VARIABILITY AND CHARACTER ASSOCIATION ANALYSIS OF PICKLING TYPE MANGO

By
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THESIS

Submitted in partial fulfilment of the requirement for the degree of

Doctor of Philosophy in Horticulture

Faculty of Agriculture
Kerala Agricultural University

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VELLANIKKARA, THRISSUR - 680656
KERALA, INDIA

2000

DECLARATION

I hereby declare that this thesis entitled "**Variability and character association analysis of pickling type mango**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled "**Variability and character association analysis of pickling type mango**" is a record of research work done independently by **Ms.Jyothi, M.L.,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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ACKNOWLEDGEMENT

I wish to place on record my deep sense of gratitude to:

Dr. S Ramachandran Nair, Professor (Horticulture), (Retd.), Kerala Agricultural University and Chairman of the Advisory Committee for his able guidance and support given throughout the course of the programme

Dr. P.K. Rajeevan, Prof. and Head, Department of Pomology and Floriculture, College of Horticulture, Vellanikkara and member, Advisory committee for all the timely advices given for the study

Dr. V.K.G. Unnithan, Professor, Department of Agricultural Statistics, College of Horticulture, Vellanikkara and member, Advisory committee for helping me in shaping the data into valuable conclusions

Dr. N. Krishnan Nair, Associate Director of Research (Retd.), Kerala Agricultural University and member, advisory committee for initiating me into the work and for the help rendered in undertaking the work.

Dr. (Mrs) T. Radha, Associate Prof., Department of Pomology and Floriculture, College of Horticulture, Vellanikkara for her sincere involvement and critical evaluation as a member of the Advisory committee.

The thesis would not have materialised but for the help provided by different persons in locating the trees, scattered in different parts. I wish to extend my sincere thanks to Sri. V.R. Narendran, Agricultural Officer, Chazhur, Sri. V.N. Chandran, Rama Nilayam, Sreekrishnapuram, Sri. Sethu and Sri. Chandran, Attoor, Sri. Navabjan, Agrl. Asst., Kongad, Dr. N.K. Parameswaran, Associate Professor, Kerala Agricultural University, Sri. Sanakara Narayanan, Mudavannoor, Sri. C. Subramanian, Anakkara, Sri. C. Gopakumar, Agricultural

Officer, Vellinezhi, Sri. Ponnumani, Agrl. Asst. Alathur, Sri. Radha Krishnahan., Mulankunnathu kavu, Sri. Hamsa, mango trader, Alanellur, Sri. Abdu, mango trader, Mundur, Sri. C. Kunjan, Koppam, and Sri. Ayyappan, Kongad for their good will and assistance provided for locating the trees.

The members of the panel who sincerely judged the quality of all the samples of hot pickles need special mention and acknowledgement.

I gratefully acknowledge the help rendered to me by Sri. M.C. Narayanankutty, Dr. T.E. George, Dr. P.V. Balachandran, Dr.(Mrs.) V.K. Mallika, Dr. Luckins C Babu, Dr. (Mrs) Mary Ukkuru, Mrs. Sulekha, Dr.(Mrs) T.J. Rehmath Niza, Mrs. Shina, Ms. Sreeja Rajendran, Ms. Geetha , Mr. Viswanathan, Mrs. Joycee and Mr. Santhosh Kumar at the various stages of my research.

Thanks are due to the staff and labourers of RARS, Pattambi, Department of Pomology and Floriculture, College of Horticulture, Vellankikara and Dept. of Processing Technology, College of Horticulture, Vellanikkara for their support given for the completion of the work.

I thank Kerala Agricultural University for providing me an opportunity for conducting the study.

The Senior Research Fellowship granted by CSIR is gratefully acknowledged.

Thanks are also due to the authorities of University library, Kerala Agricultural University, College of Horticulture, Vellanikkara, Indian Institute of Horticultural Research, Bangalore and GKVK, University of Agricultural Sciences, Bangalore for providing me the library facilities.

I am thankful M/s JMJ, computers, Thottappady, M/s Infotech, Pattambi and Info centre, Talikkulam for assisting me in the preparation of the thesis.

Pickling mangoes are a group of trees that are fast disappearing from our surroundings. Finally I thank all those who knowingly or unknowingly maintain these valuable heritage.

JYOTHI, M .L.

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INTRODUCTION

INTRODUCTION

Mango is the most important fruit in the tropical and subtropical regions of the world. It is grown in at least 87 countries, and is most valued in India with an area of 1.002 million ha which is 70 per cent of the area devoted for fruit crops (Chadha, 1988). India is the largest producer of mango with a share of 38.22 per cent in area and 26.05 per cent in production. In India, production of mango is estimated to be 1,08,10,957 T (Negi *et al.*, 1998).

Mangoes are usually eaten fresh, few being cooked or processed. They vary considerably in composition and are rich in carotene and vitamin C (IBPGR, 1986).

Mango with its versatile properties has naturally found application for processing into various products. It is however estimated that only 0.22 per cent of mangoes produced in the world is used for processing. Green mangoes are processed into traditional products like pickles, brine stock and chutney (Nanjundaswamy, 1991). Among fifteen different mango products, pickles rank fourth and has a good export market (Premi and Vijay, 1998).

The mango evolved probably in a tropical rainforest region. It tolerates wide range of climatic conditions (Millington, 1984). Indo-Burma region is considered as the centre of origin of mango. India has a rich genepool of *Mangifera* which include wild species, primitive cultivars, natural hybrids, land races, commercial types, breeding stock etc. India is considered as one of the centres of diversity in mango.

Many indigenous *Mangifera* genotypes have already been lost because of urbanisation (IBPGR, 1986). A great genetic diversity still exists owing to a large geographical area, diverse climatic conditions and the allopolyploid nature of its origin and cross fertilisation nature (Yadav and Shailendrarajan, 1993).

Attempts for collection and conservation of mango started in the beginning of seventeenth century, but received major emphasis only in the middle of twentieth century. Earlier collection and conservation were primarily done for quality of fruits,

while current research efforts are for collection of genepool with distinct desirable traits that can be utilised for improvement of cultivars (Chadha and Yadav, 1996).

Bompard (1993) suggested that a great effort is urgently needed to collect wild and semi-cultivated material and local knowledge attached to it. There is a special need to conserve promising local races and semi cultivated species found in traditional agro eco-systems, which are endangered.

In Kerala, mango occupies an area of 84537 ha (FIB, 2000). Satyavati *et al.* (1972) reported that in Kerala, a major portion of mango is covered under local varieties which is used only for pickling. Commercial cultivation is mainly concentrated in the eastern tracts of Palakkad district. The commercial cultivars of mango in Kerala include Olour, Neelum, Priyur, Bappakkai, Alphonso, Nadasala, Banglora, Muvandan etc. However, the land races available in Kerala are rich sources of variation though they are poor in dessert quality. They are restricted mainly to roadsides, homesteads and to some isolated and unutilised compounds.

A majority of these seedling progenies are used for pickling. Tender mango pickling is a speciality of Kerala and for its preparation local varieties with unique characters like high acidity and good sap flow are favoured. Chandrakaran is a known polyembryonic variety primarily used for pickling. High variability in mango is reported from Western Ghats, which are mainly used for pickling (Thimmaraju, 1993).

A good collection of local varieties/land races of mango is still available in Palakkad and Thrissur districts of Kerala. A vast majority of this rich germplasm is used for pickling, a few are good dessert types too. No systematic record is available on the characters of these genotypes, which are fast disappearing. Hence, this research project entitled '*Variability and character association analysis of pickling type mango*' in Palakkad and Thrissur districts was taken up with the following objectives.

To conduct a comprehensive survey of pickling type mango in Palakkad and Thrissur districts.

To study their variability in relation to phenotypic characters.

To study the physico-chemical properties of fruits.

To workout correlation between the characters and to analyse the characters contributing to its pickling quality and

To study the growth characters of seedlings in relation to their use as root stocks.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Cultivated mango belongs to *Mangifera indica*. It is the economically most important species of the genus *Mangifera* and is one of the most delicious tropical fruit. It is distributed throughout the tropics.

Review of research work on variability in mango, pickling quality of its fruits and seedling characters relating to its use as rootstock is presented in this chapter.

2.1 Variability in *Mangifera sp*

Origin of mango is reported to be in the regions constituting Burma, Assam and North East India. A total number of 41 species is reported in *Mangifera* (Mukherjee, 1949). It has been revised further and now 69 species is reported (Kostermans and Bompard, 1993).

Mango is valued for its delicious fruit. The fruit is a drupe, resinous and highly variable with respect to shape and size.

Almost all commercial types have arisen as a result of selection from seedlings. Wild mango in general have fruits which are unacceptably fibrous, resinous and may even be poisonous. Human selection must have been for succulence, low fibre, small stone and low resin content.

Systematic record of mango varieties was first made in *Aini Akbari* in 1590 AD. Different authors have described and classified the varieties of different locations.

The number of cultivated varieties in India is reported to be about 1000 (Mukherjee, 1949). In South India, around 350 varieties are seen. Naik and Gangolly (1950) classified South Indian Mangoes into different groups. An International check list of mango with 795 varieties was prepared by Pandey (1984).

True wild *Mangifera indica* is distributed in India, Burma, Andamans etc. Wild mangoes have small fruits with thin acidic flesh, big stone, lot of fibre and astringent resinous substances near the skin. The trees attain more than 100 ft. height and 25-30 ft. in circumference (Mukherjee, 1972).

Thimmaraju (1993) reported that there existed high variability in mango in Western Ghats and they are mainly used in pickling.

Genetic diversity of mango was reported from Uttar Pradesh (Gupta *et al.*, 1993), Tripura (Choudhary *et al.*, 1993), Western Uttar Pradesh (Lal and Gupta, 1993) and Goa (Mathew *et al.*, 1993). Variability was recorded in tree morphological characters and fruit characters (Mathura Rai, et al., 1998). Forty eight superior chance seedlings in the mango growing tracts of Azmargh district of Uttar Pradesh were studied in the light of various quality parameters of the fruits (Singh *et al.*, 1998).

2.2 Variability in tree characters

2.2.1 Tree architecture

Form or outline of the general appearance of tree is popularly considered to provide a valuable basis for classification of mango varieties (Naik and Gangolly, 1950). It may be oval with the tree spread very much smaller than height; round with height and spread almost equal and dome shaped with spread marked than height.

Naik (1947) described two pickle varieties namely Acharpasand and Gaddemar. The varieties had medium sized, dome shaped tree and medium to small sized trees, respectively.

A wild tree described from Tripura had an upright growth habit, rising to over 40 m in height. The trunk was straight, unbranched upto about 10 m from ground level (Sharma, 1976).

Sant Ram (1993) reported that dwarf and semi-dwarf trees in general were spreading. Vigorous and very vigorous ones were tall and less spreading with dense

foliage. In warm coastal climate like southern and western India, mango tree may flush five times in a year and high number of flushes generally add to the vigor. The trees of vigorous mango cultivars were erect with globose structure in the sandy and sandy loam soils. But the trees of the same cultivar in calcareous soils and clay loam soils were spreading with low vigor. The best tree form will be having clean and straight main stem with sparse and well distributed branches distributed all around the tree.

2.2.2 Leaf characters

Leaf characters form an important criteria in identification of varieties. Descriptors are provided for leaf shape, leaf tip, leaf margin (IBPGR, 1989). Mango varieties suitable for pickling were described by Naik (1947) in which leaf characters were also included. In the variety Acharpasand leaves were out held, oval lanceolate, flat, slightly reflexed on the mid rib, tip acute and emerging leaves greenish yellow. In variety Gaddemar, leaves were thick, out held, almost giving the appearance of drooping leaves, strongly reflexed on the midrib, folded, oval lanceolate and tip acute. Emerging leaves were reddish.

Classification and nomenclature of South Indian mangoes were attempted by Naik and Gangolly (1950). In their classification pose of leaf was described as either erect, out held or down held. Shape of leaf is classified into elliptic lanceolate, ovate and oval lanceolate. Leaf tip was classified as acute, acuminate and sub acuminate. In addition, leaf margin, leaf thickness, description of smell of crushed leaves and color of mature leaves and color of emerging leaves were also included. A key for identification of varieties was formulated by the authors in which form of leaves and folding of leaves were considered as secondary characters and shape of leaves as one of the tertiary characters. Size of leaf was found to vary considerably depending on environment, cultural practices etc.

Bakshi and Bajwa (1957) suggested that characters like length of petiole, pulvinous, the extent of waxiness, color of emerging immature leaves and shape of leaf can be used for identifying mango varieties in the nursery stage.

An unknown wild variety of mango described from Tripura had very large sized glossy green leaves with average length 54.0 cm, elliptic-lanceolate shape, acute apex, slightly undulated margin and very long petiole (Sharma, 1976).

Agarwal (1986) reported that leaf area varies significantly with varieties.

Davenport and Nunez-Elizea (1997) reported that the elongating vegetative structures are usually green but may be sometimes bronze or red or shades of red which depends on cultivars. They are considered mature when they turn dark green, which occurs when they are 2-3 months old.

Aroma of crushed leaf had a direct correlation with fruit flavour (Majumder and Sharma, 1990).

2.2.3 Inflorescence characters

Inflorescence characters are used in describing mango varieties. This includes shape, color, hairiness, flowering intensity etc. (IBPGR, 1989).

Floral characters included in description of South Indian mangoes by Naik and Gangolly (1950) were shape, hairiness and sex ratio.

Chacko (1984) reported that flower buds were borne generally in terminal buds of shoots produced during the previous season.

Mango inflorescence is primarily terminal but axillary and multiple panicle may also arise from axillary buds frequently (Chadha and Pal, 1986).

Flowering time in mango is closely linked with time of flower bud initiation which varies with cultivar and area where it is growing. Flowering period in mango is usually of a shorter duration of two to three weeks. Low temperature may extend it and high temperature may shorten it. The tree bears two types of flowers, male and perfect. The flower number varies from 1000 to 6000 (Majumder and Sharma, 1990).

Sex ratio significantly varies with cultivars. Sex ratio in polyembryonic varieties Bappakkai, Cecil, Kurukkan and Peach were 2.31, 3.66, 4.68 and 3.34 respectively (Singh, 1961). Ramarao and Rao (1984) reported that juicy varieties had higher proportion of perfect flowers compared to table varieties. Thimmapaiah and Suman (1987) reported that sex ratio in 13 varietes of mango studied varied from 2.8 to 31.4 per cent.

Majumder and Sharma (1990) reported that sex ratio varied from 0.74 per cent in Rumani to 69.8 per cent in Langra. The sex ratio is also reported to be influenced by environment in which these are grown.

Investigations conducted in several varieties of West Bengal showed that percentage of bisexual flowers was lowest in the lower part and highest in upper part of panicle. Trees of higher age groups contain higher percentage of perfect flowers per panicle than lower age groups (Majumder and Mukherjee, 1961). Considerably high percentage of perfect flowers was noted in upper part of panicle (Bana *et al.*, 1976).

Mixed panicles are also noticed in mango and they come up after the pure panicles are already blooming. They are found generally in twice or thrice flowering varieties (Mallick, 1957). In mango variety, Rataul, three types of panicles were reported (1) pure terminal panicle, (2) mixed panicles with some leafy structures and (3) pure axillary and terminal panicles. (Bana *et al.*, 1976).

However, Davenport and Nunez-Elisea (1997) indicated that weakly floral inductive conditions activates growth of leaf primordia to produce peduncles bearing inflorescence of mixed shoots.

Variation in inflorescence size was worked out by different authors. Narayanaswamy (1982) found that length and breadth of inflorescence in five varieties of mango varied from 21.33 cm to 34.36 cm and 18.11 cm and 32.83 cm respectively.

Chadha and Pal (1986) reported that inflorescence length varied from a few centimetre to 60 cm.

Thimmappaiah and Suman (1987) reported that panicle size in mango varied from 11.25 to 42.20 cm. Varieties having longer panicles produced largest number of flowers consisting of mostly male flowers. They also reported that the role of perfect flowers was only secondary and indirect on yield.

Almost all the cultivars of mango are biennial bearers and a certain amount of shoot maturity is an essential prerequisite for flowering (Majumder and Sharma, 1990). There are certain varieties, which bear regularly under a wide range of soil and climatic conditions. These appear to have a genetic constitution that is distinct from others, which enable them to flower and fruit regularly. Generally such varieties bear fruit of comparatively inferior quality. Banglora, Neelum, Mundappa, Banganappalli, Cherukarasam etc. were reported to be regular bearers (ICAR, 1967).

2.2.4 Fruit characters

According to Naik and Gangolly (1950), no other single structure in mango gives so many morphologically important character as the fruit. In the key developed by the authors for identification of varieties, form of fruit and form of beak were the primary characters for variety identification. Nature of venation of stone was a tertiary character.

Fruits are described by its shape, stalk insertion, shoulder, sinus, apex, skin surface, skin adherence, beak, color of pulp, consistency, fibres, stone venation etc. (IBPGR, 1989).

Description of fruits of different varieties were given by various authors (ICAR, 1967, Pandey, 1984, Majumder and Sharma, 1990 and Knight, 1997). However, description of fruits of pickle varieties and land races are comparatively less. The pickle varieties described by Naik and Gangolly (1950) had the following characters. Acharpasand fruits were medium sized, smooth skinned, beak only a point, soft, light yellow, moderately fibrous flesh, aroma and flavour pleasing, sugar and acid well blended when ripe but poor for dessert purpose. Variety Gaddemar had large sized fruits, smooth and orange yellow skin, soft flesh, sparsely fibrous, ripe taste acidic with poor dessert quality.

A wild variety identified from forests of Tripura produced about 50 fruits per bunch. Fruit size was very small (average length 3.52 cm, breadth 2.52 cm and thickness 2.34 cm), average weight 12.5 g. Fruit shape was oblong oval, sinus absent, beak inconspicuous, shoulder unequal, apex rounded, pulp lemon yellow, soft acidic. Stone size was small (average length 3.41 cm, breadth 1.8 cm and thickness 1.00 cm), average weight 5.0 g, veins thin, sunken and fine fibres covering the stone (Sharma, 1976).

Chandrakaran is a known pickle variety of Kerala. The tree produces fruits in bunches. The fruits are juicy and are suited for tender mango pickling (Radha, 1997).

2.3. Quality of fruits

Quality of fruits and its changes during development stages of fruit had been a subject of investigation by different workers. The principal chemical components, which attribute to the quality of fruits include carbohydrates, organic acids, proteins and amino acids, pigments, pectic substances, polyphenols, vitamins, minerals, fatty acids and odoriferous compounds. During initial stages fruit is highly acidic. Young fruits are astringent, acidic, rich in vitamin C whereas ripe mangoes are sweet, rich in provitamin A, moderate in vitamin C and highly aromatic. As the fruit matures, specific gravity and total soluble solids increase and acidity decreases (ICAR, 1967).

Changes in chemical components during development of fruits were described by various authors. Pandey *et al.* (1974) reported increase in acidity during maturation. Inedible components such as stone and peel accounted for about 9.4 to 30.0 per cent of total weight of fruits at various stages of development. Kapur (1974) reported that sugars were at low level in young fruit. Ascorbic acid was high in young fruit. During the process of maturation and ripening, there was increase in total soluble solids accompanied by rapid loss in acidity and ascorbic acid.

Joshi and Shiralkar (1977) reported that phenolic contents and ascorbic acid content decreased with the development of fruit.

Ramakrishna (1988) reported that in developing fruits of mango, acidity reduced from 2.26 to 0.28 per cent, total soluble solids increased from 4.1 to 20.0^0 brix, ascorbic acid reduced from 201.5 to 26.8 mg/100 g, weight, specific gravity increased and peel content decreased.

Variation in fruit characters of polyembryonic varieties was studied by Prasad and Prasad (1972). Fruit length varied from 6.20 to 10.34 cm, breadth from 3.74 to 6.82 cm, thickness from 4.10 to 5.22 cm, weight from 85.43 to 111.32 g, stone length from 4.0 to 9.02 cm, breadth from 2.92 to 4.45 cm, thickness from 1.60 to 2.8 cm, stone weight from 12.34 to 24.14 g and total soluble solids from 15.60 to 17.20^0 brix.

Qualitative characters of local varieties of mango of Kerala were analysed and reported by Satyavati *et al.*, (1972). Total soluble solids varied from 10.0 to 20.4^0 brix, acidity from 0.2 to 0.48 per cent, ascorbic acid from 19.84 to 54.72 mg/100 g, starch from 0.66 to 0.98 per cent, crude fibre from 0.35 to 0.71 per cent, average fruit weight from 192 to 321 g, peel content from 13.7 to 18.1 per cent and pulp content from 8.6 to 32 per cent.

Palaniswamy *et al.* (1974) found that in general, smaller sized fruits recorded high ascorbic acid than larger fruits. Analysis was made from varieties maintained at Fruit Research Station, Periyakulam. Average fruit weight varied from 101.5 to 671.6 g and pulp content from 53 to 83 per cent.

Awasthi and Pandey (1979) reported that large sized sucking varieties yielded larger quantity of juice. The yield of mango juice varied from 34.2 to 53.7 per cent depending upon fruit size.

Variation noted in the biochemical composition of ten mango varieties was reported by Kulkarni and Rameshwar (1981), of ten dessert varieties by Prasad (1984), ten specific varieties of Lucknow including one seedling and a Desi variety by Yadav *et al.*,(1982), twenty five polyembryonic varieties by Reddy and Singh, (1984), and some important varieties of Bihar by Syamal and Misra (1987).

Kulkarni and Rameshwar (1981) reported that in 22 cultivars studied, fruits of Alampur Baneshan were heaviest (400 g). Vanraj had maximum pulp (81%) and minimum peel (6.8%), while Fazari had the smallest stone (9.4%)).

Kalra *et al.* (1982) reported that bulky fruits had high percentage of pulp and good flavour.

Fifteen mango varieties evaluated in Madhya Pradesh showed that average weight per fruit varied from 121.8 to 385.7 g, specific gravity from 1.02 to 1.04, pulp content from 49.4 to 70.7 per cent, peel content from 14.3 to 28.8 per cent, stone content from 13.3 to 29.9 per cent and crude fibre from 0.56 to 1.6 per cent (Srivastava *et al.*, 1987).

Seven sucking varieties were analysed for physico-chemical characters. Juice content varied from 2.9 to 66.5 per cent, average fruit weight from 10.4 to 220.4 g. The range of variability was larger in fruit and stone weight, pulp percentage and its color and flavour, total soluble solids, acidity, total amino acids, vitamin A and vitamin C (Rabbani and Singh, 1988).

Yield and quality parameters of mango under south Gujarat conditions were studied and reported by Katrodia *et al.*, (1988). There was two fold variation in total soluble solids and four fold variation in acidity among the different varieties. High yielding varieties produced fruits of poor quality. Moderately yielding varieties had good quality contents.

Parida and Rao (1988) reported variation in the physico-chemical characters of 500 varieites of mango grown in Orissa and from this eleven superior types were selected.

Exudation of sap is noticed from stem and in large quantities from mango fruit and it varies with cultivars, harvest maturity and time of harvest. Joel *et al.* (1978) reported that presence of laccase was characteristic to Anacardiacea.

Mango sap is low in pH and high in oil. It could serve to repel flies. Resorcinols and terpenoline found in sap or chep has recorded antifungal properties (Johnson *et al.*, 1997).

Lakshminarayan *et al.* (1970) reported that young fruits had high polyphenol content and were astringent. Small amount of tannins is present in flesh and peel of mango which is responsible for astringency (Majumder and Sharma, 1990). The total content of polyphenols (tannins) may change during mango ripening depending on cultivar. Selvaraj and Kumar (1989) found declining levels of tannins and gallo tannins in several Indian cultivars. Prusky (1990) reported that alkenyl resorcinols are predominantly found in unripe fruit and they decrease in quantity during ripening. These compounds seem to be important in resistance of unripe fruit against fungal pathogens.

2.4 Pickling characters

The development of mango fruit on the tree from fertilisation to full maturity is divided into four distinct stages: juvenile, the adolescent, the climacteric and the senescence. The juvenile stage, which extends over 21 days from the time of fertilisation of the ovary is marked by rapid cell division and cellular growth with high respiration rates and high moisture content. The adolescent stage last over the next 28 days and is classified as the growth period. The cells elongate and it is in this period that distinct aroma develops in raw mango. This stage is generally used in pickle and chutney making (ICAR, 1967).

Mango products are prepared from both ripe mangoes and green mangoes in different stages.

Pickles are important in the Indian fruit and vegetable preservation industry. Amongst the Indian pickles made from various types of fruits and vegetables, pickles from mangoes are the most important. Not enough published information is available regarding preparation and storage of indigenous pickles especially pertaining to mango. Sastry and Krishnamurty (1974) reported that usually high acid varieties are preferred

for pickling. Mustard powder was added to traditional mango pickles. Mustard powder gave a very good pickle when compared to other flavours. It might be due to the active principle namely allyl isothiocynate and the enzyme myristase in the mustard. Acidity has got something to do with the texture rather than crude fibre.

