015. The main objective of the study was to assess the variability in papaya and select the promising types/ varieties suitable for Kerala. The salient findings of the study are summarized below:

The plant height of 40 collections varied from 2.1 to 6.6 m. Collection 17, Coll. 19 and Coll. 20 recorded the lowest plant height of 2.1m each. The cluster mean for plant height ranged from 3.00 to 5.50 m. Cluster III recorded the lowest cluster mean value of 3.00 ± 1.27 m for plant height. Collar girth of the plant ranged from 30.00 to 88.16 cm. Collection 4 recorded the highest collar girth of 88.16 cm. The cluster mean for collar girth varied from 36.50 to 60.5 cm. Cluster VI recorded the highest value of 60.50 cm for collar girth.

Number of fully developed leaves varied among the collections. Highest number of 56 leaves was recorded in Coll. 3. The cluster mean value for number of leaves ranged from 20.00 to 36.66. Cluster IX recorded the highest value of 36.66 ± 4.16 . The highest leaf area was recorded in Coll. 5 (6770 cm^2) and the lowest was recorded in Coll. 31 (940 cm^2). The cluster mean for leaf area varied from 2446.63 to 6770.00 cm^2 . Cluster VI recorded the highest value of 6770.00 cm^2 for leaf area.

Petiole length of the collections ranged from 42 to 120 cm. Collection 32 and Coll. 34 recorded the highest petiole length of 120 cm each. The cluster mean value for petiole length ranged from 59 to 110 cm. Cluster VI recorded the highest value of 110 cm. With respect to petiole colour, the plants showed variations. In most of the collections petiole was pale green and normal green in colour. Some of them have red purple petiole, it is also observed that green and shades of red purple in petiole colour.

The peak flowering season was from September to December. During the survey, it was interesting to see that different sex forms including female, hermaphrodite, male and sex reversing male plants. Female and hermaphrodite plants were selected for the study.

Fruit weight of the collections varied from 440 to 3130 g. Highest fruit weight of 3130 g was recorded in Coll. 19. Mean fruit weight varied among different clusters. This was the highest in cluster IX (1586.66 ± 1343.36 g). Highest fruit volume of 3280 ml was recorded in Coll. 19. Mean fruit volume varied among different clusters. This was highest in cluster IX (1706.66 ± 1374.38 ml) and the lowest in cluster II (666.67 ± 260.26 ml).

Fruits showed wide variation with respect to shape also. Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong to ellipsoid and club shapes were observed during the survey. Circumference of fruit varied among the collections. The highest fruit circumference recorded by Coll. 32 (52.00 cm). The cluster mean for circumference of fruit varied from 24.00 to 40.33 cm. Cluster IX recorded the highest cluster mean value of 40.33 ± 9.35 cm for circumference of fruit.

Highest flesh thickness was recorded in Coll. 10 (4.3 cm) .The cluster mean for flesh thickness ranged from 2 to 3.26 cm. Cluster IX recorded the highest cluster mean value of 3.26 ± 0.64 cm for flesh thickness. Fruits showed variation in flesh colour, ranging from light yellow to scarlet.

From the sensory evaluation, Coll. 19 was found to be promising type with respect to appearance and colour. With regard to the taste and sweetness Coll. 10 was found to be promising type.

The total soluble solids (TSS) varied from 3.8 °Brix to 14 °Brix. The highest TSS of 14 °Brix was recorded in Coll. 1 and Coll. 4. TSS was the highest in cluster VI (12.20 °Brix) and the lowest was recorded by cluster V (7.00 ± 4.39 °Brix). Reducing sugar and total sugar varied from 3.10 to 10.32 per cent and 3.90 to 12.12 respectively. Highest per cent of reducing sugar and total sugar was recorded in Coll. 4 and lowest was recorded in Coll. 37. Cluster VI recorded the highest mean value for reducing sugar (10.06 %) and total sugar (10.91 %). Collection 8 and Coll. 9 were recorded the highest non – reducing sugar (2.81 %). Among the clusters mean value for non - reducing sugars ranged from 0.31 per cent to 1.59 ± 1.18 per cent.

As a result of survey and collection twenty five accessions were selected from 40 collections for detailed studies. These twenty five accessions along with five released varieties *viz.*, Arka Prabath, CO 8, CO 7, CO 2 and Pusa Nanha were used for field evaluation.