The life of the fruit of a typical acid variety of mango, Amlet, was studied by Sastry *et al.* (1975a). The life of fruit could be divided into well defined stages, (1) enlarging stage which comprises upto eight weeks growth showing rapid growth in size as well in weight. (2) Stage of early maturity which comprises of 8^{th} to 9^{th} week. (3) Mature stage which comprise of 10^{th} to 12^{th} week. (4) Finally the stage of advanced maturity which comprised of 12^{th} and 13^{th} week. During early stage of enlargement, the fruit tasted predominantly astringent with thick green peel and slightly greenish flesh. Whole mangoes drawn from earlier stage was pickled as such. During ageing the texture of the fruit becomes leathery and shrinkage of fruits was observed. The taste of fruit was more saltish and astringent. Generally it is said that this stage is too early for pickling although, there is a practice of preparing 'Vadumango' pickle with these fruits of early growth, in some parts of the country. Mango pickles with fruits of early maturity gave a good product with shiny yellow color and good characteristic raw mango flavour.

Studies were conducted in Neelum variety at the enlarging stage, early mature stage and advanced stage of maturity to determine the best period of harvesting for pickling purpose. The study revealed that a maximum period of six weeks will be taken from the date of labelling to reach simultaneously full size and optimum stage of maturity of all fruits irrespective of their dissimilar size at the commencement (Sastry *et al.*, 1975b).

Pickle varieties with high acidity like Puliyan and Chandrakaran had maximum storage life (AICFIP, 1979).

Quality of pickle is influenced by proper stage of maturity of fruit. For pickle varieties not much information is available on this aspect. It varies with varieties.

For pickling `Avakkai' the best stage of harvest appeared to be after endocarp hardened, when there was not much reduction in acid content and not much build up of soluble solids. Presence of maximum starch at this stage may be helpful in texture retention (Ismail *et al.*, 1986).

Majumdar and Sharma (1990) reported that young and unripe fruits because of their acidic taste are utilised for culinary purposes as well as for preparing pickles, chutneys and amchoor.

A technology developed at IIHR, Bangalore showed the possibility of storing raw mango slices with good retention of color and texture for more than nine months under ambient conditions. High acid varieties having characteristic flavor are preferred for the purpose (Suresh *et al.*, 1998).

2.5 Correlation and character association

Correlation was worked out in mango between vegetative, floral and fruit characters by different workers.

Chacko and Randhawa (1971) reported that there was a positive correlation between crop load, shoot production and flower bud initiation. Leaf flavour had a direct correlation with fruit flavour. This character was suggested by Majumder *et al.* (1972) as a method in initial screening. In a highly divergent collection of 40 varieties, high genotypic coefficient of variation was found for fruit weight, fruit volume, reducing sugar and ascorbic acid, which revealed least influence of environment. Significant negative correlation was noted between total sugar and acidity (Gangwar and Tripathy, 1973).

Singh *et al.* (1976) reported that specific gravity and acidity of unripe fruits of variety Neelum were inversely correlated to each other. A direct correlation was noted between TSS and total sugars, specific gravity and starch, specific gravity and total sugars. A negative but significant correlation between starch and acidity also existed.

High yield was related to high percentage of hermaphrodite flowers and heavy flowering by Beal (1981).

Kalra *et al.* (1981) reported that mango cultivars showed significant correlation of tannin with total soluble solids, ß carotene and L-ascorbic acid. Increments in tannins, though not a favourable factor, caused conspicous upward trend in other desirable characters like total soluble solids and vitamin C.

Significant positive correlation was observed between fruit weight and other fruit characters, except with total soluble solids and stone thickness. Highest positive correlation of pulp weight with fruit weight revealed almost complete dependence and its usefulness in estimation of pulp weight directly from fruit weight. Stone thickness and total soluble solids were not related with other characters and between themselves (Suman *et al.*, 1985).

At Central Horticultural Experiment Station, Chethalli studies were conducted in twenty mango varieties from different geographical areas. Initial and final fruit set was significantly correlated with percentage of hermaphrodite flowers. Percentage of perfect flowers was positively correlated with initial fruit set but no significant correlation was observed with final fruit set. Percentage of fruits harvested was significantly and negatively correlated with average fruit weight (Yadav and Singh, 1985).

Prasad (1987) reported high heritabilities for ascorbic acid, reducing sugar, total soluble solids and number of fruits. Positive and significant correlation was recorded in number of fruits, their size with total soluble solids, ascorbic acid, pH value, fruit weight and fruit volume.

Correlation among various characters were worked out in 42 mango cultivars and reported by Iyer *et al.* (1988). Positive correlation was noted for plant height to extensive growing and mean number of internodes. High heritability was also worked out for plant height, stem girth, internode length, leaf area, total soluble solids, fruit weight, fruit number and fruit color.

Highly significant and positive correlation was observed between reducing sugar content and pulp/stone ratio and reducing sugars and edible/non edible ratio (Singh *et al.*, 1990).

A negative correlation between fruit color and harvest season was reported by Lavi *et al.* (1991) indicating an association of late picking to green fruits. A shorter juvenile period is coupled with higher productivity.

Karibasappa (1995) reported that leaf parameter exhibited significant relationship with panicle. Fruit set and fruit retention was positively correlated with number of hermaphrodite flowers in a panicle. Total soluble solids was not related to any of the physical parameters of fruit.

Kunda and Mitra (1997) reported that specific gravity was positively correlated with total soluble solids and total sugar content in cultivars Bombai and Himsagar.

Balakrishnan *et al.* (1998) reported that in 26 varieties of mango, mean fruit weight had positive and significant association with peel weight and stone weight. Pulp content had weak association with fruit size whereas total soluble solids and ascorbic acid were negatively correlated with fruit size.

Correlation between various physico-chemical characters of mango were studied at Hissar. Highly negative correlation between firmness and physiological loss in weight, firmness and rotting percentage were observed. Positive correlation was observed between rating score and total soluble solids, whereas total soluble solids and acidity were negatively correlated. Firmness in fruits was correlated negatively with total soluble solids and positively with ascorbic acid. Physiological loss in weight showed negative correlation with ascorbic acid and positive correlation with total soluble solids (Kaushik and Ranjit Kumar, 1998).

Prasad *et al.* (1998) reported from their studies in 22 varieties of mango that weight of fruits had direct and positive effect on diameter of first internode, number of

leaves/internode, breadth of leaf, length of petiole, diameter of petiole, breadth of panicle, number of male flowers per panicle, number of hermaphrodite flowers per panicle, breadth of fruit and weight of seed/stone.

2.6 Nursery characters

2.6.1 Polyembryony

The phenomenon of polyembryony i.e., the occurrence of more than one embryo in a seed has attracted much attention. It was initially noticed in orange. In *Mangifera*, embryos develop from the cells of integument and nucellus. Occurrence of adventive embryony may not be a constant feature of all individuals of a species (Maheswari, 1950).

In mango, three to eight seedlings per stone or seed, besides the one from embryo resulting from sexual union, are common in many varieties. The seedling, also known as nucellar seedlings, behave exactly like female parents and are comparable to vegetatively propagated plants, which are uniform. The famous variety Carabao of Philippines, all important varieties of Malaya and most of the Hawaiian mangoes are reported to be polyembryonic. Polyembryonic varieties of India are poor in quality and their only use is as rootstock for other superior varieties (ICAR, 1967).

Singh *et al.* (1967) reported that most of the cultivars in India, except for a few grown in malabar coast, are monoembryonic. Polyembryony is much more common in the moist tropical areas of South East Asia, such as Malayasia, Philippines and Indonesia, the reasons for it is not known.

Donadia and Alòisi-Sobrinho (1979) reported that in 26 Brazilian cultivars, only eleven were mono embryonic while the other fifteen varieties showed different degrees of polyembryony.

Around ten varieties of Kerala including Bappakkai, Chandrakaran, Olour, Kurukkan, Mylepelian, Goa, Pahutan and Bellari are reported to be polyembryonic (Radha, 1997).

Iyer (1991) reported that more attention is to be diverted to polyembryonic varieties in India since they offer the following advantages: (1) ease in propagation, (2) presence of tap root system and deeper root system permits firm establishment and growing even in extremely water deficit areas, (3) interaction of scion-root stock need not be considered, (4) enormous variability can be generated by using polyembryonic varieties as male parents. Observations made at Bangalore showed that many polyembryonic varieties had a short juvenile period. They were high yielding but poor in quality and hence the authors suggested that selection is to be done for quality, early bearing, dwarf frame work and high degree of polyembryony with suitable markers for identification of nucellar seedlings.

Significant difference in performance of polyembryonic varieties was noted in germination and extent of polyembryony. Prasad and Prasad (1972) reported that when polyembryonic cultivars were examined in India, the number of embryos per seed ranged from 2 to 5 to 2 to 11 giving rise on an average of 3.1 seedling. Varieties Bappakkai, Carabao, Cecil, Peach and Turpentine produced vigorous plants. Kurukkan and Sabre exhibited normal and dwarfing growth. Kotalawala (1973) reported that out of 13 varieties tested, Willard MI, Wallambu MI, Pandithasekkara, Ambalavi and Chembatan were 10 per cent mono embryonic while Peterpasand 2 and Parrot were 97 and 94 per cent polyembryonic, respectively. The remaining varieties showed varying degrees of seed germination giving 2 to 8 seedlings.

Singh *et al.* (1983) studied the germination, number of embryos/seed and number of seedling per seed. The number of embryos ranged from 2 to 10, seedling from 1 to 7 and germination from 40.6 to 87.5 per cent.

Singh and Reddy (1990) reported that percentage of germination was higher in polyembryonic varieties. It varied from two per cent in Chandrakaran to 100 per cent in Muvandan and 33.66 per cent to 82.33 per cent in Neelum and Alphonso. The mean range of seedling formation per stone was 2.33 to 2.75.

Significant correlation was found between seed weight and number of seedling per seed. Significant inter cultivar differences were found for the percentage of nucellar seedlings. The percentage of zygotic seedlings ranged from 2 to 4.7 per cent (Truscott *et al.*, 1993).

Karibasappa (1995) reported that percentage germination of 10 polyembryonic varieties varied from 53.3 to 86.6 per cent and mean number of plants per stone from 1.04 to 3.23.

Performance in relation to production of mono and poly seeds from mono and poly parents appears to vary with different climatic conditions. Variety Mulgoa is reported to be polyembryonic in Florida but strictly mono embryonic in India (ICAR, 1967).

Alphonso and Safeda (mono embryonic in India) showed 13.3 per cent to 23.7 per cent polyembryony respectively in an experiment in Puerto Rico. Conversely, polyembryonic varieties introduced from tropical countries to Pakistan seem to lose their capacity for embryony (Watson and Winston, 1984). They also reported that polyembryonic seedlings in general are more vigorous and uniform, than mono embryonic ones, particularly in nursery stage.

Yaqub and Choudhary (1984) from their studies did not support the view that polyembryony is determined by a genetically dominant factor.

Performance of polyembryonic varieties as rootstocks in grafting has also been investigated.

In a field experiment conducted at Agricultural Research Station, Taliparamba, Kerala for a period of six years, it was observed that grafts of Bennet Alphonso and Baneshan on the polyembryonic rootstocks of Chandrakaran and Bappakkai were superior to those on the monoembryonic rootstock of Puliyan both in vegetative growth (in terms of height and girth) and in yield (George and Nair, 1969).

Swamy *et al.* (1972) described the results of a rootstock trial involving six polyembryonic rootstocks for Baneshan and four for Neelam. Neelam grew larger on polyembryonic rootstock than on mono embryonic rootstock.

Grafting studies were conducted with four polyembryonic varieties viz., Mylepelian, Olour, Vellaikolamban, Ambalavi and Dashehari as rootstocks and Dashehri as scion. Vellaikolamban caused maximum reduction in height of trees followed by Ambalavi, Mylepelian, Olour and Dashehri seedlings. Vellaikolamban covered almost only half the area as compared to Dashehri. Maximum yield was recovered from Dashehri, largest fruit from Olour and Mylepelian gave higher total soluble solids, total sugars and reducing sugars (Singh and Singh, 1976).

Samaddar and Chakraborty (1989) found that varieties Langra and Himsagar when grafted to various rootstocks, polyembryonic rootstock Olour gave smaller trees and higher and more regular crop per unit canopy volume than other rootstocks studied.

Polyembryonic mangoes used as rootstocks were widely reported as providing significant dwarfing effect (Cull, 1991). Influence of polyembryonic rootstocks on grafting and establishment of mango was studied by Geetha (1993). The percentage of polyembryony in the five rootstocks, namely Puliyan, Chandrakaran, Olour, Tholikaipan and Muvandan ranged from 9.76 to 49.54 per cent. Success of grafting was maximum with Puliyan as rootstock. Survival was the least for Tholikaipan. Olour and Chandrakaran rootstocks produced lesser girth of stock and girth of scion respectively.

2.6.2 Anatomical characters

2.6.2.1 Stomatal density

Stomatal density and tree vigor were related in different crops by different authors. Several works relating to stomatal density and tree vigor were reported in mango also.

A good correlation between the frequency of stomatal distribution and vigor of mango plants was reported by Chakladar (1967) and this character has been

suggested for selection and classification of mango rootstocks in the nursery stage by Majumder *et al.* (1972). Rajeevan and Madhusoodana Rao (1975) reported that depending on the environmental condition in which the leaves develop, the size and distribution of stomata per unit area may show marked variation. In ten mango varieties studied, no stomata was seen on the upper surface of leaves. Average number of stomata per microscopic field varied from 26 to 32 in ten varieties studied.

Suryanarayana and Madhava Rao (1977) reported that number of stomata per unit leaf area was reduced as a result of growth retardant treatment.

Srivastava *et al.* (1980) classified mango rootstocks into dwarf, vigorous and very vigorous based on stomatal density.

Relation of stomatal density with vigor has been widely investigated in temperate fruit crops. In apple, Majumdar *et al.* (1969) reported that vigor of scion varieties budded to rootstocks was related to the number of stomata per unit leaf area of rootstock leaf. Stomata density was lowest in dwarf clone and highest in vigorous clone.

Stomatal density of apple rootstock belonging to different vigor groups was reported by Beakbane and Majumder (1975).

Pathak *et al.* (1976) classified 27 apple rootstocks based on their stomatal distribution which varied from 11.55 to 5.88. Number of stomata was highest in vigorous rootstocks and lowest in dwarfing ones.

Agarwal (1986) reported that increase in stomata number may result in increase in photosynthate formation which eventually may lead to enhanced vigor of plant.

However Kurian (1989) did not find any relation between tree vigour and stomatal count in mango.

2.6.2.2 Anatomical studies

Early screening of seedlings in the nursery stage will help in laying out field trials. Extensive work on apples at East Malling Research Station indicated correlation between anatomical structure of root and stem, the respiration rate and distribution of stomata with the dwarfing nature of seedlings as rootstock (Beakbane and Thomson, 1939, McKenzie, 1961).

Correlations between anatomical structure and vigour has been worked out in mango by several workers.

Majumder *et al.* (1972) conducted investigations with 31 different rootstock of mango including mono embryonic, polyembryonic and wild types. They found that growth of stem was negatively correlated with bark percentage of root. The grouping of rootstocks on the basis of growth of stem, stomatal count, vessel size of root and number of wood fibre per unit area tallied with the classification made on the basis of bark percentage of roots. It was concluded that growth of stem, bark percentage of roots, and area of vessels of roots can be used to classify mango rootstocks into various vigor classes.

Arora *et al.* (1978) studied vigor in mango based on bark percentage of root, stomatal count of leaves and number of xylem vessels per unit area of roots. With regard to number of xylem vessels/unit area of roots, Dashehri is classified as vigorous, Neelum semi vigorous, Totapuri Red small and Banglora as dwarf parents. According to bark percentage, vigorous type appeared to be dominant and incomplete dominance was found for stomatal count.

Anatomical screening of mango was attempted for identifying dwarfing rootstock (Mukherjee and Doradas, 1980). Vellaikolamban followed by Ambalavi, Olour, Mylepelian showed thick bark and Dashehri showed narrow bark. Number and size of vessels, unit area of meta xylem in stem were less in Vellaikolamban and others and higher in Dashehri seedling. Vellaikolamban showed low growth potential and Dashehri vigorous growth potential. Similar results were obtained in field studies also.

Singh *et al.* (1986) obtained a significant negative correlation between bark percentage of stem, root and petiole of one year old mango rootstock seedling and height and volume of trees grafted on to them. Majumder and Sharma (1990) reported that dwarfness is related to characters like high bark percentage, small area of xylem vessels and low stomatal density.

Anatomical studies indicated that higher phloem to xylem ratio was one factor associated with dwarfing in mango. These findings were established based on studies on genetic dwarf as well as dwarfing induced by paclobutrazol (Iyer, 1991).

Kurien and Iyer (1992) reported that less vigorous cultivars and trees dwarfed by paclobutrazol showed higher phloem to xylem ratio. This character can possibly be employed for prediction of vigor in genotypes. It is also suggested that plants with ratio greater than 1.0 would tend to be least vigorous, those with ratio 0.6-1.0 medium vigorous and those with ratio less than 0.6 to be most vigorous.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The experiment was conducted at the College of Horticulture, Vellanikkara and Regional Agricultural Research Station, Pattambi during 1995-98. The project was carried out in three different parts. The experiment area consisted two districts viz. Palakkad and Thrissur.

3.1 Part I

3.1.1 Preliminary survey

Preliminary data on the existing germplasm of pickle varieties are not available. Hence a preliminary survey was conducted to locate the pickle varieties of mango available in the districts of Thrissur and Palakkad. Trees were located with the help of personnels of Department of Agriculture, mango traders and announcements in the media and through personal contacts. Details of the tree were collected based on the proforma annexed as Appendix-I

3.1.2 Selection of trees

From the preliminary data trees were selected for detailed observation in such a way that they represented maximum variability and also from different agroclimatic regions.

3.2 Part II

The following observations were recorded from selected trees based on the descriptor of IBPGR (1989).

3.2.1 General characters

1. Approximate age of the tree
2. Height of trees
3. Appearance/shape of the tree
4. Condition of the tree

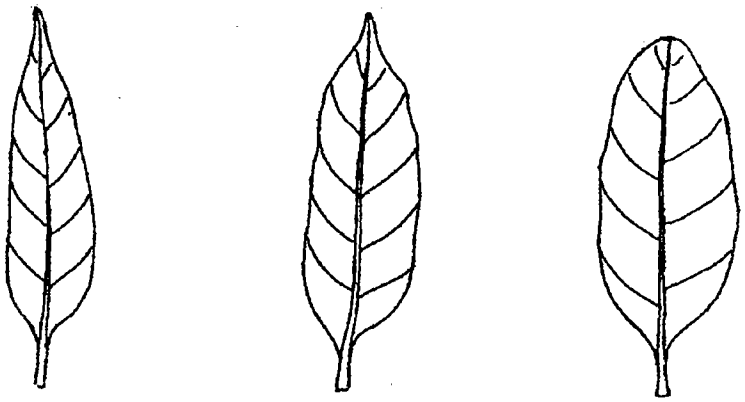
Observations were recorded from 150 trees.

3.2.2 Leaf characters

Ten fully mature leaves were collected and following observations were recorded from 150 trees.

1. Leaf shape: (i) lanceolate, (ii) oblong lanceolate, (iii) oblong (Fig.1)

Fig.1 Classification of Leaf Shape



Lanceolate Oblong Lanceolate Oblong

2. Leaf size

(i) Leaf length

Leaf length was measured from base of petiole to tip of lamina and expressed in cm.

(ii) Leaf breadth

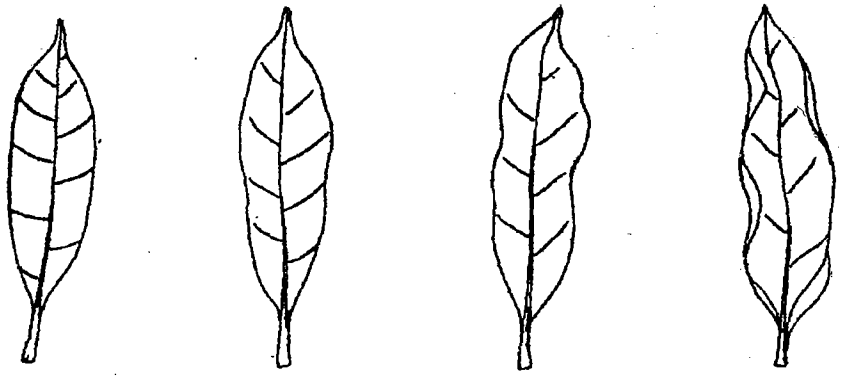
Leaf breadth was measured at the broadest part of the lamina and expressed in cm.

(iii). Petiole length

Petiole length was measured from base of petiole to base of lamina and expressed in cm.

3 Leaf margin: (i) flat, (ii) wavy, (iii) crinkled, (iv) folded (Fig. 2)

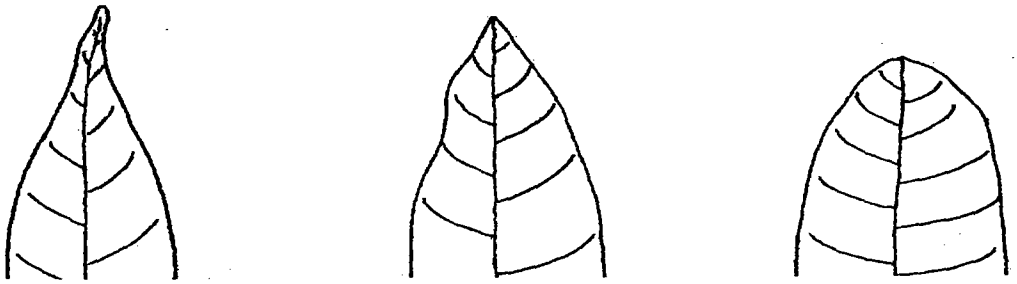
Fig. 2. Classification of Leaf Margin.



Flat Wavy Crinkled Folded

4. Leaf tip: (i) acuminate, (ii) acute, (iii) obtuse (Fig. 3)

Fig. 3. Classification of Leaf Tip



Acuminate Acute Obtuse

5. Nature of leaf lamina/leaf texture: (i) rough, (ii) smooth

6. Leaf orientation: (i) drooping, (ii) horizontal

7. Aroma of crushed leaf: (i) deep, (ii) mild

8. Color of leaf: (i) light green, (ii) dark green

9. Color of new flushes

1. Light green, 2. Yellowish green, 3. Light purple, 4. Copper

3.2.3 Inflorescence characters

Ten fully opened inflorescence were collected and the following observations were recorded from 139 trees.

1. Shape of inflorescence: (i) conical, (ii) pyramidal, (iii) broadly pyramidal (Fig. 4)

Fig. 4. Classification of Inflorescence shape.

Conical Pyramidal Broadly Pyramidal

2. Position of infloresence: (i) terminal, (ii) axillary, (iii) both
3. Size:

(i) Length

Length was measured from base to tip of main peduncle and expressed in cm.

(ii) Breadth

Breadth was measured at the base i.e., at the broadest part of the inflorescence and expressed in cm.

4. Color of inflorescence: (i) green, (ii) light pink, (iii) deep pink
5. Sex ratio: Freshly opened inflorescence was collected and the count of hermaphropdite and male flowers recorded. Sex ratio was worked out as

$$\frac{\text{Number of perfect flowers}}{\text{Total number of flowers}} \times 100$$

Observations were recorded from 25 trees selected from Pattambi and nearby areas.

6. Flowering intensity: (i) densely flowered (ii) laxly flowered, (iii) intermediate
7. Leafy bracts: (i) present, (ii) absent
8. Hairiness: (i) smooth, (ii) pubescent
9. Regularity in flowering: (i) regular, (ii) irregular

3.2.4 Fruit characters

3.2.4.1 Tender fruits

Fruits were harvested 35-40 days after flowering. Following observations were recorded from ten fruits.

1. Fruit length (cm)
2. Fruit breadth (cm)
3. Stone width (cm)
4. Skin thickness (mm)
5. Stalk length (cm)
6. Stalk thickness (mm)

   Stalk thickness and skin thickness were measured with the help of screwguage.
7. Shape of fruit (length/breadth ratio)
8. Fruit weight (g)
9. Fruit volume: Volume was measured by water displacement and expressed in ml.
10. Specific gravity (weight/volume)
11. Aroma of fruits: (i) deep, (ii) mild
12. Sap flow: (i) high, (ii) low
13. Number of fruits/bunch: Average of ten bunches were recorded

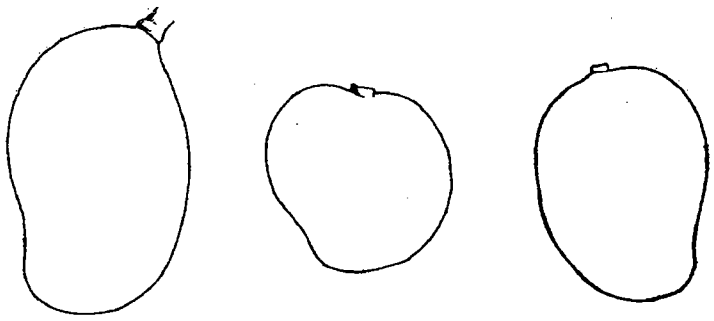
3.2.4.2 Ripe fruits

Since mature fruits were available only from 98 trees observations on ripe fruits were limited to 98 samples. Fruits were ripened at room temperature and observations were recorded from ten fruits

Observations recorded:

1. Shape of fruit: (i) ellipsoid, (ii) roundish, (iii) oblong (Fig.5)

Fig. 5. Classification of Fruit Shape



Ellipsoid Roundish Oblong

2. Stalk insertion: (i) oblique, (ii) straight

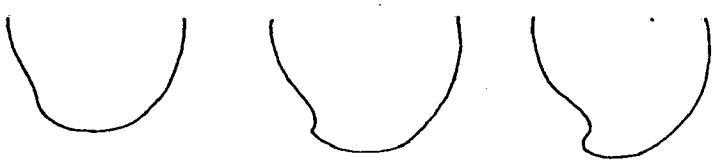
Fig. 6. Classification of Stalk Attachment

Oblique Straight

3. Shoulder: (i) level, (ii) high

4. Beak: (i) absent, (ii) a point, (iii) pointed (Fig.7)

Fig. 7. Classification of Beak



Absent A Point Pointed

5. Sinus: (i) absent, (ii) shallow, (iii) deep (Fig.8)

Fig. 8. Classification of Fruit Sinus.

Absent Shallow Deep

6. Apex: (i) acute, (ii) obtuse or rounded (Fig.9)

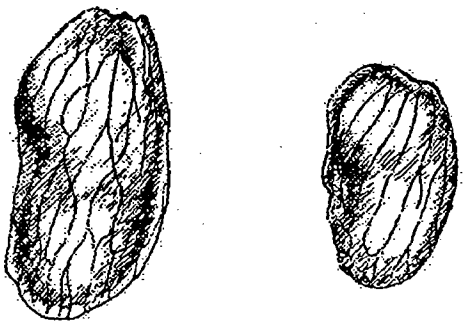
Fig. 9. Classification of Apex

Acute Rounded

7. Skin color: (i) green, (ii) yellow, (iii) red, (iv) greenish yellow, (v) green with red blotch/blush
8. Skin surface: (i) rough, (ii) smooth
9. Skin adherence: (i) adhering, (ii) free
10. Flesh color: (i) yellow (ii) orange, (iii) deep yellow, (iv) deep orange
11. Flesh texture: (i) hard, (ii) soft, (iii) juicy
12. Fruit length (cm) measured from base to apex
13. Fruit breadth (cm) measured at its widest part near shoulder
14. Fruit thickness (cm) measured near shoulder at right angles to breadh

15. Fruit weight (g)
16. Fruit volume (ml)
17. Specific gravity (weight/volume)
18. Peel weight (g)
19. Pulp weight (g)
20. Peel thickness (mm)
21. Stone weight (g)
22. Stone volume (ml)
23. Stone length (cm)
24. Stone breadth (cm)
25. Stone thickness (cm)
26. Fibrousness of stone
27. Stone venation:
    (a) (i) Forked/reticulate, (ii) Parallel (Fig.10)

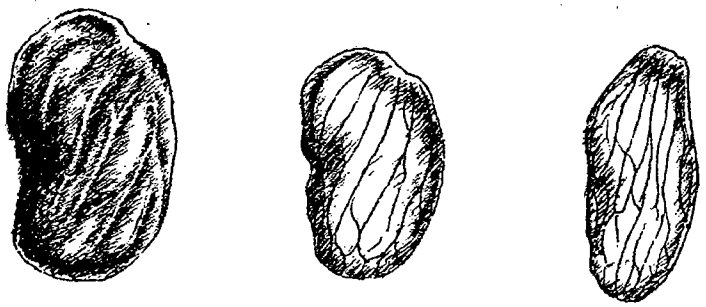
Fig.10 Classification of stone venation (a)



Forked/Reticulate Parallel

(b) (i) depressed, (ii) level with surface, (iii) elevated/raised (Fig.11)

Fig.11. Classification of stone venation (b)



Depressed Level Raised

28. Juice content: Fruit pulp from ten fully ripe fruits was extracted and homogenised. From the homogenised samples, juice was extracted by squeezing through a muslin cloth and the weight was recorded. Juice content was expressed as percentage of pulp.

$$\frac{\text{Weight of juice}}{\text{Weight of pulp}} \times 100$$

Average of ten such samples were taken.

3.2.5 Biochemical characters

1. Total soluble solids: Total soluble solids was recorded from the juice extracted from the homogenised pulp using a hand refractometer and expressed as °brix.
2. Acidity: Acidity was worked out for both tender fruits and ripe fruits. Ten uniform fruits were selected. Pulp was extracted and mixed thoroughly. Acidity was estimated from the extract made from pulp by titration with 0.1 N NaOH to a known quantity of the sample prepared and expressed as percentage of citric acid as per Ranganna (1977).

3. Ascorbic acid: Ascorbic acid content was calculated for the pulp of tender mangoes. Five gram of the homogenized pulp was taken and extracted with four per cent oxalic acid. Ascorbic acid was estimated using standard indicator dye 2,6-dichlorophenol indophenol and expressed as mg/100 g fruit as per Sadasivam and Manickam (1992).

4. Polyphenols: Polyphenols were analysed in tender fruits by Folin-Chiocalteu method as per Sadasivam and Manickam (1992). One gram of pulp was taken from homogenised samples after removing skin and stone. This sample was extracted with 10 ml of 80 per cent ethanol. The sample was centrifuged. The alcohol was evaporated. The residue was dissolved in a known volume of water and aliquot was used for color development using Folin chio-calteau reagent followed by sodium carbonate two per cent. The blue color was read in a spectrophotometer at 650 nm. A standard curve was prepared using catechol as standard.

5. Crude fibre: Crude fibre was estimated from tender fruit. Five gram of oven dried sample was digested with 50 ml 1.25 per cent sulphuric acid. Acid digestion was followed by boiling in 1.25 normal sodium hydroxide. The oven dried residue was ignited and crude fibre content analysed as per Ranganna (1977).

6. Shrinkage: Shrinkage of tender mango fruit while pickling was worked out as follows:

   Ten tender fruits of uniform size was selected and volume was recorded by water displacement method. Salt was added @ $1/8^{th}$ volume of fruit. Salt was mixed and kept in a moisture free air tight container. Mixing of the contents was repeated every day. After 10 days the brine was drained and the volume of fruits was recorded. Shrinkage expressed in percentage was worked out as

$$\frac{a - b}{a} \times 100$$

   where `a' is the initial volume of fruit and `b' is the final volume.

3.2.6 Pickling quality

Pickling quality of the fruits collected from the selected trees was assessed. Tender mango pickling was done as per the traditional methods. Pickling was done with fruits selected from all the 150 trees. Twenty five fruits each of uniform size was selected with stalk intact. The volume of fruits was estimated. The fruits were washed, wiped and dried to remove the adhering moisture. Salt was added @ $1/8^{th}$ volume of fruit. The fruits were stored in airtight containers in dark for 10 days. Mixing of the contents was done on alternate days without opening the bottles. After 10 days $1/16^{th}$ volume of mustard powder and same quantity of chilli powder was added. They were mixed and the bottles were kept closed for one year in a dark place. Quality assessment was done after one year.

Pickling quality of the fruit was assessed for six different characters.

Characters	Score				
	1	2	3	4	5
1. Color	Very acceptable	Acceptable	Less acceptable	Least acceptable	Not at all acceptable
2. Appearance	"	"	"	"	"
3. Aroma	"	"	"	"	"
4. Taste	"	"	"	"	"
5. Texture	"	"	"	"	"
6. Overall acceptability	"	"	"	"	"

Ten semi-trained persons were selected for tasting the samples and the average score was worked out.

3.2.7 Pathological test

Pickled fruits were taken out after one year. Fruits were washed and cut into pieces of uniform size. The pieces were first washed in distilled water, then surface sterilised in 80 per cent ethanol followed by three washings in distilled water.

The fruit pieces were inoculated in sterilised petridish containing potato-agar medium in a UV chamber. Observations were recorded for the time taken for development of colonies and the percentage of fruits infested. The experiment was conducted with 136 samples.

3.3 Part III - Nursery studies

Seeds were extracted from ripe mangoes and were initially sown in a raised bed in rows of 10 numbers each. After recording germination, the seedlings were planted into a polythene bag containing potting mixture having soil, sand and powdered cowdung in the ratio of 1:1:1.

3.3.1 Early growth characters

The following observations were recorded from the nursery.

1. Percentage of germination: $\frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$

2. Color of new flush: 1. Light purple 2. Deep purple 3. Copper coloured

3. Extend of polyembryony:

4. Height of plants 3 months after planting (cm)
5. Girth at collar region 3 months after planting (cm)
6. Height of plants 6 months after planting (cm)
7. Girth at collar region 6 months after planting (cm)
8. Height of plants one year after transplanting (cm)
9. Girth at collar region one year after transplanting (cm)
10. Length of tap root one year after planting (cm)
11. Number of secondary roots one year after planting

3.3.2 Stomatal count

Stomatal count was recorded on leaves of one year old seedlings. Five leaves were collected. Quickfix was smeared on the lower surface in the mid portion of the leaf, during morning hours. After drying, the peel was removed and number of stomata was counted under microscope (magnification 45x). Counts were taken from 5 fields in each sample and average of 25 fields was worked out. The procedure followed was as per Srivastava *et al.* (1980).

3.3.3 Anatomical studies

Stem cuttings were taken from tender top portion of one year old seedlings and preserved in FAA. Free hand sections were taken from these cuttings, stained with saffranin and mounted in DPX after washing in alchohol series. The sections were observed under microscope. Measurement of xylem was taken as the distance from cambial ring to last row of vessels adjoining the pith. Phloem was measured from cambium upto bark layer. Bark was measured from phloem to outer layer of the section. Total radial length from centre of pith to outer layer was also measured. Bark percentage and phloem to xylem ratio was worked out. Distances were measured from different points in each section. Five sections were selected for each variety and average was worked out.

3.4 Statistical analysis

Statistical analysis was conducted as per Panse and Sukatme (1978). Clustering was conducted as per the Suresh and Unnithan (1996). Clustering was conducted with genotypes having a score of one and 1-2 for overall acceptability of pickling quality. Forty-five genotypes were taken for clustering for which all the observations on characters relating to tender mango and pickling quality were available.

RESULTS

4. RESULTS

The research project entitled 'Variability and character association analysis of pickling type mango' was conducted in three parts.

Part I. Preliminary survey

Part II. Variability analysis of selected genotypes

Part III. Nursery studies

The results obtained are given in detail below.

The experiment was conducted and details were collected from trees selected from Palakkad and Thrissur districts of Kerala.

Part - I

4.1 Preliminary survey

Inventory on pickle varieties is not available at present. Hence preliminary survey was conducted for identification of pickle varieties. Details were collected on identified types as per the proforma attached as Appendix-I

4.1.1 Distribution of trees

A total number of 530 trees could be located and the details were collected. The frequency distribution of the 530 trees by various characters observed during the preliminary survey are presented in Table 1. Out of the 530 trees located, 349 trees were from Palakkad district and 181 were from Thrissur district. The trees belong to roadsides, temple compound and homesteads. A total number of 101 trees were identified from road sides. Out of this 101 trees, 74 trees were from Alanellur area and the rest were from Cherpulassery, Alathur, Mannarkkad and Vaniyamkulam of Palakad district and Chazhur and Attoor areas of Trissur district.

The distribution of trees in Palakkad district is presented in Fig.12 and the distribution in Trissur district is presented in Fig 13.

Table 1. Frequency distribution of trees based on preliminary survey

Character	Description	No. of trees	Frequency Distribution (%)
District	Palakkad	349	65.85
	Thrissur	181	34.15
Status of the tree	Wild	-	-
	Land race	516	97.36
	Cultivar/variety	14	2.64
Age of the trees (Years)	<10 year	20	3.77
	10-25	95	17.92
	26-50	190	35.85
	51-75	128	24.15
	76-100	66	12.45
	>100	31	5.85
Condition of the trees	Damaged and diseased	92	17.36
	Healthy	438	82.64
Planting material	Seedlings	520	98.11
	Grafts	10	1.89
Loranthes infestation	Infested	210	39.62
	Not infested	320	60.38
Fruit quality	Pickling	427	80.57
	Pickling & dessert	103	19.44
Marketing	Own use	115	21.69
	Sold	184	34.72
	Both	231	43.58
Whether the trees will be retained or not	Removed	28	5.28
	Retained	502	94.72
Whether nuts collected for rootstock production	Collected	27	5.09
	Not collected	503	94.91

Fig. 12 Distribution of Pickling Type Mango in Palakkad District

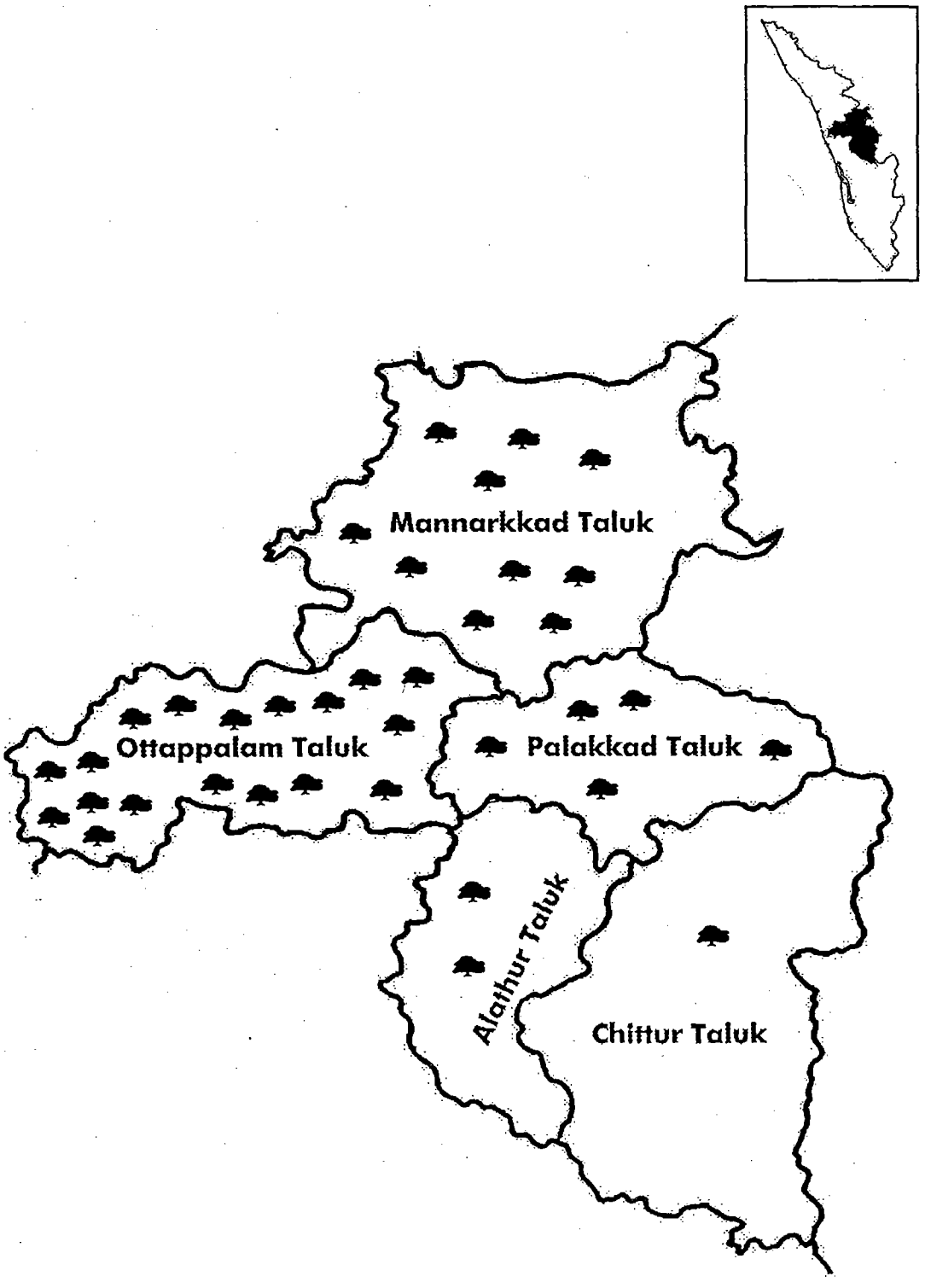
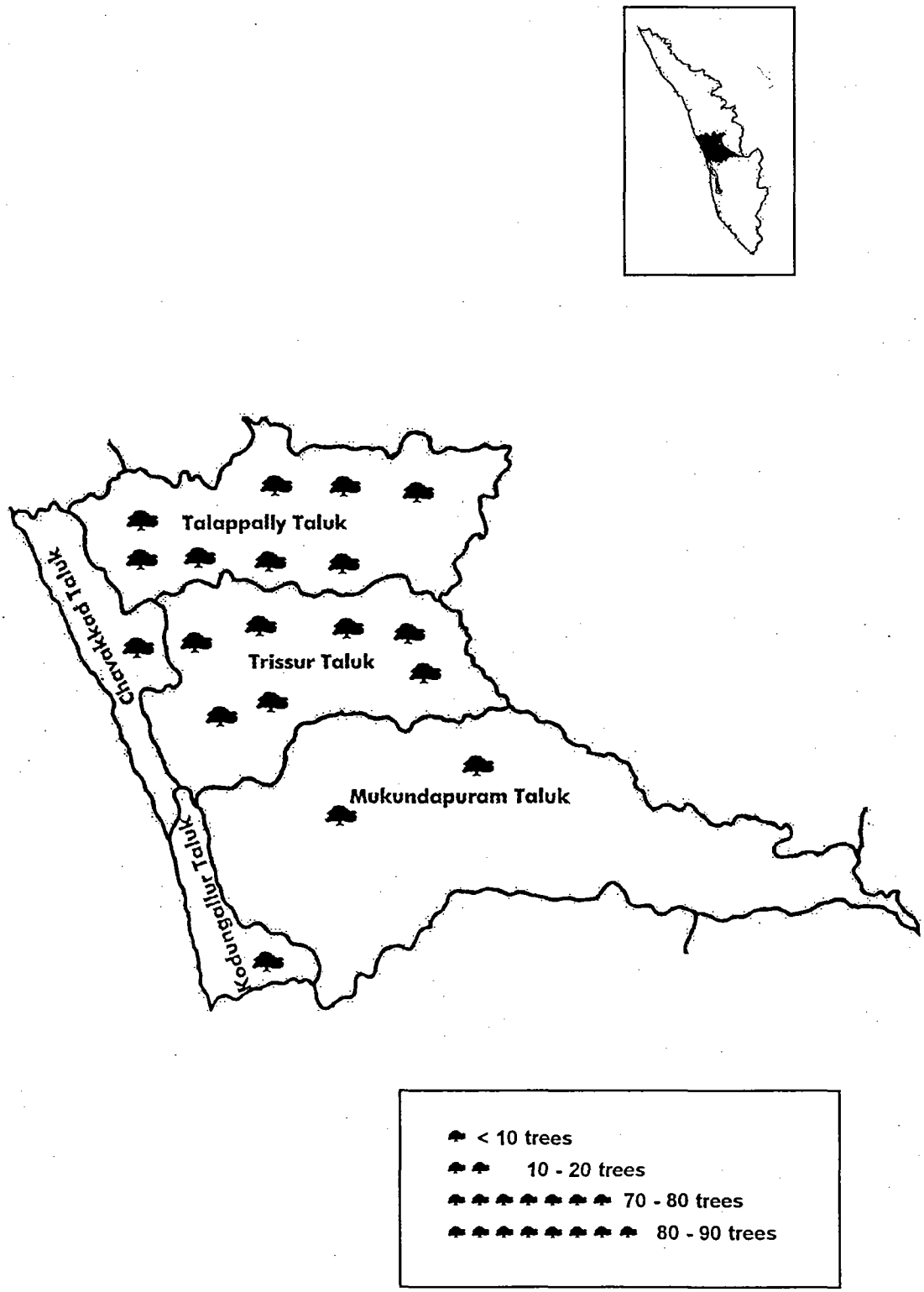


Fig. 13 Distribution of Pickling Type Mango in Trissur District



4.1.2 Status of the trees

Except for the variety Chandrakaran, all the trees located were either land races or primitive cultivars.

4.1.3 Age of the trees

Age of the trees were assessed based on the proforma. It was found that 3.77 per cent trees were less than 10 years of age, 17.92 were between 10-25 years and 35.85 per cent were between 26-50 years. 24.15 per cent of the trees surveyed were between 51-75 years, 12.45 per cent were between 76-100 years and 5.85 per cent were above 100 years of age.

4.1.4 Condition of the tree

Ninety two trees were damaged and diseased. Rest of the trees (82.64%) were healthy.

4.1.5 Planting material

Planting materials of 520 trees were seedling projenies. Ten trees were produced from grafts and the variety was Chandrakaran. These trees were located in research stations. One tree of Chandrakaran variety, produced from a graft, was located in a homestead at Koppam in Palakkad district.

4.1.6 Loranthes infestation

Infestation of *Loranthes* was noted in 39.62 per cent of the trees and the rest were free from *Loranthes* infestation.

4.1.7 Quality of fruits

Fruits of 80.57 per cent trees were good for producing pickles alone and rest could be used both as pickling as well as dessert type.

4.1.8 Marketing

Fruits of 115 trees were restricted for own use and fruits of 184 trees were sold. The fruits of rest of the trees were sold as well as used by owners. Fruits of trees located at the roadsides were sold through auction.

4.1.9 Whether the trees will be retained or not

On enquiry, it was reported that 28 trees would be removed.

4.1.10 Whether seeds are collected for rootstocks

Seeds were collected for rootstock production only from 27 trees located in different institutions where graft production of mango was undertaken.

4.1.11 Number of trees in homesteads

Most of the trees identified were located in homesteads. Distribution of homesteads by the number of trees is given in Table 2. Eightynine of the homesteads had only one tree each, 31 had two trees, 16 had three trees, 10 had four trees and five had five trees. One homestead each had six and nine number of trees and four homesteads had 10 trees each. More than 10 number of trees were located in nine homesteads.

Table 2. Distribution of homesteads based on number of trees of pickle type mango

Number of trees	Number of homesteads
1	89
2	31
3	16
4	10
5	5
6	1
7	-
8	-
9	1
10	4
>10	9

4.1.12 Local names

Local names were available only for a few number of genotypes. They included *Chandrakaran, Chakiri manga, Kolan manga, Chakiriyan, Pulīyan, Kadukkan, Nannariyan, Uruniyan, Kozhimutta mavu, Karinkulavan, Thekkekulavan, Cheriya irrattan, Vazhiyan* etc. Rest of the trees were known in general, either as *Nattumavu* or *Pulimavu*. Names were given either based on the location of the tree or on the quality of the fruit or appearance of fruit.

Part-II

Variability analysis of selected genotypes

4.2 Tree characters

4.2.1 Age of the trees

Trees selected for variability analysis were under different age groups. About 50 per cent of the trees were above 50 years of age, 8.67 per cent were between 41-50 years, 15.33 per cent were in the age group of 31-40 years, 16.67 per cent wee in the age group of 21-30 years 7.33 per cent of the trees were between 10-20 years age. Only 1.33 per cent were less than 10 years of age (Table 3).

4.2.2 Height of trees

Height of 90 per cent of the trees were above 10 m of which 56 per cent of the trees were between 10-20 m high and 33.33 per cent were more than 20 m in height. Only 10.67 per cent were less than 10 m height (Table 3).

4.2.3 Branching habit

Open branching habit was common and it was noted in 82.66 per cent of the trees. Rest of the trees had a closed branching habit (Table 3).

4.2.4 Condition of trees

More than 75.00 per cent of the trees studied were healthy and 23.3 per cent were either diseased or partially damaged due to felling of branches, ageing, and due to attack of *Loranthes*. None of the trees studied were receiving special care and management (Table 3).

Table 3. Tree characters and distribution of genotypes

Sl.No.	Character	Description	No. of trees	Frequency distribution (%)
1	Age (years) (approx.)	<10	2	1.33
		10-20	11	7.33
		21-30	25	16.67
		31-40	23	15.33
		41-50	13	8.67
		>50	76	50.67
2	Height (cm)	<10	16	10.67
		10-20	84	56.00
		>20	50	33.33
3	Branching habit	Open	124	82.66
		Closed	26	17.33
4	Condition of the tree	Healthy	115	76.67
		Diseased and damaged	35	23.30

4.3 Leaf characters

4.3.1 Descriptive characters

Observations recorded on the descriptive characters of leaves are presented in Table 4.

4.3.1.1 Leaf shape

Lanceolate leaf was noticed in 69.33 per cent of the trees, 24.66 per cent had oblong lanceolate leaves and 6.0 per cent had oblong leaves.

4.3.1.2 Margin

Flat leaf margin was common and was noticed in 60.66 per cent of the trees, followed by wavy leaf margin, noticed in 36.66 per cent of trees. Folded leaf margin was recorded from 2.66 per cent of the trees. Only one tree had leaves with crinkled leaf margin.