In the field evaluation Pusa Nanha recorded the lowest plant height throughout the observation period. Accession 15 and Acc. 13 comparatively short in nature. Highest collar girth of 94.62 cm was recorded in CO 8 towards the end of the observation period.

The number of fully developed leaves and leaf area did not show a steady increase, instead the trend was found different among the accessions/ varieties. Petiole length was increased with the advancement of growth. With respect to petiole colour, the plants showed variations. Five types of petiole colour *viz.*, pale green, normal green, dark green, green and shades of red purple, red purple were observed in the accessions/ varieties.

Accession 4, Acc. 2, Acc. 17 and Acc. 12 were earlier in flowering. Among the accessions/ varieties evaluated the plant height at first flowering varied from 61.00 to 152.27 cm. Lowest flowering height was recorded by CO 8 (61.00 cm)

followed by Pusa Nanha (62.73 cm), Acc. 23 (81.04 cm), CO 2 (84.14 cm), Acc. 15 (85.49 cm) and Acc. 1 (87.67 cm).

Highest fruit weight (1830 g), fruit length (29.00 cm) and fruit volume (2060 ml) was recorded in Acc. 15. Highest circumference of fruit was recorded in CO 8 (48.00 cm). With respect to fruit shape, the fruits showed wide variation. Acron, pear shaped, oval, round, elongate, blossom end tapered, lengthened cylindrical, oblong, elliptic, oblong to ellipsoid and club shapes were observed.

Highest flesh thickness of 2.98 cm was recorded in Pusa Nanha followed by CO 2 (2.70 cm), Acc. 6 (2.68 cm), Acc. 11 (2.67 cm), Acc. 4 (2.62 cm) and Acc. 23 (2.60 cm). Lowest peel pulp ratio was recorded by Acc. 8 (0.093). Lowest cavity volume (25 ml) and cavity index (6.11) was recorded by Acc. 22. Fruits of different accessions showed variation in flesh colour which included light yellow, bright yellow, deep yellow to orange, reddish orange and scarlet.

Highest number of seeds per fruit was recorded in CO 8 (687.23) followed by CO 7 (634.28), Acc. 20 (600.12) and Acc. 23 (547.77). The highest seed weight for 100 seeds was recorded in Acc. 12 (3.42 g).

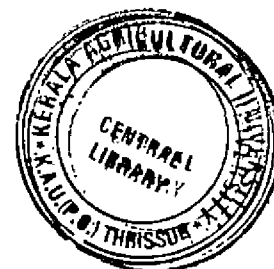
Accession 25 produced highest number of fruits per plant (35.11) followed by Acc. 1 (32.66), Acc. 5 (32.33) and Acc. 6 (30.11). Significantly highest per plant yield of 31.50 kg was recorded in Acc. 25 followed by Acc. 6 (27.63 kg/ plant), Acc. 1 (26.57 kg/ plant), Acc. 9 (25.77 kg/ plant) and Pusa Nanha (25.12 kg/ plant). Lowest time taken for fruit ripening (103.77 days) and harvesting (228.75) was recorded in Acc. 14.

From the sensory evaluation, Acc. 8 was found to be promising type with respect to taste and sweetness. The highest TSS of 15.17 °Brix was recorded by Acc.21 followed by Acc. 11 (14.68 °Brix), Acc. 22 (14.47 °Brix) and Acc. 8 (14.43

^oBrix). Highest per cent of reducing sugar was recorded by Acc. 11 (10.49 %) followed by Acc. 14 (10.36 %), Acc. 22 (9.92 %), Acc. 3 (9.92 %), Acc. 13 (9.90 %) and Acc. 29 (9.86 %). Accession 3 recorded the highest per cent of total sugar (10.89 %), followed by Acc. 11 (10.65 %), Acc. 14 (10.63 %), Acc. 4 (10.51 %) and Acc. 13 (10.40).

Vitamin C exhibited significant difference among the accessions/ varieties. It was highest in CO 7 (164.3 mg/ 100 g) followed by Acc. 20 (120 mg/ 100 g), Acc. 6 (117.6 mg/ 100 g), Acc. 8 (114.67 mg/100 g) and Acc. 11 (114.40 mg/ 100 g). The highest β carotene content was observed in Acc. 22 (42.67 mg/ 100 g) followed by Acc. 13 (40.43 mg/ 100 g).