4.3.1.3 Leaf tip

Based on the leaf tip character, three groups were made and among this acuminate leaf tip was noticed in 88 per cent of the trees. Acute leaf tip was noticed in ten per cent of the trees and the rest had obtuse leaf tip.

4.3.1.4 Leaf texture

Leaf texture was smooth in 58.6 per cent of the genotypes and it was rough in rest of the samples

4.3.1.5 Leaf orientation

Drooping leaf orientation was commonly noticed in 63.33 per cent of the trees. The rest had either horizontal or oblique leaf orientation.

4.3.1.6 Leaf colour

Dark green leaf colour was predominant among the trees sampled. 81.3 per cent of trees had dark green upper surface of the leaf. In the rest of the samples leaves were having light green color.

4.3.1.7 Colour of new flushes

Color of new flushes varied from light green to yellowish green, light purple and copper color. Of these light green and yellowish green flushes were noticed in more than 90 per cent of the trees. Light purple flushes and copper colored flushes were noticed in 4.48 and 2.9 per cent each of the trees, respectively.

4.3.1.8 Aroma of crushed leaf

Seventy per cent of the samples had a deep smell for the crushed leaves. It was mild in 30 per cent of the samples.

Table 4 . Distribution of genotypes based on descriptive characters of leaf

Sl.No	Character	Description	No. of trees	Frequency distribution (%)
1	Leafshape	Lanceolate	104	69.33
		Oblong lanceolate	37	24.66
		Oblong	9	6.00
2	Leaf margin	Folded	4	2.66
		Wavy	55	36.66
		Flat	90	60.66
		Crinkled	1	0.66
3	Leaf tip	Acute	15	10.00
		Acuminate	132	88.00
		Obtuse	3	2.00
4	Leaf texture	Smooth	88	58.60
		Rough	62	41.30
5	Leaf orientation	Drooping	95	63.33
		Horizondal/oblique	55	36.67
6	Leaf colour	Dark green	122	81.30
		Light green	28	18.70
7	Colour of new flushes	Light green	85	63.43
		Yellowish green	39	29.10
		Light purple	6	4.48
		Copper brown	4	2.90
8	Aroma of crushed leaf	Deep	105	70.00
		Mild	45	30.00

4.3.2 Leaf size characters

A representation of variation in leaf size observed is presented in plate 1. Results of the observations recorded on the leaf size are presented in Table 5. Variation was noted in the size of the leaves as described below.

4.3.2.1 Leaf length

The average leaf length recorded was 22.66 cm. It ranged from 14.4 to 48.0 cm with a coefficient of variation of 17.44 per cent.

4.3.2.2 Leaf breadth

Mean leaf breadth was 5.19 cm. Leaf breadth varied from 3.0 to 8.0 cm with a coefficient of variation of 18.39 per cent.

4.3.2.3 Petiole length

When compared with leaf length and leaf breadth, petiole length showed higher variation. Petiole length varied from as low as 1.8 cm to as high as 11.9 cm with a coefficient of variation of 31.49 per cent. Mean petiole length was 3.27 cm.

4.3.2.4 Length/breadth ratio

Length/breadth ratio of leaf varied from 2.61 to 6.61 cm with a mean value of 4.45. The coefficient of variation was 15.89 per cent.

Table 5 . Variation in leaf size characters

Sl.No.	Character	Range	Mean	Coefficient of variation (%)
1	Leaf length (cm)	14.4-48	22.66	17.44
2	Leaf breadth (cm)	3.0-8.0	5.19	18.39
3	Petiole length (cm)	1.8-11.9	3.27	31.49
4	Leaf length/breadth	2.61-6.61	4.45	15.89

4.4 Inflorescence characters

4.4.1 Descriptive characters

The results are presented in Table 6

4.4.1.1 Inflorescence shape

Inflorescence shape was divided into three and broadly pyramidal shape was predominant (79.14%). The rest of the trees had pyramidal inflorescence .

4.4.1.2 Inflorescence position

Terminal inflorescence was noted in 62.58 per cent of the trees. Rest had both terminal and axillary inflorescence.

4.4.1.3 Inflorescence colour

Green coloured inflorescence was noted in 76.25 per cent of the genotypes. Light pink colour was noted for the inflorescence axis of 21.58 per cent of the samples and 2.16 per cent had deep pink color on the inflorescence axis. Colour variation in inflorescence is presented in plate 2.

4.4.1.4 Inflorescence hairiness

Smooth inflorescence axis was noticed in almost all the trees studied. Hairiness of inflorescence was noticed only in one sample.

4.4.1.5 Presence of leafy bracts

Presence of leafy bracts was not common and it was noticed only in 6.47 per cent of the samples. An inflorescence with leafy bracts is presented in plate 3.

4.4.1.6 Flowering intensity

Densely flowered inflorescence was noticed in 74.1 per cent of the samples, 20.86 per cent had intermediate inflorescence and 5.03 per cent had laxly flowered inflorescence.

4.4.1.7 Flowering habit

Irregular bearing habit was common among the genotypes. Irregular bearing was noticed in 77.87 per cent of the genotypes.

Table 6 . Distribution of genotypes based on inflorescence characters

Sl.No.	Character	Description	No. of trees	Frequency distribution (%)
1	Inflorescence shape	Broadly pyramidal	110	79.14
		Pyramidal	29	20.87
		Conical	-	-
2	Inflorescence position	Axillary	-	-
		Terminal	87	62.58
		Both	52	37.41
3	Inflorescence colour	Green	106	76.25
		Light pink	30	21.580
		Deep pink	3	2.16
4	Inflorescence hairiness	Hairy	1	0.70
		Smooth	138	99.30
5	Presence of leafy bracts	Present	9	6.47
		Absent	130	93.50
6	Flowering intensity	Densely flowered	103	74.10
		Laxly flowered	7	5.03
		Intermediate	29	20.86
7	Flowering habit	Irregular	108	77.87
		Regular	31	22.38

4.4.2 Inflorescence size characters

The results on the biometric characters of inflorescence are presented in Table 7

4.4.2.1 Inflorescence length

Inflorescence length ranged from 11.6 to 38.6 cm with a mean value of 24.22 cm. The coefficient of variation was 18.32 per cent.

4.4.2.2 Inflorescence breadth

Breadth of inflorescence varied from 12.6 to 36.9 cm with a mean value of 24.7 cm. Coefficient of variation was 19.81 per cent.

PLATE - 1 VARIATION IN LEAF SIZE

PLATE - 2 COLOR VARIATION IN INFLORESCENCE

PLATE - 3 INFLORESCENCE WITH LEAFY BRACTS

4.4.2.3 Sex ratio

Sex ratio of trees studied varied from as low as 20.64 per cent to as high a 69.3 per cent. Sex ratio had a high coefficient of variation of 40.91 per cent and a mean of 52.12 per cent.

Two fertile anthers were noted in three genotypes.

Flower color was either yellow turning brown or yellow turning pink

Cauliflorus inflorescence was noted in three genotypes. In T.No.139 cauliflorus inflorescence was commonly noted unlike the other two trees. Occasionally, cauliflorus inflorescence was noted in heavily pruned branches also.

Hermaphrodite flowers were in general noted more in the upper part of the inflorescence.

Table 7 . Variation in inflorescence size characters

Sl.No.	Character	Range	Mean	Coefficient of variation (%)
1	Inflorescence length (cm)	11.6-38.6	24.22	18.32
2	Inflorescence breadth (cm)	12.6-36.9	24.70	19.81
3	Sex ratio (%)	20.64-69.3	52.12	40.91

4.5 Tender mango characters

A representation of variation noted in tender mango characters are presented in plate 4

4.5.1 Fruit smell

Tender fruits had a deep smell in 89.33 per cent of the samples. The rest had only a mild smell.

4.5.2 Sap flow

Sap flow was high in majority of the samples (87.33%) and it was scanty in 12.97 per cent of the fruit samples.

4.5.3 Fruit length

Length of fruits ranged from 2 to 5.4 cm with an average value of 3.24 cm. The coefficient of variation for fruit length was 22.47 per cent (Table 8).

4.5.4 Fruit breadth

Breadth of fruits showed a variation similar to that of fruit length. The coefficient of variation was 21.21 per cent. Breadth of fruits ranged from 1.6 to 3.4 cm with a mean of 2.45 cm (Table 8).

4.5.5 Length/breadth ratio

Length/breadth ratio of tender fruits ranged from 0.9 to 1.79. The mean value was 1.34. The coefficient of variation was comparatively low (14.93%) (Table 8).

4.5.6 Stone width

Stone width in the tender fruit varied from 0.6 to 1.9 cm with a mean value of 1.01 cm. The coefficient of variation was 26.29 per cent (Table 8).

4.5.7 Stalk length

Stalk length of tender mangoes varied from 0.6 to 2.7 cm with a mean value of 1.4 cm. Coefficient of variation was 20.2 per cent (Table 8).

4.5.8. Stalk thickness

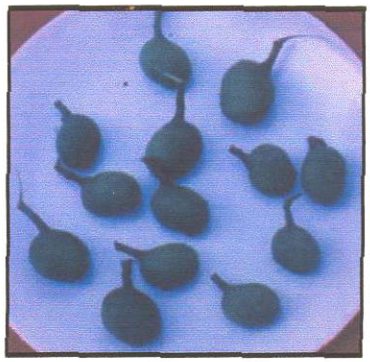
Stalk thickness varied from 2.3-8.3mm. The mean stalk thickness was 2.6mm. The coefficient of variation was 34.18 per cent.

4.5.9 Fruit weight

High variation was noticed in the weight of fruits with a coefficient of variation of 46.75 per cent. The mean fruit weight was 8.74 g (Table 8).

PLATE - 4 VARIATION IN TENDER FRUITS


T 68


T 57


T 47

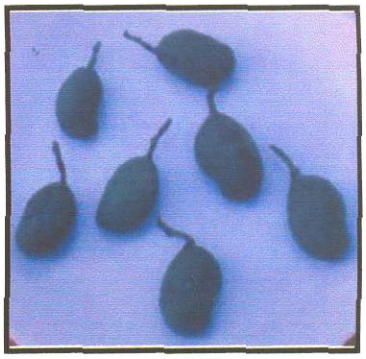

T 53


T 63


T 55


T 41


T 34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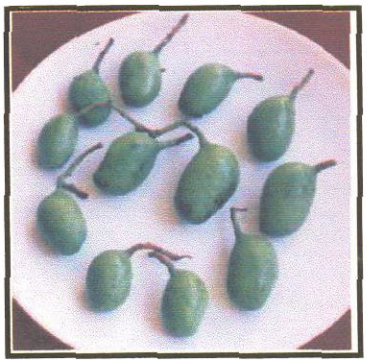
T 48


T 60


T 122

4.5.10 Fruit volume

Volume of fruits recorded a coefficient of variation of 36.01 with a mean value of 8.22 ml. Volume of fruit varied from 3.5-15.1ml (Table 8)

4.5.11 Specific gravity

Specific gravity of tender fruits varied from 0.4 to 1.9 with an average value of 0.99. Coefficient of variation was 24.74 per cent (Table 8).

4.5.12 Skin thickness

Coefficient of variation noticed in the skin thickness of tender fruits was 26.31 per cent. It varied from 0.1 mm to 1.2 mm with an average value of 0.85 mm (Table 8).

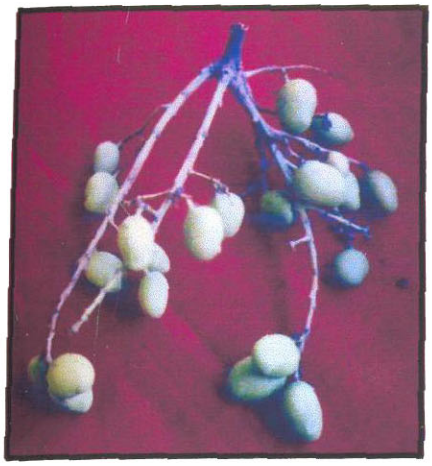
4.5.13 Number of fruits/bunch

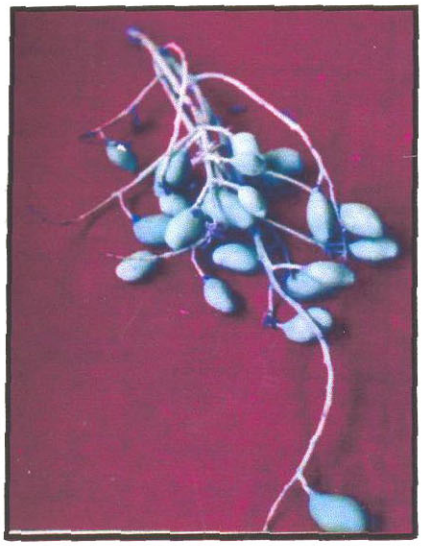
Number fruits/bunch recorded at the tender stage varied from 6.0 to 28.7. The coeffficient of variation was 51.18 per cent. The average number of fruits per bunch was 14.75 (Table 8). Plate 5 depicts the variation noted in number of fruits produced per bunch.

Table 8 . Variation in tender fruit characters

Sl.No.	Character	Range	Mean	Coefficient of variation (%)
1	Length (cm)	2.0-5.4	3.24	22.47
2	Breadth (cm)	1.6-3.4	2.45	21.21
3	Length/breadth	0.9-1.79	1.34	14.93
4	Stone width (cm)	0.6-1.9	1.01	26.29
5	Stalk length (cm)	0.6-2.7	1.40	20.20
6	Stalk thickness (mm)	2.3-8.3	2.6	34.18
7	Weight (g)	2.8-14.5	8.74	46.75
8	Volume (ml)	3.5-15.1	8.22	36.01
9	Specific gravity	0.4-1.9	0.99	24.74
10	Skin thickness (mm)	0.1-1.2	0.85	26.31
11	Fruits/bunch	6.0-28.7	14.75	51.18
12	Shrinkage(%)	11.1-71.4	46.64	25.23

PLATE - 5 TENDER FRUITS IN BUNCHES





4.5.14 Shrinkage

Coefficient of variation noticed in the shrinkage of tender fruits was 25.23 per cent. It varied from 11.1 to 71.4 per cent with an average value of 46.64 per cent (Table 8)

4.6 Ripe fruit characters

4.6.1 Descriptive characters

The results are presented in Table 9

Variability noted in ripe fruit characters are presented in plates 6 and 7

4.6.1.1 Shape

Ripe fruit shape was grouped into three of which round shape was predominant (47.92%) followed by oblong shape (39.79%). Only 12.24 per cent of the samples had elliptic fruits.

4.6.1.2 Stalk insertion

Stalk insertion was oblique in 52.04 per cent of the fruit samples and the rest had straight stalk insertion.

4.6.1.3 Shoulder

Shoulder was level in 37.26 per cent of the fruit samples. In the rest of the samples shoulder was high.

4.6.1.4 Beak

Beak was pointed in 37.76 per cent, absent in 30.61per cent and a point in 31.63 per cent of the samples studied.

4.6.1.5 Sinus

Sinus was shallow in 47.95 per cent, absent in 29.59 per cent and deep in

24.94 per cent of the samples.

4.6.1.6 Fruit apex

Apex of the fruits was obtuse or rounded in 83.67 per cent and the rest had pointed fruit apex.

4.6.1.7 Skin surface

Smooth skin surface was predominant (84.69%) than rough skin surface.

4.6.1.8 Fruit colour

Green skin colour was noticed in 52.04 per cent of the fruit samples, followed by greenish yellow colour (27.55%). Yellow skin colour was noticed in 14.28 per cent. Red skin and green skin with red blotches was noticed in 3.06 per cent each of the samples Colour variation noted in ripe fruits are presented in plate 8.

4.6.1.9 Skin adherence

Skin was free in 93.88 per cent of the fruit samples studied and it was adhering in 6.12 per cent of the samples.

4.6.1.10 Flesh colour

Wide variation was noticed in the flesh colour in ripe fruits. 47.96 per cent of the fruits had orange coloured flesh, 31.63 per cent of the samples had light yellow coloured flesh. Deep orange colour was noticed in 12.24 per cent and deep yellow in 8.16 per cent of the samples.

4.6.1.11 Flesh texture

Flesh was soft in texture in 69.38 per cent of the fruits. Juicy texture was noted in 27.55 per cent and the rest of the genotypes had hard textured flesh.

Table 9. Distribution of genotypes based on descriptive characters of fruits

Sl.No	Character	Description	No. of trees	Frequency distribution (%)
1	Shape (ripe fruit)	Oblong	39	39.79
		Roundish	47	47.92
		Elliptic	12	12.24
2	Stalk attachment	Oblique	51	52.04
		Straight	47	47.95
3	Shoulder	Level	36	37.26
		High	62	62.25
4	Beak	Absent	30	30.61
		A point	31	31.63
		Pointed	37	37.76
5	Sinus	Absent	26	29.59
		Shallow	48	47.95
		Deep	24	24.94
6	Fruit apex	Obtuse	82	83.67
		Acute	16	16.12
7	Skin surface	Rough	15	15.31
		Smooth	83	84.69
8	Fruit colour	Green	51	52.04
		Greenish yellow	27	27.55
		Yellow	14	14.28
		Reddish	3	3.06
		Green with red blotches	3	3.06
9	Skin adherence	Adhering	6	6.12
		Free	92	93.88
10	Flesh colour	Orange	47	47.96
		Deep orange	12	12.24
		Deep yellow	8	8.16
		Light yellow	31	31.63
11	Flesh texture	Hard	3	3.06
		Soft	68	69.38
		Juicy	27	27.55

4.6.2 Biometric characters

The observations recorded on ripe fruit characters are presented in Table 10.

PLATE – 6 VARIATION IN RIPE FRUITS


T 16

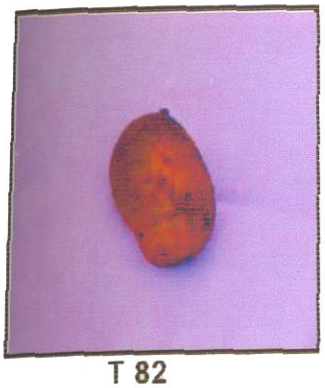

T 93


T 10


T 79


T 51


T 18


T 82


T 73


T 97


T 55


T 87

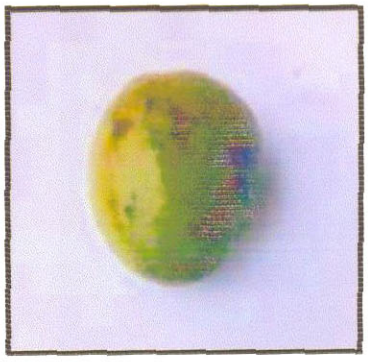
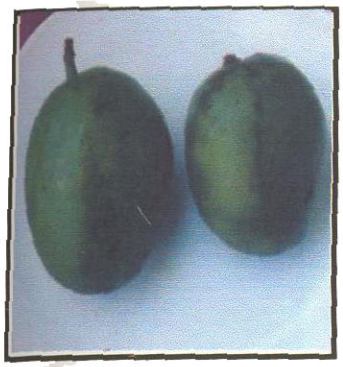

T 83

PLATE - 7 VARIATION IN RIPE FRUITS



T 98

T 36

T 129

T 61

T 121

T 109

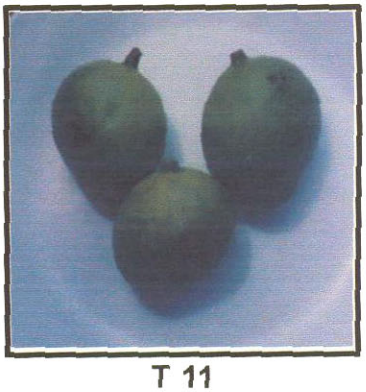
T 62

T 30

T 43

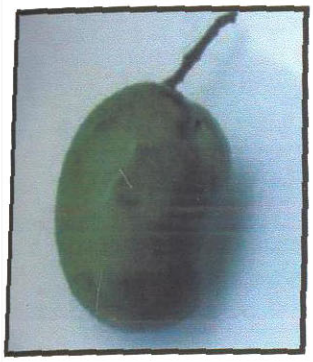
T 32

T 17



T 11

PLATE - 8 VARIATION IN RIPE FRUIT COLOR



GREEN

YELLOW

YELLOWISH GREEN

GREEN WITH RED BLOTCH

REDDISH

4.6.2.1 Length

Length of ripe fruits ranged from 4.11 to 10 cm. The coefficient of variation was 17.51 per cent and the mean fruit length was 6.07 cm.

4.6.2.2 Breadth

The breadth of ripe fruits ranged from 3.2 to 7.1 cm with a coefficient of variation of 15.84 per cent. The average fruit breadth was 4.85 cm.

4.6.2.3 Thickness

The thickness of fruits ranged from 2.8 to 5.9 cm with an average of 4.31 cm. The coefficient of variation was as low as 14.3 per cent.

4.6.2.4 Weight

The weight of fruits showed a high variation with a coefficient of variation of 45.05 per cent. The minimum fruit weight recorded was 20.3 g and maximum was 203 g. The average was 82.82 g.

4.6.2.5 Volume

Volume of fruits also showed similar variation with a minimum of 19.8 ml and maximum of 211.7 ml. The average was 81.49 and the coefficient of variation was 46.02 per cent.

4.6.2.6 Specific gravity

The average specific gravity recorded was 1.03 and the coefficient of variation was as low as 9.71 per cent. Specific gravity ranged from 0.88 to 1.55.

4.6.2.7 Skin weight

Average skin weight of ripe fruits was 19.26g. Skin weight varied from 7.3 to 53.7 g and the coefficient of variation was 41.56%.

4.6.2.8 Pulp weight

Pulp weight of fruits varied from 7.4 to 120.6g. The average pulp weight was 42.16g and the coefficient of variation was 60.45%.

4.6.2.9 Stone weight

Stone weight of ripe fruits varied from 3.8 to 40.8g. The average stone weight was 20.11g and the coefficient of variation was 36.54%.

4.6.2.10 Skin content of fruits

Skin content of fruits varied from 12.49 per cent to 36.3 per cent with a coefficient of variation of 23. 43 per cent. The mean skin content was 24.21 per cent.

4.6.2.11 Stone content of fruits

Stone content of ripe fruits varied from 13.69 to 38.62 per cent. The mean stone content was 26.24 per cent

4.6.2.12 Pulp content of fruits

Pulp content of the ripe fruits varied from 20.92 to 70.43 per cent with a mean value of 47.49 per cent.

4.6.2.13 Length/breadth ratio

Length/breadth of ripe fruits varied from 1.02-1.75 and recorded only a low coefficient of variation of 11.31 per cent.

4.2.6.2.14 Pulp/peel ratio

Pulp/peel ratio of fruits varied from 0.87 to 5.15 with an average value of 2.21. The coefficient of variation was 39.71 per cent.

4.6.2.15 Pulp/stone ratio

Pulp/stone ratio of fruits varied from 0.99 to 4.76 with an average value of 2.06. The coefficient of variation was 45.54 per cent.

Table 10. Variation in ripe fruit characters

Sl.No.	Character	Range	Mean	Co efficient of variation (%)
1	Length (cm)	4.11-10.0	6.07	17.51
2	Breadth (cm)	3.2-7.1	4.85	15.84
3	Thickness (cm)	2.8-5.9	4.31	14.30
4	Weight (g)	20.3-203.0	82.82	45.05
5	Volume (ml)	19.8-211.7	81.49	46.02
6	Specific gravity	0.88-1.55	1.03	9.71
7	Skin weight (g)	7.3-53.7	19.26	41.56
8	Pulp weight (g)	7.4-120.6	42.16	60.45
9	Stone weight (g)	3.8-40.8	20.11	36.54
10	Skin (%)	12.49-36.13	24.21	23.43
11	Stone (%)	13.69-38.62	26.14	29.72
12	Pulp (%)	20.22-70.43	47.49	22.15
13	Length/breadth	1.02-1.75	1.25	11.31
14	Pulp/peel ratio	0.87-5.15	2.21	39.71
15	Pulp/stone ratio	0.99-4.76	2.06	45.54

4.7 Stone characters

4.7.1 Descriptive characters

4.7.1.1 Stone venation

Parallel venation was noted in 62.24 per cent of the samples while 37.75 per cent had forked or reticulate venation on the stone.

53.06 per cent of the samples had depressed venation, while 6.12 per cent had raised venation, and the rest had venation parallel to the surface (Table 11)

4.7.1.2 Fibre attachment

Abundant fibre attachment was noted in more than 90 per cent of the stone

samples studied. 9.60 per cent were less fibrous (Table 11).

Table 11. Distribution of genotypes based on descriptive characters of stone

Sl.No.	Character	Description	No. of trees	Frequency distribution (%)
1	Stone venation	Parallel	61	62.24
		Forked	37	37.75
2	Stone venation	Depressed	52	53.06
		Raised	6	6.12
		Level with surface	40	40.81
3	Fibre attachment	Fibrous	89	90.40
		Less fibrous	9	9.60

4.7.2 Biometric characters

4.7.2.1 Stone length

The stone length ranged from 2.7 to 8.7 cm. The average stone length was 4.97 cm with a coefficient of variation of 19.09 per cent (Table 12).

4.7.2.2 Stone breadth

The stone breadth ranged from 1.9 to 3.79 cm. The average was 3.01 cm. The coefficient of variation was 21.17 per cent (Table 12).

4.7.2.3 Stone thickness

Stone thickness varied from 1.0 to 2.67 cm with a coefficient of variation of 30.97 per cent. The average stone thickness noted was 1.91 cm (Table 12).

4.7.2.4 Stone weight

Stone weight varied from 3.8 to 40.8 g with an average of 20.11 g and coefficient of variation of 36.54 per cent (Table 12)

4.7.2.5 Stone volume

The average stone volume was 20.11 ml with a coefficient of variation of 36.59 per cent. It ranged from 9.5 ml to 41.3 ml.

Table 12. Variation in biometric characters of stone

Sl. No.	Character	Range	Mean	Coefficient of variation(%)
1	Stone length (cm)	2.7-8.7	4.97	19.09
2	Stone breadth (cm)	1.9-3.79	3.01	21.27
3	Stone thickness (cm)	1.0-2.67	1.91	30.97
4	Stone weight (g)	3.8-40.8	20.11	36.54
5	Stone volume (ml)	9.5-41.3	20.11	36.59

4.8 Biochemical characters

Variation recorded in the biochemical characters of tender and ripe fruit are presented in Table 13.

4.8.1 Tender fruits

4.8.1.1 Acidity

Acidity of tender fruits ranged from 1.1 per cent to 3.5 per cent. The coefficient of variation was 27.49 per cent. The mean value for acidity was 2.09 per cent.

4.8.1.2 Ascorbic acid

Variation noted in ascorbic acid was high with a coefficient of variation of 39.75 per cent. Ascorbic acid content varied from 16.7 to 191.5 mg/100 g with a mean value of 113.86.

4.8.1.3 Polyphenol

Polyphenol content expressed in mg/g fruit varied from 0.5 to 3.4 with a mean value of 1.75 mg/g. The coefficient of variation was 33.32 per cent.

4.8.1.4 Crude fibre

Crude fibre content on dry weight basis varied from 4.4 to 13.9 per cent among the samples. The average was 8.76 per cent and the coefficient of variation was 20.64 per cent.

4.8.2 Ripe fruit

4.8.2.1 Juice content

The juice content of fruits was on an average 58.49 per cent. Juice content varied from 40 to 72.7 per cent.

4.8.2.2 Total Soluble Solids

T.S.S. content of fruits varied from 5°-22° brix with an average of 13.58°. The coefficient of variation was 26.46 per cent.

4.8.2.3 Acidity

Acidity of ripe fruits varied from 0.3-3.5 per cent with an average of 0.99. The coefficient of variation for acidity was 54.39 per cent.

4.8.2.4 TSS/acid ratio

Sugar/acid ratio of ripe fruits varied from 5.29-40.0 per cent with an average value of 17.91. The coefficient of variation was 58.87 per cent

Table 13. Variation in biochemical characters of fruits

Sl.No.	Character	Range	Mean	Coefficient of variation (%)
1	Tender fruit - Acidity (%)	1.1-3.5	2.09	27.49
2	Tender fruit - Ascorbic acid (mg/100g)	16.7-191.5	113.86	39.75
3	Tender fruit - Polyphenol (mg/g)	0.5-3.4	1.75	33.32
4	Tender fruit - Crude fibre (% on dry weight base)	4.4-13.9	8.76	20.64
5	Ripe fruit - Juice (content %)	40.0-72.7	58.49	22.32
6	Ripe fruit - TSS (°brix)	5.0-22.0	13.58	26.46
7	Ripe fruit - Acidity (%)	0.3-3.5	0.99	54.39
8	Ripe fruit - TSS/acid	5.29-40.00	17.91	58.87

4.9 Pickling quality of tender fruits

Pickling quality was based on six characters and the results are as follows. The characters were scored from 1-5 with score 1 attributed for most acceptable and score 5 for least acceptable. The results are presented in table 14

4.9.1 Appearance of pickled fruits

Appearance of fruits one year after pickling showed a variation of 37.69 per cent. The highest score of 1 i.e., best appearance was recorded from 14.19 per cent of the samples and 55.4 per cent of the samples recorded a score of 1-2. Average score was 1.78. A score of 2-3 was recorded for 27.03 per cent of the samples and 3.38 per cent of the samples had a score of 3-4.

4.9.2 Colour of pickled fruits

The colour of fruits after pickling showed a coefficient of variation of 34.66 per cent. Best score was recorded from 17.61 per cent and 43.66 per cent recorded a score from 1-2. The average score was 1.85.

4.9.3 Aroma of pickled fruits

Aroma of pickled fruits showed a coefficient of variation of 34.66 per cent. 10.41 per cent of the samples had a score of 1 and 46.15 per cent had a score between 1 and 2. The average score was 2.14.

4.9.4 Texture of pickled fruits

Texture variations were high with a coefficient of variation 40.95 per cent. The percentage of samples that scored 1 was 13.11. The percentage of samples with score between 1 and 2 were 51.03. Average score was 1.86. Only less than 10 per cent of the samples had a score above 3.

4.9.5 Taste of pickled fruits

The coefficient of variation for taste was 39.72 with 2.76 per cent giving a score of 1 and 47.59 giving a score between 1 and 2. Average score was 2.14. Only less than 12 per cent of the samples had a score above 3.

4.9.6 Overall acceptability of pickled fruits

The overall acceptability showed a coefficient of variation of 35.47 per cent. The best score of one was recorded from 3.49 per cent of the samples where as 47.95 per cent recorded a score between 1 and 2. Average for overall acceptability was 2.11.

Table 14 . Distribution of genotypes based on pickling quality

Sl.No.	Characters	Score	Frequency distribution(%)	Coefficient of variation (%)
1	Appearance	1	14.19	
		1-2	55.40	
		2-3	27.03	37.69
		3-4	3.38	
		4-5	-	
2	Colour	1	17.61	
		1-2	43.66	
		2-3	33.09	34.66
		3-4	5.64	
		4-5	-	
3	Aroma	1	10.41	
		1-2	46.15	
		2-3	32.87	34.66
		3-4	7.69	
		4-5	-	
4	Texture	1	13.11	
		1-2	51.03	
		2-3	28.96	40.95
		3-4	6.89	
		4-5	-	
5	Taste	1	2.76	
		1-2	47.59	
		2-3	37.93	39.72
		3-4	11.03	
		4-5	0.69	
6	Overall acceptability	1	3.49	
		1-2	47.95	
		2-3	34.93	35.47
		3-4	13.01	
		4-5	0.69	

*Score 1- Most acceptable; Score 2 - Acceptable; Score 3 - Less acceptable; Score 4 - Least acceptable; Score 5 - Not at all acceptable

4.10 Character association and correlation

Correlation and character association was worked out between leaf characters, fruit characters, pickling quality, biochemical characters and also between fruit characters and biochemical characters.

4.10.1 Leaf characters

4.10.1.1 Character Association

4.10.1.1.1 Leaf shape and leaf tip

Association of leaf tip character and leaf shape character was significant. Lanceolate leaf shape and acuminate leaf tip was common followed by oblong lanceolate shape and acuminate leaf tip. (Table 15)

Table 15. Distribution of trees according to leaf shape and leaf tip classification

Leaf shape	Leaf Tip		
	Acute	Acuminate	Obtuse
Lanceolate	7	96	1
Oblong Lanceolate	6	30	2
Oblong	2	5	1
Chi square	44.384**		

** Significant at 0.01 level

4.10.1.1.2 Leaf shape and Leaf margin

Flat and wavy leaf margin was common for all leaf shapes. Folded and crinkled leaf margin was noted only for six trees. Leaf shape and leaf margin was not having any significant association (Table 16).

Table 16. Distribution of trees according to leaf shape and leaf margin classification

Leaf shape	Leaf Margin			
	Flat	Wavy	Folded	Crinkled
Lanceolate	67	34	2	1
Oblong Lanceolate	21	16	1	0
Oblong	3	3	1	1
Chi square	7.675 NS			

4.10.1.1.3 Leaf tip and leaf margin

Association between leaf tip and leaf margin was not significant (Table 17). Acuminate leaf tip with flat or wavy leaf margin was very common among the trees studied.

Table 17. Distribution of trees according to leaf tip and leaf margin classification

Leaf Tip	Leaf Margin			
	Flat	Wavy	Folded	Crinkled
Acute	8	7	0	0
Acuminate	81	45	4	1
Obtuse	2	1	0	1
Chi square	1.753 NS			

4.10.1.2 Correlation

Leaf length had a significant positive correlation with leaf breadth and petiole length. Leaf breadth also had a significant positive correlation with petiole length (Table 18)

Table 18. Correlation coefficients between leaf characters

	Breadth	Petiole length
Length	0.544*	0.665**
Breadth		0.329*

** Significant at 0.01 level

4.10.2 Character association between inflorescence characters

4.10.2.1 Inflorescence color and shape

There was no significant relation between inflorescence color and inflorescence shape. Broadly pyramidal infloresence and green color of inflorescence axis was common. Deep pink color was rarely noted (Table 19)

Table 19. Distribution of trees according to inflorescence shape and inflorescence color classification

Inflorescence shape	Inflorescence color		
	Green	Light pink	Deep pink
Pyramidal	29	11	1
Broadly pyramidal	85	22	2
Chi square	0.859 NS		

4.10.3 Tender fruit characters

4.10.3.1 Character association

4.10.3.1.1 Fruit smell and leaf smell

Deep smell of fruits and leaves were noticed in 89 genotypes. In 44 genotypes deep smell of fruits was associated with mild smell of leaves. However, fruit smell and aroma of leaves were not having any significant association (Table20).

Table 20. Distribution of trees according to fruit smell and leaf aroma

Fruit smell	Leaf aroma		
	Mild	Deep	No smell
Deep	44	89	2
Mild	4	11	-
Chi square	1.793 NS		

4.10.3.2 Correlation

The correlation matrix is presented in Table 21.Tender fruit length was significantly and positively correlated with fruit breadth, stone width, stalk length, weight, volume and specific gravity of fruits. Breadth of tender fruits was significantly and positively correlated with stone width, weight and volume of tender fruit. Stone width was positively correlated with weight and volume of fruits. Weight of fruits was positively correlated with volume of fruits. Both weight and volume of fruits were significantly correlated with specific gravity of fruits.

Table 21. Correlation coefficients between tender fruit characters

	Breadth	Stone width	Stalk length	Stalk thickness	Weight	Volume	Specific gravity
Length	0.743**	0.637**	0.256**	-0.032^{NS}	0.434**	0.531**	0.229*
Breadth		0.752**	0.150^{NS}	0.048^{NS}	0.378**	0.530**	0.145^{NS}
Stone width			0.172^{NS}	-0.019^{NS}	0.235*	0.395**	0.057^{NS}
Stalk length				-0.150^{NS}	0.092^{NS}	0.164^{NS}	0.127^{NS}
Stalk thickness					-0.093^{NS}	-0.062^{NS}	-0.096^{NS}
Weight						0.707**	0.441**
Volume							0.215*

* Significant at 0.05 level

** Significant at 0.01 level

4.10.4 Ripe fruit characters

4.10.4.1 Character association

4.10.4.1.1 Fruit shape and sinus

Significant relationship was obtained between shape of fruit and sinus of fruit. Round fruits had almost an equal distribution of all sinus forms whereas oblong and elliptic fruits had more of shallow sinus (Table 22).

Table 22. Distribution of trees according to fruit shape and fruit sinus classification

Fruit sinus	Fruit shape		
	Oblong	Ellipsoid	Roundish
Absent	9	2	18
Shallow	22	8	17
Deep	8	2	12
Chi square	22.256**		

** Significant at 0.01 level

4.10.4.1.2 Fruit shape and apex

Obtuse or rounded apex was common for the ripe fruits of all the three different shapes (Table 23). The relationship was not significant.

Table 23. Distribution of trees according to fruit shape and fruit apex classification

Fruit apex	Fruit shape		
	Oblong	Ellipsoid	Roundish
Obtuse or rounded	34	7	41
Acute	5	5	6
Chi square	5.545^{NS}		

4.10.4.1.3 Sinus and beak

Shape of sinus and shape of beak was found to be significantly related. In fruits with sinus absent, beak was either a point or absent. Shallow sinus was more associated with pointed or a point beak. (Table 24).

Table 24. Distribution of trees according to beak and sinus classification of fruits

Fruit beak	Sinus		
	Absent	Shallow	Deep
Absent	13	10	7
Pointed	1	20	10
A point	12	18	7
Chi square	37.994**		

** Significant at 0.01 level

4.10.4.1.4 Fruit shape and beak

Significant association was recorded between fruit shape and beak shape. In round fruits beak was either absent or a point. In oblong fruits beak was commonly a point followed by pointed beak. Ellipsoid fruits had more of pointed beak (Table 25).

Table 25. Distribution of trees according to fruit shape and beak classification

Fruit shape	Beak		
	Absent	Pointed	A point
Oblong	9	13	17
Ellipsoid	1	7	4
Roundish	20	11	16
Chi square	30.301**		

** Significant at 0.01 level

4.10.4.1.5 Fruit shape and stalk attachment

Type of attachment of stalk and shapes of fruit were closely associated. Straight stalk attachment was more commonly associated with roundish fruits. Oblong and ellipsoid fruits were associated with oblique stalk attachment (Table 26).

Table 26. Distribution of trees according to fruit shape and stalk attachment classification

Stalk attachment	Fruit shape		
	Oblong	Ellipsoid	Roundish
Straight	13	3	28
Oblique	26	9	19
Chi square	27.855**		

** Significant at 0.01 level

4.10.4.1.6 Skin color and flesh color

The relationship between color of skin and color of flesh was significant. The genotypes studied had in general fruits with green color or shades of green and yellow color. Green skin and orange flesh was maximum noted followed by green skin and yellow flesh. Red skin color was rarely noted. Orange flesh was common followed by yellow flesh (Table27).

Table 27. Distribution of trees according to skin colour and flesh colour of ripe fruits

Skin color	Flesh color			
	Orange	Deep orange	Deep yellow	Yellow
Green	27	6	4	14
Greenish yellow	13	4	2	10
Yellow	5	2	1	6
Reddish	3	0	0	0
Green and red	1	0	1	1
Chi square	26.339**			

** Significant at 0.01 level

4.10.4.1.7 Skin adherence and pulp texture

Skin adherence to pulp and pulp texture had a significant association. Juicy and soft flesh was associated with free skin (Table 28).

Table 28. Distribution of trees according to skin adherence and pulp texture

Pulp texture	Skin adherence	
	Free	Adhering
Juicy	26	1
Soft	64	3
Hard	1	1
Chi square	27.449**	

** Significant at 0.01 level

4.10.4.2 Correlation

Length of fruits was significantly and positively correlated with breadth, thickness, weight, volume, skin weight, pulp weight and stone weight. Breadth of ripe fruits was significantly and positively correlated with thickness, weight, volume, skin weight, pulp weight, stone weight and juice content. Thickness of fruits was positively and significantly correlated with weight, volume, skin weight, pulp weight. Weight and volume of ripe fruits was significantly and positively correlated with skin weight, pulp weight and stone weight. Skin weight of ripe fruits was positively correlated with pulp weight and stone weight. Pulp weight was positively correlated with stone weight (Table 29).

Table 29. Correlation coefficients between ripe fruit characters

	Breadth	Thick-ness	Weight	Volume	Skin weight	Pulp weight	Stone weight
Length	0.797**	0.709**	0.869**	0.869**	0.770**	0.757**	0.724**
Breadth		0.846**	0.914**	0.928**	0.774**	0.805**	0.716**
Thickness			0.834**	0.830**	0.685**	0.758**	0.608**
Weight				0.982**	0.808**	0.900**	0.718**
Volume					0.826**	0.883**	0.711**
Skin weight						0.715**	0.720**
Pulp weight							0.536**

** Significant at 0.01 level

Relations were worked out between biometric and biochemical characters of ripe fruit. The results are presented in table 30. Juice content was positively correlated with breadth of fruits. Total soluble solids was negatively correlated to length of fruits. No significant relation was obtained for rest of the characters

Table 30. Correlation coefficients between biometric and quality characters of ripe fruit

	Juice (%)	TSS	Acidity
Length	-0.004^{NS}	-0.203*	-0.109^{NS}
Breadth	0.203*	-0.157^{NS}	-0.119^{NS}
Thickness	-0.010^{NS}	0.134^{NS}	0.104^{NS}
Weight	0.005^{NS}	0.106^{NS}	0.176^{NS}
Volume	0.024^{NS}	-0.116^{NS}	-0.165^{NS}
Skin weight	0.080^{NS}	0.079^{NS}	-0.045^{NS}
Pulp weight	0.011^{NS}	0.018^{NS}	-0.173^{NS}
Stone weight	-0.128^{NS}	-0.166^{NS}	0.037^{NS}

* Significant at 0.05 level

4.10.5 Stone characters

4.10.5.1 Character association

4.10.5.1.1 Stone venation

The relation between the two types of stone venation was significant. Parallel and depressed venation was more common among the trees studied. Reticulate venation was more associated with level venation (Table 31).

Table 31. Distribution of trees according to stone venation

Stone venation	Stone venation	
	Parallel	Reticulate
Depressed	38	14
Level	21	19
Raised	2	4
Chi square	28.000**	

** Significant at 0.01 level

4.10.5.2 Correlation

Stone length was significantly and positively correlated with breadth, thickness, weight and volume of stone. Similarly breadth of stone was significantly and positively correlated to stone thickness, weight and volume of stone. Thickness of stone was positively correlated to weight and volume. Weight of stone was positively correlated to volume (Table 32).

Table 32. Correlation coefficients between stone characters

	Breadth	Thickness	Weight	Volume
Length	0.730**	0.432**	0.750**	0.665**
Breadth		0.569**	0.698**	0.524**
Thickness			0.357**	0.224**
Weight				0.925**

** Significant at 0.01 level

4.10.6 Pickling quality

4.10.6.1 Correlation between different of components of pickling quality

The correlation coefficients between the different components of pickling quality are presented in Table 33.

Pickling characters were rated on the basis of a score from 1 to 5 with the most acceptable having a score of one and least acceptable with a score of five.

Appearance of pickled fruits had a significant and positive correlation with colour, taste, texture and overall acceptability.

Colour of pickled fruits had a significant positive correlation with aroma, taste, texture and overall acceptability of pickled fruits.

Aroma of pickled fruits was positively correlated with taste, texture and overall acceptability of pickles.

Taste of fruits after pickling was positively related to texture and overall acceptability.

Texture was positively correlated with overall acceptability.

Overall acceptability of pickled fruits had significant positive relation with the rest of the components of pickling quality.

Table 33. Correlation coefficients between components of pickling quality

	Colour	Aroma	Taste	Texture	Overall acceptability
Appearance	0.945**	0.844**	0.864**	0.612**	0.883**
Colour		0.872**	0.876**	0.600**	0.894**
Aroma			0.835**	0.511**	0.842**
Taste				0.671**	0.918**
Texture					0.686**

** Significant at 0.01 level

4.10.6.2 Correlation between fruit size and pickling quality

Appearance of pickled fruits had a significant negative correlation with length, breadth and stone width of tender fruits. Overall acceptability of pickled fruits was not found to be correlated with size characters of tender fruits (Table 34).

Table 34. Correlation coefficients of appearance and overall acceptability of pickled fruits with tender fruit characters

	Appearance	Overall acceptability
Length	-0.261**	-0.176^{NS}
Breadth	-0.265**	-0.184^{NS}
Stone width	-0.203*	-0.147^{NS}
Stalk length	-0.154^{NS}	-0.175^{NS}
Stalk thickness	-0.064^{NS}	-0.036^{NS}
Skin thickness	0.104^{NS}	0.092^{NS}

* Significant at 0.05 level

** Significant at 0.01 level

4.10.6.3 Correlation between quality characters of tender fruits and pickling quality

Pickling characters were rated on the basis of a score from 1 to 5 with the most acceptable having a score of one and least acceptable with a score of five. Appearance of pickled fruits was negatively correlated with acidity and shrinkage of tender fruits. This indicated that when acidity and shrinkage were high, pickling quality had lower scores which were given for better acceptance. Appearance of pickled fruits had only a weak correlation with polyphenol and crude fibre content.

Color of pickled fruits had no significant relation with biochemical characters studied and the shrinkage of fruits.

Aroma was negatively related to acidity indicating that high values for acidity is related to a better aroma of pickled fruits.

Taste of pickled fruits was negatively correlated with acidity and crude fibre. This indicated that fruits with high acidity and crude fibre content was better in taste after pickling.

Texture was negatively correlated with acidity and crude fibre indicating a positive association of good texture of pickled fruits with high acidity and crude fibre content.

Overall acceptability had significant negative correlation with acidity of tender fruits indicating that fruits with more acidity was more acceptable. There was no correlation with polyphenol content (Table 35).

Acidity of tender fruits had a significant relation only with ascorbic acid (0.237) and polyphenol content had a significant positive correlation with crude fibre content (0.254).

Table 35. Correlation coefficients between quality of tender fruits and pickling quality

	Acidity	Polyphenol	Crude fibre	Shrinkage
Appearance	-0.228*	-0.094^{NS}	-0.136^{NS}	-0.986**
Colour	-0.223*	-0.117^{NS}	-0.153^{NS}	0.018^{NS}
Aroma	-0.230*	-0.124^{NS}	0.017^{NS}	0.114^{NS}
Taste	-0.190*	-0.145^{NS}	-0.214*	0.017^{NS}
Texture	-0.197*	-0.121^{NS}	-0.195*	0.114^{NS}
Overall acceptability	-0.213*	-0.101^{NS}	-0.104^{NS}	0.030^{NS}

* Significant at 0.05 level

** Significant at 0.01 level

4.11 Influence of descriptive characters on biometric characters

Analysis of variance was conducted to find out the relation between descriptive characters and biometric characters. Analysis was done between the following characters

1. Leaf shape on leaf length
2. Leaf shape on leaf breadth
3. Leaf shape on petiole length
4. Leaf shape on length/breadth ratio of leaves
5. Inflorescence shape on inflorescence length
6. Inflorescence shape on inflorescence breadth
7. Ripe fruit shape on ripe fruit length
8. Ripe fruit shape on ripe fruit breadth
9. Ripe fruit shape on ripe fruit thickness
10. Ripe fruit shape on ripe fruit weight
11. Ripe fruit shape on ripe fruit volume
12. Ripe fruit shape on ripe fruit specific gravity
13. Ripe fruit shape on stone length
14. Ripe fruit shape on stone breadth
15. Ripe fruit shape on stone thickness
16. Ripe fruit shape on stone weight
17. Ripe fruit shape on stone volume
18. Ripe fruit shape on ripe fruit length /breadth ratio
19. Ripe fruit texture on juice content
20. Ripe fruit texture on TSS
21. Ripe fruit texture on acidity

Significant results obtained are presented below.

4.11.1 Leaf shape and breadth of leaves

There was significant difference in the breadth of leaves between the different shapes of leaves. Oblong leaves had maximum breadth and lanceolate leaves had the minimum breadth (Table 36).

Table 36. Effect of leaf shape on breadth of leaves

Sl.No.	Shape	Breadth (cm)
1	Lanceolate	4.940
2	Oblong lanceolate	5.614
3	Oblong	6.457
C D (0.05)		0.656
SEm±		0.08

4.11.2 Leaf shape and length/breadth ratio of leaves

There was significant difference in the length/breadth ratio between the leaves of different shapes. Lanceolate leaves had the maximum ratio between length and breadth of leaves followed by oblong lanceolate leaves (Table 37).

Table 37. Effect of leaf shape on leaf length/breadth ratio of leaves

Sl.No.	Leaf shape	Length/breadth ratio
1	Lanceolate	4.669
2	Oblong lanceolate	4.125
3	Oblong	3.615
CD(0.05)		0.469
SEm±		0.06

4.11.3 Inflorescence shape and inflorescence breadth

Significant difference was noticed between the different shapes of inflorescence in breadth of inflorescence. Broadly pyramidal inflorescence had the maximum breadth (Table 38)

Table 38. Effect of Inflorescence shape on inflorescence breadth

Sl.No.	Inflorescence shape	Inflorescence breadth (cm)
1	Broadly pyramidal	25.981
2	Pyramidal	21.298
	CD(0.05)	1.825
	SEm±	0.04

4.11.4 Fruit shape and fruit length of ripe fruits

Elliptic fruits had maximum length followed by oblong fruits. Round fruits had the minimum fruit length (Table39)

Table 39. Effect of ripe fruit shape on ripe fruit length

Sl.No.	Shape	Mean length of ripe fruits (cm)
1	Oblong	6.195
2	Elliptic	6.877
3	Roundish	5.708
	CD(0.05)	0.700
	SEm±	0.11

4.11.5 Ripe fruit shape and length/breadth ratio of ripe fruits

Length/breadth ratio of ripe fruits was lowest when the fruits were round in shape (Table 40). Length/breadth ratio was maximum when the fruits were elliptic in shape.

Table 40. Effect of ripe fruit shape on length/breadth ratio of ripe fruits

Sl.No.	Shape	Length/breadth ratio
1	Oblong	1.333
2	Elliptic	1.347
3	Roundish	1.167
	CD(0.05)	0.738
	SEm±	0.10

4.11.6 Ripe fruit shape and length/breadth ratio of tender fruits

Round shaped ripe fruits had a lower length/breadth ratio for tender fruits followed by oblong shaped fruits. Elliptic fruits had the maximum length/breadth ratio at the tender stage (Table 41).