As a result of survey, collection and evaluation eight accessions and Pusa Nanha were selected for further research work. These included Acc. 1, Acc. 6, Acc. 8, Acc. 11, Acc. 13, Acc. 14, Acc. 15, Acc. 25 and Pusa Nanha.





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APPENDICES

APPENDIX 1

Score card for the organoleptic evaluation of fruits

Name of the scorer:

Please score the given fruit samples using 9 point hedonic scale.

Score	Inference
9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Treatments	Appearance	Colour	Taste	Sweetness	Aroma	Texture

Remarks:

APPENDIX II

Physico – chemical properties of soil

Soil physical properties	
Sand	77.25 %
Silt	4.89 %
Clay	17.21 %
Soil chemical properties	
pH	5.5
Electrical conductivity (dS/m)	0.05
Organic carbon (%)	1.46
Available Phosphorus (kg/ ha)	48.34
Available Potassium(kg/ ha)	436.8
Available Calcium (mg/ kg)	695.5
Available Magnesium (mg/ kg)	132
Available Sulphur (mg/ kg)	2.17
Micronutrients	
Copper (mg/ kg)	2.33
Iron (mg/ kg)	16.36
Zinc (mg/ kg)	1.62
Manganese (mg/ kg)	8.49
Boron (mg/ kg)	0.45

APPENDIX III

Weather data 2014-2015 - Vellanikkara

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Mean maximum temperature (0 C)													
2014	32.9	34.7	36.7	35.3	33.2	30.9	29.5	29.5	31.3	31.9	31.6	31.9	32.5
2015	32.5	34.3	35.8	34.0	32.9	31.0							
Mean minimum temperature (0C)													
2014	23.0	22.9	24.2	25.7	24.2	24.4	23.1	23.2	23.3	23.7	23.2	22.5	23.6
2015	22.1	23.0	24.9	24.6	24.7	23.9							
Mean relative humidity (%)													
2014	51	56	55	73	77	85	87	87	82	81	72	65	73
2015	58	55	63	77	80	85							
Rainfall (mm)													
2014	0.0	0.0	0.0	61.0	323.6	469.8	768	599.8	215.1	224.6	85.3	9.6	2756.8 (total)
2015	0.0	0.0	72	162.2	259.0	629.8							
Rainy days													
2014	0	0	0	4	5	21	26	22	13	15	5	1	112 (total)
2015	0	0	2	8	12	23							
Total evaporation (mm)													
2014	171.3	145.0	191.5	130.8	107.5	88.7	77.6	90.2	92.8	86.1	96.9	112.1	115.9
2015	135.4	157.4	151.6	106.9	95.8	77.0							
Mean evapotranspiration (mm)													
2014	5.5	5.2	6.2	4.4	3.5	3.0	2.5	2.9	3.1	2.8	3.2	3.6	3.8
2015	4.4	5.6	4.9	3.6	3.1	2.6							
Sunshine (hrs)													
2014	277.6	240.8	264.2	192.4	182.0	90.1	49.3	81.3	172.6	135.2	151.9	188.5	168.8
2015	271.5	246.7	248.6	203.8	156.4	54.6							
Mean sunshine (hrs)													
2014	9.0	8.6	8.5	6.4	5.9	3.0	1.6	2.6	5.8	4.4	5.1	6.1	5.6
2015	8.8	8.8	8.0	6.8	5.0	1.8							
Mean wind speed (km/ hr)													
2014	6.9	4.5	3.9	2.3	2.5	2.2	2.1	1.9	2.2	2.2	3.7	5.4	3.3
2015	5.6	5.8	3.3	2.4	1.7	1.5							



ABSTRACT

EVALUATION OF PAPAYA TYPES

By
RESHMA N.T.
(2013- 12-122)

**ABSTRACT OF THE
THESIS**

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**VELLANIKKARA, THRISSUR- 680656
KERALA, INDIA
2015**

ABSTRACT

Papaya (*Carica papaya* L.) belonging to the family Caricaceae is a popular fruit of tropical world. India is the largest producer of papaya in the world (NHB, 2011). The project entitled “Evaluation of papaya types” was conducted in the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara during 2013 - 2015. The major objective of the study was to assess the variability in papaya and to select the promising types/ varieties suitable for Kerala. The study comprised of two experiments, namely assessment of variability and evaluation of promising types/ varieties.

In experiment I, a preliminary survey was conducted in the homesteads of Thrissur, Palakkad and Ernakulum districts of Kerala. Seventy five plants were tagged in different locations consisting of twenty five plants in each district. Then forty plants were selected from the initial tagged ones based on the different biometric, fruiting and flowering characters. Fruits from these forty plants were collected and subjected to quantitative and qualitative analysis. Further screening was done with special reference to plant height, fruit weight, TSS, sugars and organoleptic characters. Based on the qualitative characters viz. flesh colour, fruit shape, sex expression of plant, time of flowering and petiole colour, forty collections were grouped into nine clusters by using the statistical tool of agglomerative hierarchical clustering.

Finally twenty five accessions were evenly selected from the forty collections of nine clusters for detailed evaluation in the field. Plant height of the selected twenty five accessions ranged from 2.1 to 5.6 m and fruit weight varied from 440.0 to 2105.0 g. Total sugar and TSS of the selected 25 accessions ranged from 6.44 to 12.12 per cent and 9.40 to 14 °Brix respectively.

In experiment II, the selected twenty five accessions along with five released varieties namely Arka Prabath, CO 8, CO 7, CO 2 and Pusa Nanha were subjected to detailed studies in the field. The experiment was laid out in RBD with three replications at spacing of 2 x 2 m.

Among the accessions/ varieties evaluated, Pusa Nanha, Acc. 15 and Acc. 13 were found to have lowest plant height of 1.79, 1.87 and 1.95 m respectively, at 12 months after planting. Highest fruit weight of 1830 g was recorded in Acc. 15 followed by CO 8 (1770 g), and Pusa Nanha (1621.67 g). Highest flesh thickness of 2.98 cm was recorded in Pusa Nanha followed by CO 2 (2.70 cm), Acc. 6 (2.68 cm) and Acc. 11 (2.67 cm).

Accession 25 produced higher number of fruits per plant (35.11) followed by Acc. 1 (32.66), Acc. 5 (32.33), Acc. 6 (30.11) and these three were on par. The highest yield per plant of 31.50 kg was recorded in Acc. 25 followed by Acc. 6 (27.63 kg/ plant), Acc. 1 (26.57 kg/ plant), Acc. 9 (25.77 kg/ plant), Pusa Nanha (25.12 kg/ plant) and these were on par.

Total soluble solids (TSS) of the fruits showed significant variation among treatments. The TSS of Acc. 21, Acc. 11, Acc. 22, Acc. 8, Acc. 3, Acc. 17, Acc. 23, Acc. 18, Acc. 19 and Acc. 6 ranged from 13.13 to 15.17 °Brix and were on par. Highest per cent of reducing sugar was recorded by Acc. 11 (10.49 %) followed by Acc. 14 (10.36 %), Acc. 22 (9.92 %), Acc. 3 (9.92 %) and Acc. 13 (9.90 %). Accession 3 recorded the highest per cent of total sugar (10.89 %), followed by Acc. 11 (10.65 %), Acc. 14 (10.63 %), Acc. 4 (10.51 %) and Acc. 13 (10.40) were on par.

The highest vitamin C was recorded by CO 7 (164.27 mg/ 100 g) followed Acc. 20 (120 mg/ 100 g), Acc. 6 (117.6 mg/ 100 g), Acc. 8 (114.67 mg/100 g) and

Acc. 11 (114.40 mg/ 100 g). Sensory evaluation of fruits indicated that the Acc. 8 scored highest mean rank for sweetness and taste.

Significant variability was observed during the survey and twenty five accessions were selected for detailed study. As a result of field evaluation of 25 accessions and 5 varieties, eight accessions and Pusa Nanha were found to be promising. These included Acc. 1, Acc. 6, Acc. 8, Acc. 11, Acc. 13, Acc. 14, Acc. 15, Acc. 25 and Pusa Nanha. Further evaluation of accessions is necessary to get confirmatory results.