Table 41. Effect of ripe fruit shape on length/breadth ratio of tender fruits

Sl.No.	Shape	Length/breadth ratio
1	Oblong	1.390
2	Elliptic	1.411
3	Roundish	1.259
	CD(0.05)	0.134
	SEm±	0.02

4.11.7 Pulp texture and juice content in ripe fruits

Pulp texture of ripe fruits were grouped into juicy, soft and hard. It was found that juicy types had more juice content and the soft and hard textured fruits were on par (Table 42).

Table 42. Effect of pulp texture on juice content of ripe fruits

Sl.No.	Pulp texture	Juice content (%)
1	Juicy	64.815
2	Soft	55.903
3	Hard	57.700
	CD (0.05)	15.34
	SEm±	1.35

4.11.8 Pulp texture and TSS of ripe fruits

TSS content of fruit pulp varied between the different texture groups of pulp. Maximum TSS was recorded for fruits with hard pulp texture followed by fruits with soft pulp texture. Juicy fruits recorded the minimum TSS (Table 43)

Table 43. Effect of pulp texture on TSS of ripe fruits

Sl.No.	Pulp texture	Total Soluble Solids °Brix
1	Juicy	12.741
2	Soft	14.015
3	Hard	17.000
	CD(0.05)	4.38
	SEm±	0.37

4.11.9 Fruit shape and stone length in ripe fruits

Stone length in ripe fruits was lowest when the fruits were round in shape followed by oblong shape. Stones of elliptic fruits had the maximum length(Table 44)

Table 44. Effect of ripe fruit shape on stone length

Sl.No.	Shape	Stone Length(cm)
1	Oblong	5.164
2	Elliptic	5.567
3	Roundish	4.612
	CD(0.05)	0.627
	SEm±	0.10

There was no significant relation between the rest of the characters studied.

4.12 Pathological tests

Fruit samples were stored for one year and samples were drawn out for inoculation in potato agar. Differences were noted between the samples in the days taken for developing fungal infestation and on the intensity of infestation. It was noted that nine out of one hundred and thirty six samples developed fungal infestation in two days after inoculation. By the fourth day 87 out of 136 were infested. By 6^{th} day 131 out of 136 samples were infested.

There was variation in the intensity of fungal infestation. In 27 samples 100 per cent infestation was noted in four days period. In rest of the samples initially only 16.6 to 33.3 per cent infestation was noticed. In eight days period, 109 samples were completely covered by fungi. In five samples first infestation by the fungi was noted only after six days.

The important fungi noted were *Aspergillus niger* and *Pencillium citrinum*. *Aspergillus flavus* was not noticed in early stages but by 10^{th} and 12^{th} day after inoculation *Aspergillus flavus* was also noticed.

Correlation was worked out between development of fungus and the quality parameters of tender fruits. The results are presented in table 45.

Polyphenol content and crude fibre content had significant negative correlation with fungal development 6 days after inoculation.

Table 45. Correlation coefficients between fungal infestation and quality characters of fruits

	4 days	6 days
Acidity	0.037	-0.030
Polyphenol	-0.059	-0.208*
Crude fibre	-0.087	-0.290*

* Significant at 0.05 level

** Significant at 0.01 level

4.13 Path analysis

Path analysis was conducted to work out the direct and indirect effects of factors influencing pickling quality.

4.13.1 Direct and indirect effects of components of pickling quality on overall acceptability of pickled fruits.

The direct effect on pickling quality was maximum for taste followed by colour of pickled fruits. The indirect effects of taste for all the other characters were also positive This was followed by texture of pickled fruits and aroma of pickled fruits. Appearance of pickled fruits had only a low negative indirect effect on the overall acceptability of pickled fruits and all indirect effects were also negative. (Table 46)

Table 46. Matrix of direct and indirect effects of components of pickling quality on overall acceptability of pickled fruits

	Appearance	Colour	Aroma	Taste	Texture
1	-0.1271	0.2457	0.1296	0.4659	0.1590
2	-0.1206	0.2590	0.1310	0.4805	0.1584
3	-0.1093	0.2251	0.1507	0.4667	0.1405
4	-0.1103	0.2318	0.1310	0.5368	0.1629
5	-0.0964	0.1959	0.1011	0.4174	0.2095
Residual :	0.0596				

4.13.2 Direct and indirect effects of tender fruit size and quality characters on overall acceptability of pickled fruits.

Direct and indirect effects of the size components of tender fruits and quality characters on overall acceptability of pickled fruits were analysed. No significant effect was noted for both the characters as the residual effect was high for length, breadth, stone width, stalk length, length/breadth ratio, weight, volume, acidity, polyphenol and crude fibre content of tender fruits.

4.14 Cluster analysis

Genotypes were grouped into nine clusters based on selected fruit characters. The data on range and mean of tender fruit characters and pickling quality parameters are presented in Table 47. Genotypes under different clusters are indicated in Table 55 (Appendix III).

Cluster number eight which included genotypes 38, 60, 85 and 125 had the best score for appearance, colour, aroma, taste, texture and overall acceptability of pickled fruits. Acidity and polyphenol content were higher for this cluster (2.3% and 1.75 mg/100g respectively). The length/ breadth ratio of tender fruits was comparatively higher for this cluster (1.34). Crude fibre content was also on the upper range.

Cluster number one was the next best in the overall acceptability of pickled fruits. Cluster number nine and five included genotypes which were poor in pickling quality.

Table 47. Clustering of genotypes-Range and mean values of tender fruit characters

Clus-ter No.	Characters											
	Appearance of pickled fruits (Score)	Colour of pickled fruits (Score)	Aroma of pickled fruits (Score)	Taste of pickled fruits (Score)	Texture of pickled fruits (Score)	Overall acceptability of pickled fruits (Score)	Acidity (%)	Ascorbic acid (mg/100 g fruit)	Poly phenols (mg/g fruit)	Crude fibre (%)	Specific gravity	Length/ breadth ratio
1	2	3	4	5	6	7	8	9	10	11	12	13
I	1.0-3.3 (1.73)	1.1-3.8 (1.88)	1.0-3.8 (1.78)	1.1-3.7 (2.03)	1.1-3.3 (2.03)	1.1-3.0 (1.95)	1.4-3.5 (2.3)	83.2-128 (116.5)	1.6-2.7 (1.95)	5.9-11.9 (8.83)	0.8-1.37 (1.1)	0.85-1.32 (1.26)
II	1.0-3.0 (1.78)	1.0-3.1 (1.87)	1.1-3.0 (2.03)	1.1-3.5 (2.15)	1.0-4.0 (2.35)	1.0-2.9 (2.13)	1.8-2.8 (2.23)	10.8-179.5 (98.9)	1.1-2.9 (1.17)	9.7-13.9 (10.78)	1.0-1.4 (1.1)	1.1-2.57 (2.1)
III	1.0-2.3 (1.93)	1.0-2.8 (2.0)	1.0-3.0 (2.13)	1.4-3.1 (2.3)	1.0-3.2 (1.83)	1.1-3.2 (2.23)	1.4-2.57 (2.57)	45.3-178.2 (108.5)	0.9-3.4 (1.93)	5.6-10.0 (7.58)	0.8-1.3 (1.0)	1.21-1.68 (1.37)
IV	1.0-2.6 (1.5)	1-2.7 (1.56)	1.0-4.0 (1.88)	1.0-2.4 (1.76)	1.0-2.6 (1.42)	1.0-2.4 (1.7)	1.5-2.6 (2.14)	89.7-179.9 (132.1)	1.0-2.9 (1.92)	6.2-12.0 (9.68)	0.8-1.1 (1.02)	1.07-1.8 (1.32)

contd...

Table 47 (Continued) Clustering of genotypes – Range and mean values of tender fruit characters

1	2	3	4	5	6	7	8	9	10	11	12	13
V	1.6-2.7 (1.95)	1.9-2.2 (2.1)	1.2-2.8 (2.3)	1.8-2.9 (2.28)	1.2-2.6 (1.93)	1.8-2.9 (2.28)	1.4-2.9 (2.07)	36.0-166.5 (140.3)	1.6-2.8 (1.92)	6.7-9.9 (8.63)	0.5-1.2 (0.98)	1.2-1.6 (1.3)
VI	1.2-2.0 (1.73)	1.2-4.0 (1.83)	1.1-2.6 (1.8)	1.3-2.9 (1.96)	1.0-2.3 (1.47)	1.3-2.7(2.03)	1.7-2.9 (2.13)	35.7-191.5 (159.3)	0.3-0.9 (0.92)	6.8-11.8 (8.76)	0.6-1.5 (0.94)	1.22-1.5 (1.31)
VII	1.0-1.9 (1.54)	1.1-1.7 (1.26)	1.1-2.2 (1.54)	1.1-2.6 (1.54)	1.0-2.2 (1.2)	1.2 -3.0 (1.64)	1.3-2.4 (1.85)	77.2-195.1 (105.1)	1.6-2.1 (1.95)	8.6-10.0 (9.4)	0.9-0.98 (0.92)	1.1-1.6 (1.3)
VIII	1-1.2 (1.05)	1.0(1.0)	1.0(1.0)	1.0-1.6 (1.25)	1.0-1.2 (1.1)	1.0-1.1 (1.05)	2.0-2.6 (2.3)	68.8-135.0 (106.9)	0.6-2.5 (1.75)	6.2-11.7 (9.1)	0.9-1.6 (1.3)	1.2-1.6 (1.34)
IX	1.1-2.6 (1.7)	1.2-2.9 (1.93)	1.8-2.4 (2.03)	1.7-3.1 (2.23)	1.2-2.9 (1.8)	1.8-3.0 (2.3)	2.6-2.9 (2.7)	123.0-151.3 (145.0)	1.2-2.3 (1.7)	4.4-9.0 (6.96)	0.8-1.1 (0.98)	1.27-1.6 (1.5)

PART-III

4.15 Nursery studies

Nursery studies were conducted with the same genotypes. Since sufficient number fruits were not available, nursery studies were limited to 80 genotypes. Results obtained from the observation are presented below.

4.15.1 Early growth characters

4.15.1.1 Germination

Germination of seeds showed high variation. It ranged from 12 per cent to 93 per cent with a mean germination of 48.31% and coefficient of variation of 44.73 per cent (Table 48)

4.15.1.2 Polyembryony

Polyembryony was noted in 43.75% of the samples. Only one sample (T.No.126) had all seeds that were polyembryonic. In the rest of the samples, it varied. An average number of 2-3 seedlings was noted in polyembryonic sprouts though in one of the genotype, 4-5 sprouts was noticed. Polyembryonic seedlings are presented in Plate 9.

4.15.1.3 Color of new Flushes

New Sprouts were noted in three different colors. 30.66 per cent of the samples had deep purple color for the new sprouts. 64 percent had light purple color 5.33 per cent had copper colored new flushes. Colour variation in emerging leaves in seedlings are presented in Plate10.

4.15.1.4 Seedling Growth

Results on the seedling growth are presented table 48

4.15.1.5 Plant height

After three months of growth mean height of seedlings was 16.76 cm and it

PLATE - 9 POLYEMBRYONIC SEEDLINGS

PLATE - 10 COLOR VARIATION IN SEEDLING FLUSHES

ranged from 10.3 to 23.6 cm with a coefficient of variation of 18.96 per cent. After six months, height of seedlings varied from 15.9 cm to 32.63cm. Coefficient of variation was 22.91 per cent. After one year, the mean height of plants was 34.09 cm. The coefficient of variation was 19.65%. The height of plants varied between 23.1cm and 45.6 cm.

4.15.1.6 Girth of seedlings

Girth of plants varied from 0.3 cm to 0.7 cm at three months stage with a coefficient of variation 21.74 per cent. The mean girth was 0.46 cm. At six months stage the mean girth was 0.54 cm and it ranged from 0.3 cm to 0.8 cm. The coefficient of variation was 18.51%. At one year stage the mean girth was 0.82 cm and it ranged between 0.6 into 1.18 cm. The coefficient of variation was 17.25%.

Table 48. Early growth characters of seedlings

Sl.No.	Character	Range	Mean	Coefficient of variation
1	Germination	12-93%	48.31%	44.73%
2	Plant height (3 months) (cm)	10.3-23.6 cm	16.76 cm	18.96%
3	Plant height (6 months) (cm)	15.9-32.63 cm	20.97 cm	22.91%
4	Plant height (1 yr) (cm)	23.1-45.6 cm	34.09 cm	19.65%
5	Girth (3 months) (cm)	0.3-07 cm	0.46 cm	21.74%
6	Girth (6 months) (cm)	0.3-0.8 cm	0.54 cm	18.51%
7	Girth (1 yr) (cm)	0.6-1.18 cm	0.82 cm	17.25%
8	Root length (cm)	13.65-32.95 cm	22.32 cm	17.68%
9	No. of secondary roots	6.0-23.0	12.05 cm	58.43%

4.15.1.7 Root growth

Root length after one year ranged between 13.65 cm and 32.95 with a mean value of 22.32 cm. The coefficient of variation was 17.68 per cent.

Number of secondary roots ranged between 6.0 and 23.0 with a mean value of 12.05 and coefficient of variation of 58.43 per cent

4.15.2 Grafting Percentage

Grafting percentage varied from 35.3 per cent to 71 per cent.

4.15.3 Correlation

Correlations were worked out between early growth characters of seedlings and also with seed characters. Significant positive correlation was recorded between seed length and germination percentage (0.230). Plant height after three months was positively correlated with girth after 3 months, height after 6 months and one year. Plant height at six months was positively correlated with girth at six months growth stage. Plant height at one year had a significant and positive correlation with girth at one year and root length. The relation with number of secondary roots was weak. Girth of plants after three months growth was significantly and positively correlated with plant girth after six months. Girth of plants after six months was positively correlated to girth after one year.

There was only a weak relation between root length and number of secondary roots (Table 49).

Table 49. Correlation matrix of early growth characters of seedlings

	Girth (3 months)	Plant height (6 months)	Girth (6 months)	Plant height (1 year)	Girth (1 year)	Root length	No. of second-ary roots
Plant height (3 months)	0.531**	0.215*	0.065^{NS}	0.232*	0.015^{NS}	-	-
Girth (3 months)		0.117^{NS}	0.256**	0.044^{NS}	0.112^{NS}	-	-
Plant height (6 months)			0.610**	0.085^{NS}	0.183^{NS} *	-	-
Girth (6 months)				0.090^{NS}	0.302**	-	-
Plant height (1 year)					0.588**	0.253*	0.113^{NS}
Girth (1 year)						0.226*	0.094^{NS}
Root length							0.164^{NS}

* Significant at 0.05 level

** Significant at 0.01 level

4.15.4 Anatomical characters

Anatomical characters were studied in one year old seedlings and the results are presented in Table 50.

4.15.4.1 Stomatal count

Stomatal count varied between 10.1 and 25.5 with a mean value of 13.14. The coefficient of variation 46.72 per cent.

4.15.4.2 Xylem / phloem ratio

The xylem/phloem ratio varied between 0.7 to 2.44 with a mean value of 1.48. The coefficient of variation was 43.79 per cent.

4.15.4.3 Bark content

Bark content showed a variation betyween 10.2 per cent and 24.22 per cent with a mean value of 16.86. The coefficient of variation was 22.47 per cent. A representation of variation in xylem/phloem ratio and bark content are presented in plate 11.

Table 50 Anatomical characters of seedlings

Sl.No.	Character	Range	Mean	Coefficient of variation
1	Stomatal count (No.)	10.1-25.5	13.14	46.72%
2	Xylem:Phloem ratio	0.7-2.44	1.48	43.79%
3	Bark percentage (%)	10.2-24.22	16.86	22.47%

4.15.4.4 Correlation between anatomical characters

Stomatal count had no significant relation with bark percentage and xylem/ phloem ratio. But bark percentage had significant negative relation with xylem/phloem

Plate. 9 Xylem/phloem ratio and bark content of stem

T. No. 93

Xylem: phloem ratio 2.33

Bark content : 10.0%

T. No. 13

Xylem: phloem ratio 1.26

Bark content : 11.33%

T. No. 148

Xylem: phloem ratio - 2.02

Bark content : 19.65%

T. No. 32

Xylem: phloem ratio 1.05

Bark content : 20.28%

T. No. 39

Xylem: phloem ratio 1.42

Bark content : 17.07%

T. No. 82

Xylem: phloem ratio 1.55

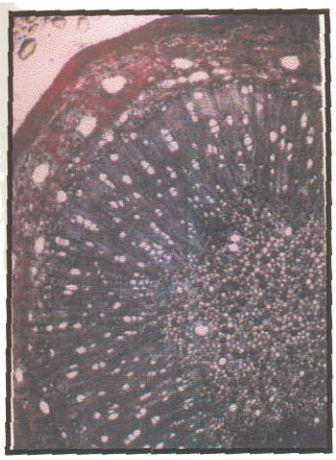
Bark content : 13.75%

PLATE - 11 VARIATION IN STEM ANATOMY

T 93

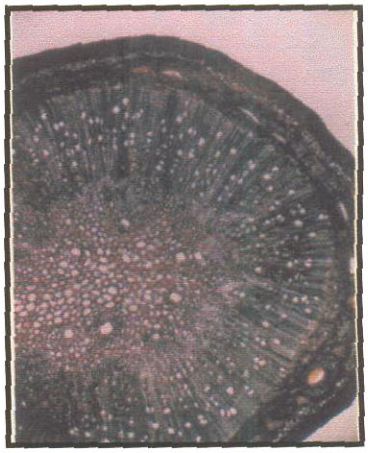
T 13

T 148



T 32

T 39



T 82

ratio (Table 51).

Table 51. Correlation coefficients between anatomical characters

	Bark (%)	Xylem/Phloem ratio
Stomata count	-0.062^{NS}	0.123^{NS}
Bark (%)		-0.471**

** Significant at 0.01 level

4.16 Grouping of the genotypes

Grouping of the genotypes were attempted based on TSS:acid ratio, overall acceptability of pickled fruits, and xylem/phloem ratio. The groups are presented in table 52-54 respectively as Appendix III

Pickling types studied in general had a low value for TSS:acid ratio. It was less than 30 in more than 70 per cent of the samples.

Based on the overall acceptability of pickled fruits seventyfive trees were identified as good pickling varieties. The fruits of these genotypes had either a score of 1 or 1-2 for overall acceptability.

Trees were grouped into three based on the xylem/phloem ratio of stem at the seedling stage. Trees which had a xylem/phloem ratio of less than one could be considered as less vigorous and those with a ratio of more than 2 can be considered vigorous.

DISCUSSION

5. DISCUSSION

Mangoes are known for the choice dessert types that have high commercial value. A vast majority of these known varieties of mango originated through human selection from the wide gene pool. The local land races/wild types have many positive characters. The potentials of these land races are not yet fully identified and exploited.

Varieties of mango evolved under different climatic conditions. They have unique characteristics in tree architecture, flowering and fruiting pattern, fruit characters and in their reaction to different agro-climatic situations. Mangoes from the coastal belt and from the evergreen humid forests are different from those growing in the plains with subtropical conditions. Kerala's natural wealth of mango population is rich with wild mango and land races and they are mainly juicy and pickling types. Satyavati *et al.* (1972) reported that a major portion of mango in Kerala is covered by local varieties used for pickling. Thimmaraju (1993) reported that high variation in mango was noted in the Western ghats which are mainly used for pickling. However these genotypes do not find a place in the commercial mango cultivation scenario of the country. No inventory is available on the genotypes that are available and on their characters. Hence an attempt was made to study the pickle varieties available in Thrissur and Palakkad Districts. Trissur and Palakkad districts of Kerala are considered to have a rich wealth of local varieties located in the homesteads, roadsides, temples etc. Hence the study was concentrated in these two districts.

5.1 PART I

5.1.1 Preliminary survey.

Results of the preliminary survey indicated that maximum concentration of trees was in Palakkad district. In Palakkad district, concentration of trees was noted in Mannarkkad and Ottappalam Taluks and in Trissur district concentration of trees was noted in Taluppully and Trissur Taluks. These areas are characterized

by the presence of forests and ghat roads where alley planting with wild trees was earlier undertaken. The Ottappalam Taluk has a rich heritage of traditional homesteads and mango is an integral part of the homesteads. Similar is the situation in the traditional homesteads of Trissur district. However none of these trees were receiving any care and attention. They are naturalised to the specific situation. Tender mango pickling is a conventional method of pickling which is popular in these areas especially among the traditional hindu families. Hence the pickle variety finds a place in their homesteads. Traditional methods of pickling with mango are yet to be documented. Tender mango pickling is done without addition of any artificial preservatives. The quality of pickle and their shelf life is mainly attributed to the quality characteristics of the fruit. High acid fruits and fruits with specific qualities such as good sap flow is usually chosen for tender mango pickling. Hence fruits are collected for tender mango pickling from selected trees only. The local knowledge associated to these trees is to be collected and documented as suggested in general by Bompard (1993).

Basic details of the genotypes were collected based on the proforma. It could be inferred that more than 50 per cent of the trees were above the age of 50 years and the fruits were mainly used for pickling. Around 40 per cent of the trees were infested with *Loranthes* which suggested the fate of these trees. Damaged and diseased trees accounted for 16 per cent of the stock. New planting with seedlings could be noted very rarely. Only one or two trees were present in each plot. When the locale of the trees were considered, most of the trees were identified from homesteads. Twenty per cent of the trees were located on the roadsides which were all very old. Roadside planting was more located in Palakkad district. Local name could be gathered only for a few and the rest were known as '*Nattu mavu*' meaning local variety or '*Puli mavu*' meaning high acid types. Among the trees identified, 98.11 per cent were seedling progenies indicating the richness in variation of the gene pool. Only ten trees were produced from grafts of known varieties.

Pickling type mangoes at present command a premium price in the market at the pickle stage, which varies from Rs.10 to Rs.40/kg. Hence sale of mangoes at pickle stage is becoming popular and it is done through agents. Only 21.69 per cent of the trees surveyed were restricted for own use. Rest were sold during each fruiting season. This practice of sale is common indicating the commercial prospects of these genotypes. Collection of nuts for seedling production as root stocks was not common and was noted only from trees belonging to public institutions. The commercial nurseries in the state are located mainly in towns and suburbs. Hence seeds of these pickling varieties located mainly in the villages and roadsides were not collected.

A majority of the owners of the trees were of the opinion that these trees would not be cut and removed. However, because of social pressure and due to the pressure on land many of the owners are not in a position to maintain these valuable trees. Trees on the roadsides are being removed as and when they are found damaged and also when they pose threat to public. New planting is rarely undertaken and hence the population of pickle mangoes is fast declining.

5.2 Part-II

5.2.1 Tree characters

Preliminary observations were made to identify the pickle varieties. From the identified types, 150 trees were selected for detailed observations. Trees were selected from areas where maximum distribution of the trees were noted and also to include maximum variability, based on local enquiry.

Traditional varieties located in homesteads were all noted to be tall. More than 80% of the trees were above 10 m in height. 33.33% of the genotypes were above 20 m in height. This could be because of the growing habit of the trees. Another reason could be that these trees were growing admist other trees in the homesteads having thick vegetation. These trees might have grown high in search of sunlight. A wild mango tree was reported from the forests of Tripura growing

to a height of 40m (Sharma, 1976). Trees growing in open condition were noted to have only lesser height compared to the ones growing in groves and back yards. In mango orchards located in campuses, trees were comparatively lesser in height. Specific instances were noted in the Medical College campus at Mulankunnathukavu.

Around eighty three percent of the trees had an open branching habit. Sant Ram (1993) reported that vigorous and very vigorous cultivars were tall with dense foliage.

Around 76 per cent of the trees were healthy and the rest was either diseased, damaged or severely affected by *Loranthes*. No special care and management are given to these trees and hence the damaged and diseased ones are likely to be lost.

Observations were recorded in detail from the selected types on leaf, flower and fruit characters. Attempts were made to study the relationship among these characters.

5.2.2 Leaf characters

As per the IBPGR (1989) descriptor for mango, leaf characters are important for description and cataloging of mango varieties. Variation on leaf characters was comparatively less. More than sixty per cent of the trees had common characters for leaf shape, leaf tip and leaf margin. Lanceolate leaf shape and acuminate leaf tip were common and were noted in 69.33 per cent and 88 per cent of trees respectively. Leaf margin was flat in 60.66 per cent of the samples and wavy in 36.66 per cent of the samples. Crinkled and folded leaf margin was noted only rarely. It could hence be observed from the study that pickle varieties had in general lanceolate shaped leaves with acuminate leaf tip and flat leaf margin. The trees can hence be distinguished based on leaf characters. Naik and Gangolly (1950) included leaf characters as secondary and tertiary characters for varietal identification. The description was provided for South Indian varieties of

mango. Besides leaf shape and leaf tip, leaf margin and color of emerging leaves were also included for identification of varieties.

Color of young and emerging flushes also varied and it was noted that 63.43% had light green colour followed by yellowish green/brownish green color. The commonly noted flush colours are presented in plate 12. Unlike the table varieties, purple and copper brown flushes were noted only rarely. Purseglove (1988) described that young leaves in mango are generally reddish. The results obtained in the present investigation were contrary to the general description for young leaves in mango. Leaf orientation, another important character for varietal description showed distinct differences within the genotypes. Drooping leaf orientation as presented in plate 13 was more common than oblique or horizontal leaf orientation. Color of emerging flushes and pose of leaves was suggested for identification of varieties by Naik and Gangolly (1950) and Davenport and Nunez-Elizea (1997).

Aroma of crushed leaves was suggested as a genetic marker in mango (Majumder and Sharma, 1990). Seventy per cent of the trees studied had deep smell for the crushed leaves. Pickle varieties are known for their deep smell of fruit and hence this character has a bearing in identification of pickle varieties. It could hence be suggested that pickle varieties in general had deep smell for the crushed leaves.

Association was worked out between leaf shape and leaftip, leaf shape and leaf margin and leaf tip and leaf margin. Significant association was noted between leaf shape and leaf tip. Lanceolate leaf shape and acuminate leaf tip were noted in 96 out of 150 trees. There was no significant relation between leaf shape and leaf margin and leaf tip and leaf margin.

Biometric characters of leaves showed substantial variation with respect to petiole length, leaf length and leaf breadth. Petiole length varied from 1.8 -11.9 cm, leaf length varied from 14.4 - 48.0 cm and leaf breadth varied from 3.0 - 8.0cm. Length by breadth ratio of leaves varied from 2.61 to 6.61 which

indicated the wide range in the size of leaves. Very long petiole and long leaves were reported for a wild mango variety in Tripura (Sharma, 1976). Bakshi and Bajwa (1957) suggested that length of petiole and shape of leaf could be considered for identifying mango varieties in nursery stage. Leaf area was utilized for predicting vigor of trees (Pal *et al*, 1981, Kurian, 1989). Leaf characters could hence be studied further in relation to vigor.

Correlation was worked out between biometric characters of leaves and it showed that leaf length had a significant positive relation with leaf breadth and petiole length. Leaf breadth was also positively related with petiole length. Similar results were reported by Karibasappa (1995).

Influence of descriptive characters on biometric characters was also worked out. It was observed that oblong leaves had more breadth and lanceolate leaves had more length/breadth ratio (Fig 14 & Fig 15). In appearance, breadth of lanceolate leaves was lesser when compared to other shape forms of leaves.

5.2.3 Inflorescence characters

Characters included for describing the inflorescence as per IBPGR (1989) descriptor are the shape, color, hairiness, presence of leafy bracts, size, flowering intensity and flowering habit. Pickle varieties studied in general had broadly pyramidal inflorescence. They had a predominance of green color in the inflorescence axis, noted in 76.25 per cent of the genotypes. Mango, as described by Purseglove (1988), produces inflorescence with branches often tinged with red colour. However, green color was predominant in the inflorescence axis of the samples included in the study . Association between inflorescence shape and inflorescence colour was studied but there was no significant relationship.

Hairiness was absent in the inflorescence axis in almost all the trees studied. Inflorescence position was terminal but in 37.41% of the cases axillary inflorescence was also noted along with terminal inflorescence. It could be concluded that primarily they are terminal bearers, though occasionally axillary

inflorescene could be noted. Three of the genotypes were producing cauliflorous inflorescenc. Tree number 139 was bearing cauliflorous inflorescence regularly. Cauliflorous inflorescence was also noted occasionally in heavily pruned branches. Inflorescence in general were either densely flowered or inter mediate giving the inflorescence a thickly flowered bunch like appearance (Plate14).

Inflorescence character of mango was studied and reported by several authors. Naik and Gangolly (1950) used inflorescence characters in the description of South Indian varieties. Chacko (1984) has reported that in mango inflorescence is borne generally in terminal buds of the shoots but Chadha and Pal (1986) reported that axillary and multiple inflorescence might also arise from axillary buds frequently. Bana *et al.* (1976) reported that mixed panicles with some leafy structures were noted in mango. In the present study leafy bracts were noted at random in 6.47 per cent of the trees. Hence it cannot be concluded that presence of leafy bracts in inflorescence is a genetic character. Davenport and Nunez – Elisea (1997) suggested that leafy structures might also emerge in panicle under weakly floral inductive condition.

Mango in general is reported as a biennial bearer. Regular bearing habit is considered as one of the important character in breeding programs though as per ICAR (1967) report, regular bearers are comparatively inferior in quality. In the present study 31 trees were noted as regular bearers. These genotypes could be utilised further in the breeding programmes.

Sex ratio varies considerably in mango. In the present study the minimum noted was 20.64 per cent and the maximum noted was 69.3 per cent. Ramarao and Rao (1984) reported that juicy varieties had higher proportion of perfect flowers compared to table varieties. In mango sex ratio as low as 0.74% is reported in var. Rumani (Majumder and Sharma, 1990).

Majumder and Mukherjee (1961) reported that trees of higher age groups contain higher percentage of perfect flowers. This is applicable in the present study also since most of the trees studied were in the upper age groups.

PLATE - 12 COLOUR OF NEW FLUSHES

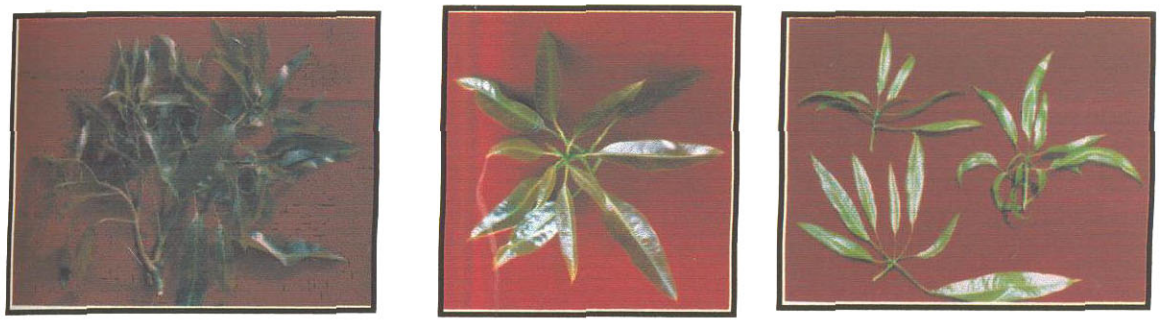


PLATE - 13 DROOPING ORIENTATION OF LEAVES

PLATE - 14 DENSELY FLOWERED INFLORESCENCE

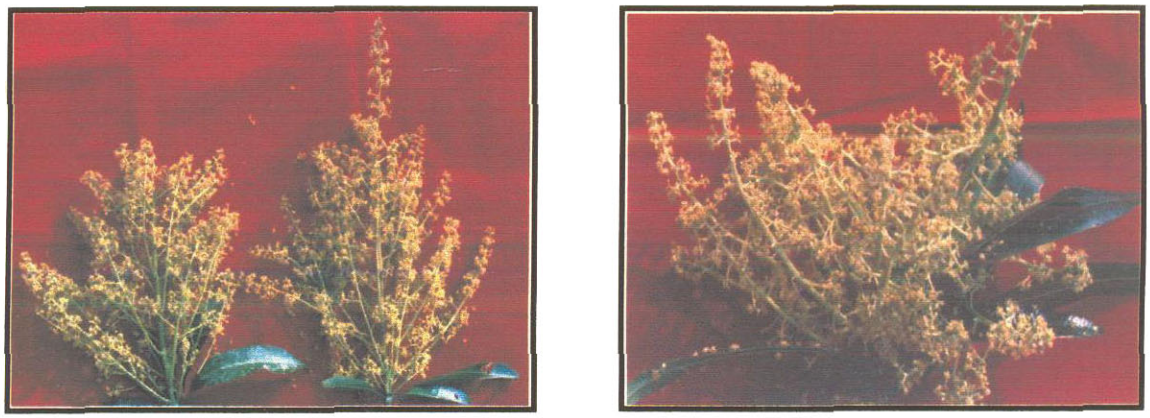


Fig. 14 Influence of leaf shape on leaf breadth

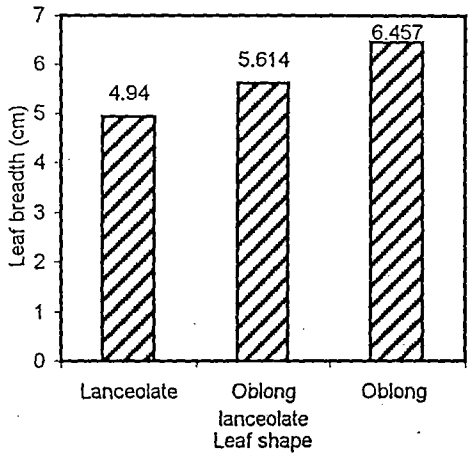


Fig. 15 Influence of leaf shape on length/breadth ratio of leaves

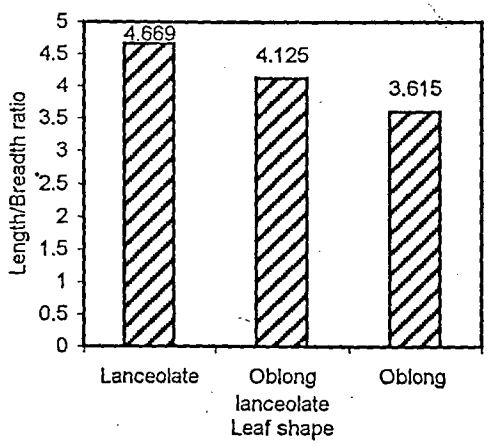
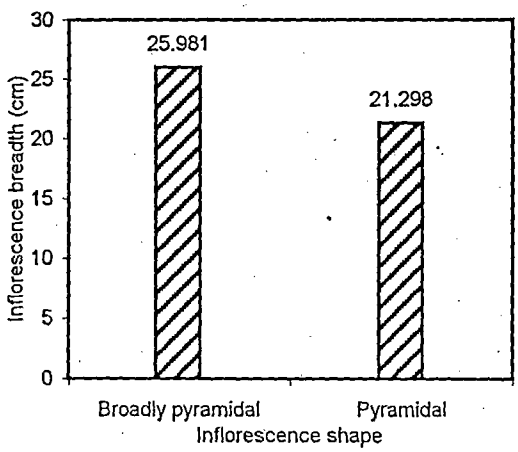


Fig. 16. Influence of inflorescence shape on inflorescence breadth



The authors had also reported that percentage of perfect flowers were more in the upper part of the inflorescence. Similar results were obtained in the present study. However further studies are required for confirming the influence of age, climate and also the seasonal variations on the sex ratio of pickle varieties.

In sample number 60, 68 and 79 two fertile anthers were noted. Mukerhjee (1972) reported that *Mangifera indica* has only one fertile anther where as *Mangifera duppereana* has ten, *Mangifera cochinchinensis* and *Mangifera pentandra* has five fertile anthers. Hence the trees which were noted to have two anthers have to be investigated further for their species status.

Biometric characters of inflorescence showed lesser variation when compared to leaf and fruit characters. Inflorescence length and breadth had only a low coefficient of variation. Length ranged from 11.6 cm to 38.6 cm and breadth ranged from 12.6 cm to 36.9 cm. The mean values of length and breadth were almost similar indicating that inflorescence had a broadly pyramidal appearance.

Influence of inflorescence shape on inflorescence size was also worked out. Broadly pyramidal inflorescence had maximum breadth (Fig 16). In the appearance also broadly pyramidal inflorescence had the inflorescence breadth either equal or more than the length of inflorescence.

5.2.4 Tender fruit characters

Biometric observations were taken on tender fruit characters. Variations were noted in all the characters studied. Maximum co-efficient of variation was noted in number of fruits/bunch which was 51.18. Production of fruits in bunches could be considered as one of the important characters of pickle varieties as the minimum number noted was 6.0 and maximum was 28.7 at the pickling stage. Chandrakaran, a known pickle variety was reported to produce fruits in bunches (Radha, 1997). A wild variety from Tripura was reported to produce fruits up to 50 per panicle (Sharma, 1976). Wide variation was noted in the length, breadth, shape, weight and volume of tender fruits and this could be

due to the varietal character. However length/ breadth ratio had comparatively only a low co-efficient of variation which ranged from 0.9 to 1.79. Stone width was measured at the tender stage and it varied from 0.6 to 1.9 cm with a co-efficient of variation of 26.29%. Stalk length varied from 0.6 to 2.7cm. and stalk thickness from 2.3 to 8.3mm

Shrinkage of fruits was on an average 46.64 per cent with a variation from 11.1 to 71.4 per cent. Fruits with good shrinkage are generally preferred for pickling.

Available studies relating to fruit characters were mainly on the ripe fruits and information on tender fruit characters are scanty.

Another character considered important in tender mango pickling is sap flow. In mangoes used for tender mango pickling, good sap flow is considered as a positive factor though sap flow and the injury and staining caused to the fruit is considered as a negative factor in mature fruits. More than 80% of the trees studied had good sap flow. Joel *et al.* (1978) reported that exudation of sap varies with cultivar, harvest maturity and harvest time. Mango sap is low in pH and high in oil and it was reported to have antifungal properties (Johnson *et. al.*, 1997). This property, attributed to sap in mango could be one of the reason behind selecting fruits with good sap flow for tender mango pickling. More than 89.33 per cent of the trees had a deep smell for the fruits, which is also considered as a preferred character for tender mango pickling.

Association between leaf smell and fruit smell was studied. Deep smell of fruits and leaves were noticed in majority of the fruit samples (89 trees out of 150 trees had deep smell for leaves and fruits). However the relation between these two characters were not found significant.

Tender fruit length was significantly and positively correlated to fruit breadth, stone width, weight, volume and specific gravity of fruits. It could be inferred that increase in fruit length was associated with increase in the dimensions

of characters contributing to the size of fruits. However no significant relation was obtained with stalk length and stalk thickness. Similarly breadth of fruits had a positive relation with stone width, weight. It could be inferred that an increase in both length and breadth of fruits cause an increase in weight and volume of fruits. Fruits, which had higher length, had higher stalk length also. Fruit weight was positively correlated with fruit volume. Studies relating to correlation of fruit characters with reference to tender mangoes are scanty.

5.2.5 Ripe fruit characters

Ripe fruit characters were studied based on their descriptive character as per IBPGR (1989) and biometric characters. In the case of pickle varieties studied no generalisation could be made on the shape characteristics of ripe fruits. High variation was noted for ripe fruit characters. Fruits were round in 47.92 per cent of the trees, 12.24 per cent of the trees had fruits with elliptic shape and the rest had oblong shaped fruits. Stalk attachment was equally distributed between straight and oblique attachment among the different genotypes. In more than 60% of the cases shoulder level was high. No generalisation could be given on the beak characters of the genotypes as it was noticed that there was almost equal distribution between the different shapes of beak. Apex was obtuse and sinus was either shallow or absent in fruits of majority of the trees.

Skin surface of the fruits were mostly smooth and color of ripe fruits were either green or greenish yellow. Rarely yellowish and reddish and green with red blotches are noted among the varieties. Similarly the flesh color was either orange or light yellowish. Pickle varieties had in general green colored skin unlike good dessert varieties. Smooth skin was a common character in almost all types studied. A few were having rough skin. Flesh texture of the fruits was either soft or juicy and the skin was free in most of the cases. Pickle varieties described by Naik and Gangully (1950) had smooth skinned fruits, soft flesh with light yellow color and beak expressed only as a point. Similarly, a wild variety, identified from forests of Tripura and described by Sharma (1976) had oblong oval shape, sinus

absent, beak inconspicuous, apex rounded and shoulder unequal. Literature on the description of pickle varieties are however scanty. Description of dessert mango varieties were given by ICAR (1967), Pandey, (1984), Majumder and Sharma, (1990) and Knight, (1997).

Association between the descriptive characters of ripe fruits were studied. Significant relation was obtained between fruit shape and stalk attachment, fruit shape and sinus of fruits, fruit shape and form of beak, skin color and flesh color of ripe fruits and pulp texture and skin adherence. Round fruits had more of straight stalk attachment and oblong and elliptic fruits had more commonly oblique stalk attachment. Fruit shape was noted to influence the shape of sinus and beak. In roundish fruits sinus was either absent or shallow but in oblong and elliptic fruits, more number of fruits had shallow sinus. Similarly in roundish fruits, beak was either absent or a point but in oblong fruits pointed or a point beak was common. When the beak was noted as a point or when it was absent, more number of fruits had sinus which were either absent or shallow but when it was pointed, sinus was either deep or shallow. Skin was free in most of the fruits studied. There was a predominance of green colored and greenish yellow colored skin and yellow and orange colored flesh.

High variation was also noted in the size characters of ripe fruits. Biometric characters of ripe fruits studied include length, breadth, thickness, weight and volume of fruits and also the pulp, skin and stone content of the fruits and variation was noticed in all these characters. But variation was comparatively less in the case of specific gravity and length by breadth ratio of fruits. Maximum variation was noticed for pulp weight followed by skin weight, weight and volume of fruit. High variation was also obtained for pulp/peel ratio and pulp/stone ratio.

Weight of fruits varied from as low as 20.3 g to as high as 203 g. Similar variation was there is volume also. Length of fruits varied from 4.11 to 10 cm, breadth from 3.2 to 7.1 cm and thickness from 2.8 to 5.9 cm.

Among the three characters contributing to the weight of fruit viz. pulp, peel and stone, pulp content was maximum (47.49%). Contribution of skin and stone to fruit weight was almost similar, being 24.21 and 26.14 per cent respectively. Very high variation was noted in the case of skin, pulp and stone content of the fruits. Fruit length was more than breadth and thickness with an average of 6.07 cm. Thickness and breadth were similar (4.85 cm to 4.31 cm respectively). Stone breadth was more than stone thickness. In general for pickle varieties, no generalisation could be made on the ripe fruit characters and it was found to be highly varying.

Fruit characters of polyembryonic varieties were studied by Prasad and Prasad (1972). Variation was reported in length, breadth, thickness, weight, fruit color, flesh color, pulp texture, taste, TSS and stone size.

Variability in the size of ripe fruit were studied and reported in dessert varieties by various authors. But studies relating to pickle varieties are scanty. Palaniswamy *et al.* (1974) observed that variation in pulp content was from 53 to 83 per cent in different mango varieties. Similarly evaluation of mango varieties conducted at Madhya Pradesh (Srivastava *et al.*, 1987) showed that specific gravity varied from 1.02 to 1.04, pulp percentage from 49.4 to 70.7 per cent and peel content from 14.3 to 28.8 per cent. In Vanraj variety of mango 81 per cent pulp was reported. (Kulkarni and Rameswar, 1981). Kalra *et al.* (1982) reported that bulky fruits had high percentage of pulp. Rabbani and Singh (1988) reported that in seven sucking varieties studied, range of variability was larger in fruit and stone weight and pulp percentage. It could be inferred that pulp content of pickle varieties was less than that of dessert varieties. The average pulp content noted was only 47.49 per cent making them less useful as dessert varieties. Stone content as high as 38.6 per cent was noted in one of the samples studied. Similarly skin content of 36.15 per cent was also noticed.

Significant positive relation was noticed among the physical parameters of the fruit. Ripe fruit length, breadth and thickness were positively correlated.

Length, breadth and thickness of ripe fruits had significant positive relation with weight, volume, skin weight, pulp weight and stone weight. Weight and volume were positively correlated and both these characters were related to skin weight, pulp weight and stone weight. Similar results are reported by Suman *et al.* (1985), Singh *et al.* (1990), Karibasappa (1995) and Balakrishnan *et al.* (1998).

Fruit shape was found to have a significant influence on the size characters of ripe fruits. Elliptic fruits had maximum length and maximum length/breadth ratio for both tender as well as ripe fruits. Both length and length/breadth ratio were minimum for roundish fruits (Fig 17, Fig 18 and Fig 19).

Pulp texture was found to influence juice content of ripe fruits. It was found that juice content was maximum when the texture was juicy but there was no significant difference between soft and hard pulp texture on juice content (Fig 20). TSS was maximum for hard textured fruits (Fig 21).

5.2.6 Stone characters

Stone venation has been included in varietal description as per the descriptor developed by IBPGR (1989). Venation was either depressed, level with surface or raised from the surface. Parallel venation was more common than forked venation in the samples studied. Similarly the veins were either depressed or level with surface. Raised venation was noted rarely. Abundant fibres were noted on the stone. A wild tree reported by Sharma (1976) from the forests of Tripura had their veins sunken and covered with fine fibres. Sunken venation was more commonly noticed in the samples studied.

Association between the two forms of stone venation was significant and it was noted that parallel and depressed venation was predominant among the pickling varieties studied. Reticulate venation was more associated with level venation. Raised venation was only rarely noted and it was more associated with reticulate venation.

Fig. 17.Influence of fruit shape on ripe fruit length

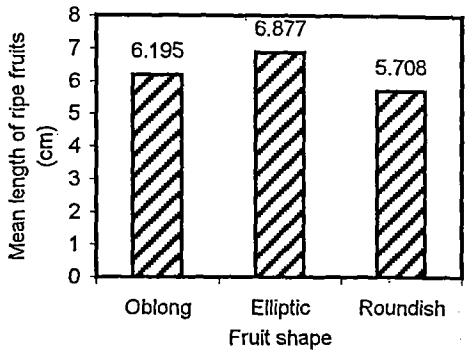


Fig. 18. Influence of fruit shape on length/breadth ratio of tender fruits

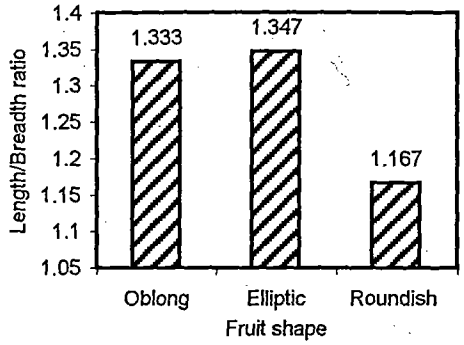


Fig. 19. Influence of fruit shape on length/breadth ratio of ripe fruit

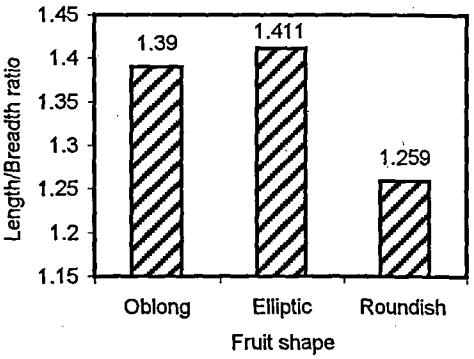


Fig. 20. Influence of pulp texture on juice content

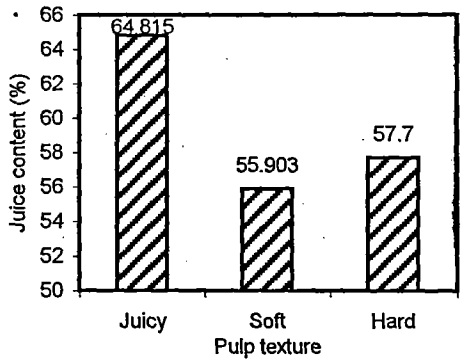


Fig. 21.Influence of pulp texture on TSS

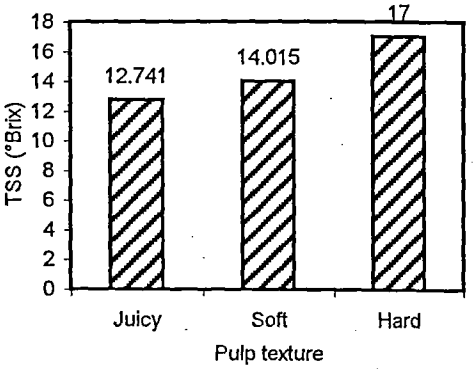
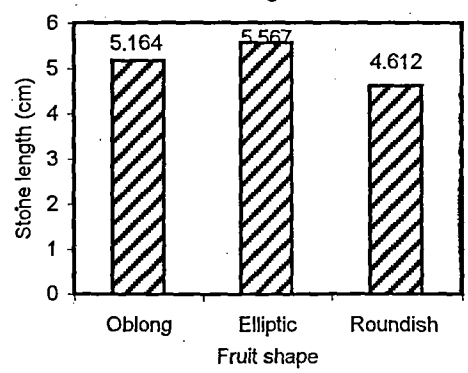


Fig. 22.Influence of fruit shape on stone length



Among the stone characters studied, maximum variation was noted for stone weight and stone volume followed by stone thickness and stone breadth. Stone length showed comparatively lesser variation.

Physical characters of stone viz. length, breadth, thickness, weight and volume were found to have significant positive relation and the trend was similar to that obtained in fruit characters. Length, breadth, weight and volume of stone were mutually related.

Fruit shape had a significant influence on stone length. Elliptic fruits had maximum stone length. Roundish fruits recorded the minimum stone length (Fig 22).

5.2.7 Fruit quality characters

Quality characters of fruits were studied at the tender stage and ripe stage. Characters studied include acidity, ascorbic acid, poly phenol and crude fibre content of tender mangoes and juice content, TSS and acidity of ripe fruits. All the characters studied showed high variation and the maximum coefficient of variation was noted for TSS/acid and acidity of ripe mangoes followed by ascorbic acid content of tender mangoes. Acidity at tender mango stage varied from 1.1 to 3.5 per cent, ascorbic acid from 16.7 to 191.5 mg/ 100 g fruit, polyphenols from 0.5 to 3.4 mg/g fruit and crude fibre from 4.4 to 13.9 per cent. Juice content of ripe fruit varied from 40 to 72.7 per cent, TSS from as low as 5° to as high as 22° brix and acidity from 0.3 to 3.5 per cent.

Acidity of young fruits varied from 1.1 to 3.5 per cent. There was high variation in acidity in tender mangoes and on an average it was 2.09 per cent. In ripe mangoes the average acidity was only 1.75%. Kapur (1974) and Ramakrishnan (1988) reported that acidity reduced during the development of fruit. Pandey *et. al.* (1974) reported that acidity increased during maturation. In the present study, acidity was more in young fruits and it reduced in ripe fruits. In young fruits mean acidity was 2.09 per cent and in ripe fruits it was 0.99 per cent.

Satyavati *et al.* (1972) reported that ascorbic acid content varied from 19.84 to 54.72 per cent, acidity from 0.2 to 0.48 percent and total soluble solids from 10 to 20.1 percent in the local varieties of mango of Kerala. Kapur (1974) also reported that ascorbic acid was high in young fruit. Palaniswamy *et al.* (1974) reported that in general smaller sized fruits recorded higher ascorbic acid content than heavy fruits. Rabbani and singh (1988) reported that variability in sucking varieties were larger for acidity and vitamin C. Similarly Katrodia *et al.* (1988) reported that variation was high with regard to TSS and acidity. Variation in TSS was two fold and variation in acidity was four fold. In the present study the mean vitamin C content was 113.86mg/100g and it showed a very wide variation (16.7 to 191.5 mg/ 100 g fruit).

Polyphenol content was 1.75 mg/g on an average in the tender fruits analysed. It varied from 0.5 to 3.4 mg/g. Lakshmi narayana *et al.* (1970) reported that young fruits had high polyphenol content and were hence astringent. Majumder and Sharma (1990) reported the presence of small amounts of tannins in flesh and peel of mango which were responsible for astringency. They also reported that total content of polyphenols (tannins) might change during maturity and ripening depending on the cultivar. Joshi and Shiralkar (1977) reported that phenolic contents decreased with the development of fruit. Wild fruits are reported to be more astringent. The local land races included in the study were all seedling progenies which might be progenies of wild varieties and hence the high polyphenol content. Crude fibre content also showed wide variation, ranging from 4.4 to 13.9 per cent with an average of 8.76 per cent. Wide variation in crude fibre was reported in mango by Satyavti *et al.* (1972) and Srivastava *et al.* (1987).

Juice content of ripe mangoes was high. It is in agreement with the textural quality of the flesh, which was either soft or juicy. Awasthi and Pandey (1979) reported that large sized sucking varieties yielded larger quantity of juice and it varied from 34.2 to 53.7 per cent depending on fruit size. Rabbani and Singh (1988) reported that juice content studied in seven sucking varieties varied from 2.9

to 66.5 percent. Juice content of the genotypes studied was in general high with an average of 58.49% indicating that pickle varieties yield high quantity of juice.

Quality characteristics of ripe fruits have been studied and reported by several authors. Ramakrishna (1988) reported that TSS was as high as 20° in ripe fruits. Satyavti *et al.* (1972) reported that TSS of ripe fruits of local varieties of Kerala varied from 10 to 20.4 and acidity from 0.2 to 0.48 per cent. Variation of TSS and acidity of ripe fruit was high in the present study also. The average was 13.58° brix TSS and 0.99% acidity which is high when compared to dessert varieties.

Physical characters of fruits had only a weak relation with the biochemical characters. Breadth of fruits was found to have a significant relation with juice content but other biometrical characters had no relation with juice content.

Earlier studies conducted on dessert varieties of mango show significant relation of biometric characters with quality characters. (Gangwar and Tripathy, 1973, Suman *et al.*, 1985, Prasad, 1987, Singh *et al.*, 1990, Kunda and Mitra, 1997). However no such relation was obtained in the present study. Only the TSS had a significant negative correlation with length of fruit indicating that fruits with higher length were having lower TSS. Karibasappa (1995) reported that TSS was not related to any of the physical parameters of the fruit. In the present study, acidity as not found related to any of the physical parameters of the fruit.

In the present study no significant relation was obtained between TSS and acidity unlike other reported results. (Gangwar and Tripathy, 1973, Kaushik and Ranjit Kumar, 1988).

5.2.8 Pickling Quality

Pickling quality was assessed based on scoring with a five point scale from 1 to 5 with 1 for the best score and 5 for the least acceptance. Pickling quality of the fruit was adjudged based on six characters such as appearance of fruit, color of fruit, aroma of fruit, texture of fruit, taste of fruit and overall acceptability. .

All the characters had a coefficient of variation of more than 30 per cent. For all the six characters, 50 per cent of the samples had a score of either 1 or 1-2. More than 60 per cent of the samples had either a score of 1 or 1-2 for appearance and color of fruits after pickling. But in the case of aroma, texture and taste, the number of samples getting a score 1 and 1-2 was comparatively lesser. Fifty per cent of the samples had a score up to 2 for overall acceptability. These trees can be considered as good varieties for pickling. Evaluation and conservation of these trees are to be undertaken further as there are no known good varieties available for pickling.

Quality characters for scoring was based on the traditionally accepted preferences. Appearance of the pickled fruits was dependent on colour of fruits. Blackening of fruits was a less acceptable character. Taste was dependent on acidity and astringency. Texture was dependent on the toughness. Samples which had lost their consistency (mushy), were given scores above 3 and were less acceptable.

It could be inferred that though all the varieties chosen for the study were reported as pickling varieties, they showed high variation in their pickling quality. Only 50 per cent of the samples had good attributes for pickling.

Not enough published work is available on pickling quality of mango especially in the case of tender mango pickling. Sastry and Krishnamoorty (1974) reported that usually high acid varieties are preferred for pickling. They also reported that acidity had some thing to do with the texture rather than crude fibre.

Majumder and Sharma (1990) reported that the young and unripe fruits because of their acidic taste are utilised for pickling. Pickle varieties with high acidity like Puliyan and Chandrakaran had maximum storage life (AICFIP, 1979). In *Amlet* variety early stage of maturity i.e. 8 to 9 weeks was reported to be used for traditional method of 'Vadumango' pickling. During this stage fruits tasted predominantly astringent with thick green peel and slightly greenish flesh (Sastry *et al.*, 1975b).

Scoring technique has been reported for judging the quality of ripe mangoes by several authors but reports on scoring for pickling quality of tender mango were not available.

Relations were worked out between the components of pickling quality and also between the tender mango characters and pickling quality. The tender mango characters studied include the size and the quality characters.

Significant positive relation was obtained between the different pickling characters which includes color, appearance, taste, aroma, texture and overall acceptability. The results indicated that there is a positive influence between all the characters. Appearance, colour, aroma, taste and texture also had a significant positive influence on the overall acceptability of pickled fruits.

Appearance of pickled fruits had a significant negative relation with length (Fig. 23) breadth (Fig. 24) and stone width of tender fruits (Fig. 25). A negative relation with pickling quality indicated a positive influence of length, breadth and stone width on appearance of pickling quality since lower scores were given for better acceptance. Fruits with more length, breadth and stone width had a better acceptance for pickling in appearance of pickled fruits.

Acidity of pickled fruits had a significant negative correlation with appearance (Fig. 26), colour (Fig. 27), aroma(Fig. 28), taste, (Fig. 29), texture

Fig. 23. Relationship between appearance of pickled fruits and tender fruit length

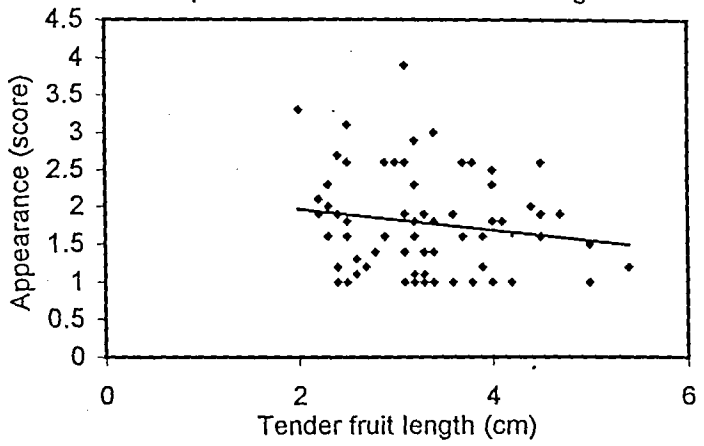


Fig. 24. Relationship between appearance of pickled fruits and tender fruit breadth

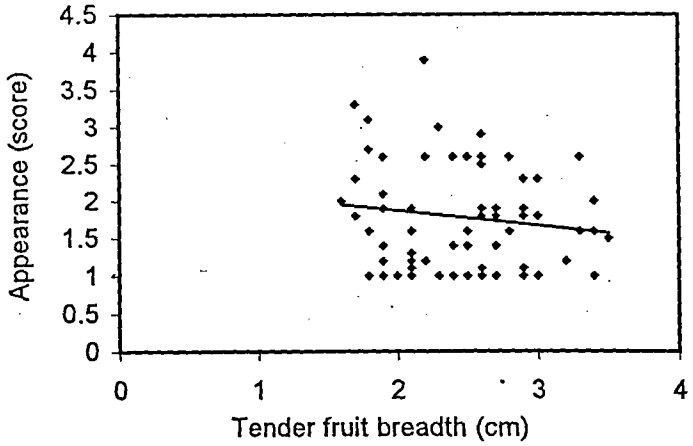


Fig. 25. Relationship between appearance of pickled fruits and stone width of tender fruits

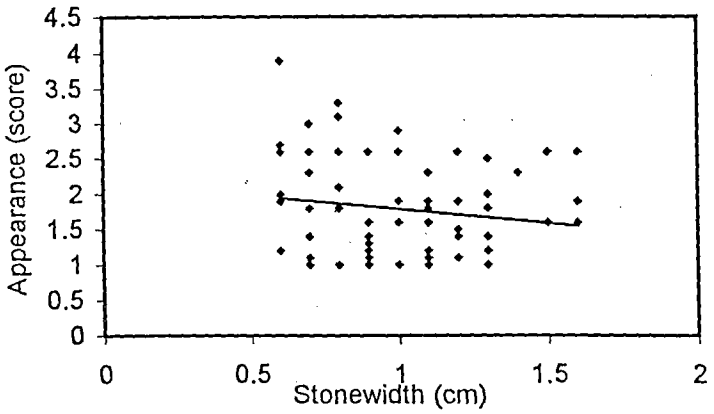


Fig 26 Relationship between appearance of pickled fruits and tender fruit acidity

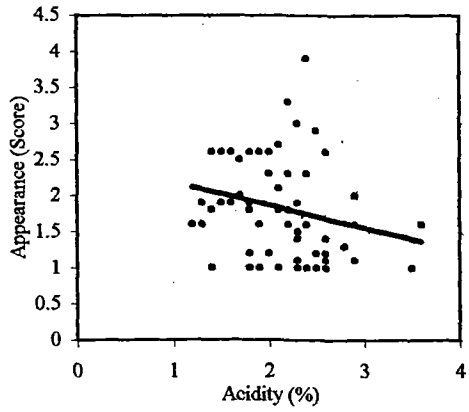


Fig.27 Relationship between colour of pickled fruits and tender fruit acidity

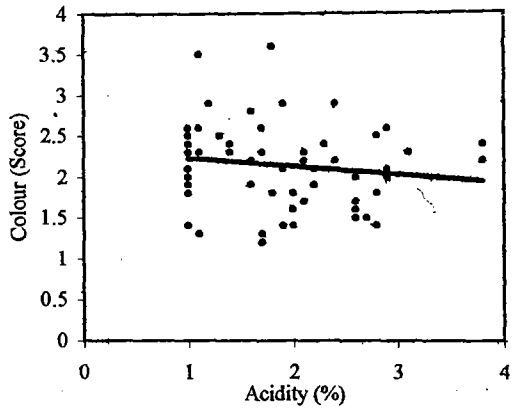


Fig. 28 Relationship between aroma of pickled fruits and tender fruit acidity

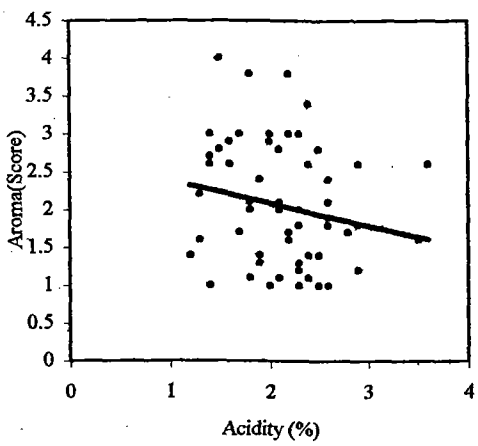


Fig. 29 Relationship between taste of pickled fruits and tender fruit acidity

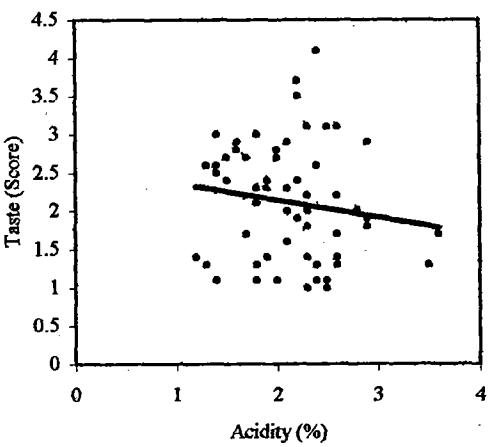


Fig. 30 Relationship between texture of pickled fruits and tender fruit acidity

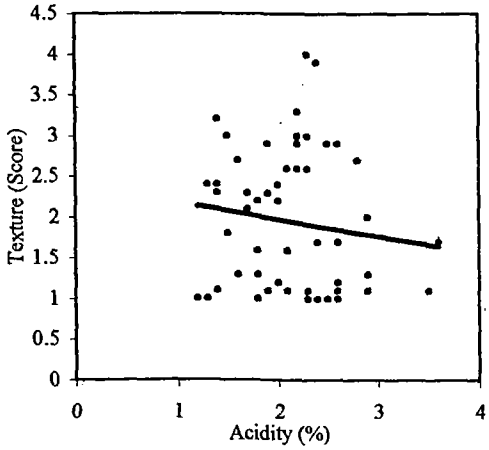


Fig. 31 Relationship between overall acceptabilty of pickled fruits and tender fruit acidity

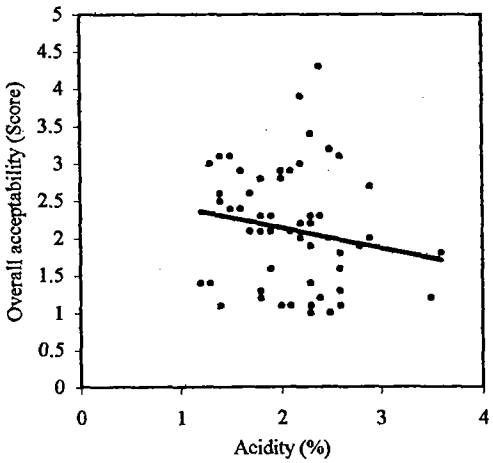


Fig. 32. Relationship between crude fibre content of tender fruits and taste of pickled fruits

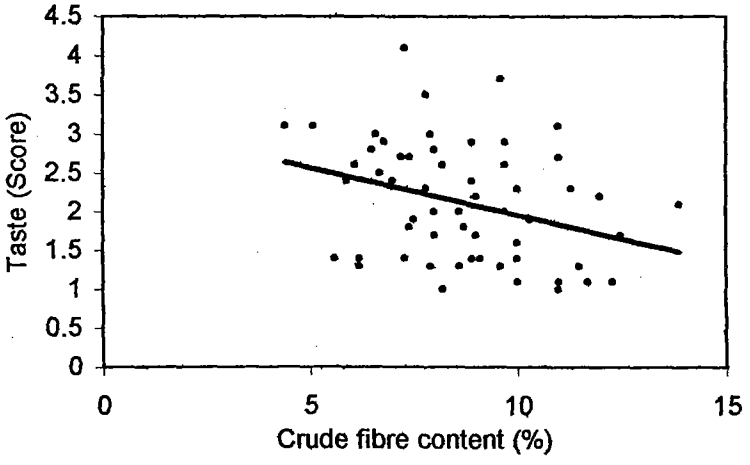
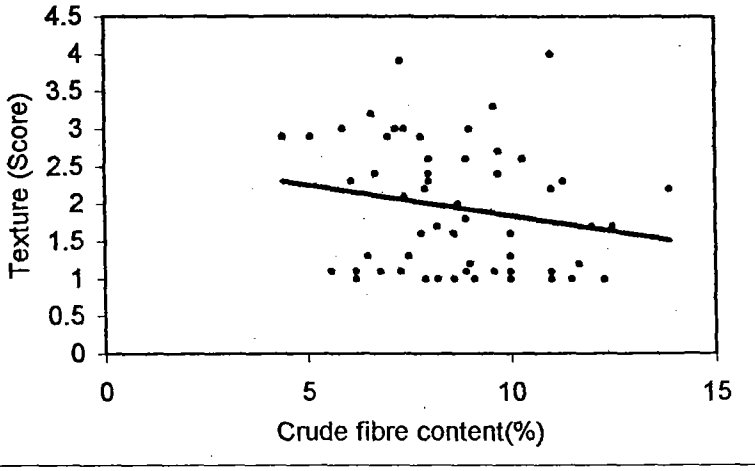


Fig. 33 Relationship between crude fibre content of tender fruits and texture of pickled fruits



(Fig. 30) and overall acceptability (Fig. 31) of pickled fruits indicating that fruits that are highly acidic had a better acceptance in relation to appearance, colour, aroma, taste and texture of pickled fruits since lower scores were given for better acceptance. Sastry and Krishnamurty (1974) reported that acidity had an influence on texture. Majumder and Sharma (1990) reported that young fruits were used for pickling because of their acidic taste.

No significant relation was obtained for polyphenol content and quality characters. But crude fibre content was found to have a significant correlation with texture (Fig. 32) and taste of pickled fruits (Fig. 33).

In general it was observed from the study that fruits with more length and breadth and fruits with high acidity, crude fibre are best suited for pickling

Acidity of fruit had only a weak relation with polyphenol content, crude fibre content and shrinkage of fruits. Polyphenol content had a negative relation with shrinkage indicating that better shrinkage was noted for fruits with lesser polyphenol content. No supporting works were available in tender mangoes, but in ripe mangoes Prasad (1987) reported that increase in tannins caused a conspicuous upward trend in other desirable characters of fruits, especially TSS and vitamin C.

Acidity of fruits studied had a significant positive relation with ascorbic acid content.

5.2.9 Pathological tests

Pickled fruits were studied for the development of fungal colonies and it was found that the fruit samples differed in the time taken for fungal development as well as in the intensity of infestation. The changes could be related to the quality characters of pickled fruits. Polyphenol content and crude fibre content were found to have an influence on the fungal infestation. Lesser infestation by fungus was noticed in fruits with high polyphenol and crude fibre content. Prusky (1990) and Johnson *et al.* (1997) reported that resorcinol and

terpenoline found in fruit sap has antifungal properties and they help in imparting resistance of unripe fruits against fungal pathogens.

5.2.10 Direct and indirect effects of components of pickling quality and tender fruit characters on overall acceptability of pickled fruits

The direct and indirect effects were worked out for the various characters influencing pickling quality and it was found that taste of pickled fruits had the maximum direct effect on the overall acceptability of pickled fruits. Indirect effects were also positive. This suggests that taste is the most important character contributing to overall acceptability of pickled fruits followed by colour, texture, aroma and appearance.

Appearance had a negative direct effect and all the indirect effects were also negative. Appearance had a significant correlation with overall acceptability(0.883). Among the five characters contributing to pickling quality, colour and appearance are highly related. Apart from colour which already has a significant contribution for pickling quality, what remains is mostly contributed by shape of fruits in which length, breadth and stone width had a significant influence on appearance and hence the contribution of appearance may be negative.

Tender fruit characters including length, breadth, stone width, stalk length, acidity, polyphenols and crude fibre were not much related to overall acceptability of pickled fruits. The contribution of these characters on the overall acceptability was less and hence the more residual effect.

5.2.11 Clustering of genotypes

Clustering was done as suggested by Suresh and Unnithan (1996). The trees were grouped into nine clusters. Cluster number 8 which included genotypes number 38, 60, 85 and 125 were having high values for pickling quality. These genotypes had high values for quality characters of tender fruits also.

Grouping of the genotypes was done based on overall acceptability of pickling quality, juice content and TSS/acid ratio. Seventy-five genotypes were identified with a score of 1 or 1-2 for overall acceptability of pickling quality. These genotypes are to be conserved and evaluated for developing varieties for tender mango pickling.

Grouping base on TSS/acid ratio indicated that more number of trees were having a narrow sugar: acid ratio.

Grouping of trees based on juice content showed that more number of pickling type trees had moderate to high juice content.

5.3 PART-III

5.3.1 Nursery studies

5.3.1.1 Germination and polyembryony

Germination of seeds showed a variation from 12 to 93 per cent with a mean of 48.31 per cent. The high variation noted in germination could be due to varietal characters. Presence of nut weevil could also affect germination of seeds which has to be studied further. In the variety Chandrakaran, Singh and Reddy (1990) observed only two percent germination. They also reported that percentage of germination was high in polyembryonic cultivars.

Land races of Kerala are reported to be polyembryonic. However in the present study only 43.75 per cent were polyembryonic. Variation was also noted in the number of polyembryonic seedlings produced. It was noted that only one genotype produced polyembryonic seedlings in all the seeds that germinated. The average number of seedlings noted was two to three. It can not be generalized that these types are polyembryonic but it can be grouped as genotypes with a tendency to produce polyembryonic seedlings. Polyembryony is reported in varieties growing in moist tropical conditions (Singh *et al.*, 1967). Tendency for polyembryony could also be due to the influence of prevailing climatic condition. ICAR (1967), Yaqub and Choudhary (1984) and Watson and Winston (1984) reported that polyembryony is influenced by climatic condition. Nature of polyembryonic behaviour of the trees observed during the course of study is to be investigated further.

Color of the first flush/emerging flush of seedlings varied and it was either light purple, deep purple or copper colored. Among these light purple colour and deep purple colour were common.

5.3.1.2 Seedling growth

Seedling growth was observed in terms of height and girth increment at periodic intervals.

Mean height of plants was 16.7 cm after three months, 20.97 cm after six months and 34.09 cm after one year. Similar increment in girth was also noted. Root growth measured in terms of root length and number of secondary roots also varied with genotypes.

High degree of variation was expressed in the early growth characters in all the genotypes. The influence of seedling vigour on further growth has to be studied after undertaking field planting so that plants can be selected for vigour in the early stage itself.

Graft take varied when these genotypes were used as rootstock. Polyembryonic varieties have been extensively used in grafting studies since they have an advantage that they produce uniform stocks. George and Nair (1966) and Swamy *et al.* (1972) reported that polyembryonic rootstocks were better for grafting than monoembryonic varieties.

Correlation was worked out between germination and seed characters and it was found that germination of seeds had a positive correlation with seed length.

Positive correlation was noticed between the early growth characters studied. Increase in height was related with girth increment. Root growth was also correlated with growth of stem. The number of roots and root length had only a weak relation. Similar studies have been earlier reported in mango. Iyer *et al.* (1988) reported positive correlation for plant height with growth extension and

mean number of internode. High heritability was also worked out for plant height, stem girth and internode length.

5.3.1.3 Anatomical characters

5.3.1.3.1 Stomatal count

Stomatal count has been reported to be related to vigor of the tree. Hence attempt was made in this study to analyse the variation in stomatal count in the genotypes. Stomatal count was taken from leaves of one year old seedlings. It was observed that stomatal count varied from 10.1 to 25.5 with a coefficient of variation of 46.72 per cent. However the relation ship between stomatal count and tree vigour has to be assessed further by undertaking field planting.

Positive correlation was observed between frequency of stomtal distribution and vigor of plants (Chakladar, 1967). This character was suggested for selection and classification of mango rootstocks at the nursery stage (Majumder *et al.*, 1972). Growth retardants are reported to reduce the number of stomata per unit area. (Suryanarayana and Madhava Rao, 1977). Similar results were also reported in apple (Majumder *et al.*, 1969 and Beakbane and Majumder, 1975 and Pathak *et al.*, 1976) . However Rajeevan and Madhava Rao (1975) and Kurian (1989) did not find any relation between tree vigor characteristics and stomatal count in mango.

5.3.1.3.2 Bark percentage

Early screening of seedlings for vigor will be helpful in selecting dwarfing rootstocks. Attempts were made mainly in temperate tree fruits to utilise anatomical characters of stem for predicting tree vigor. Studies on similar line were conducted in mango also.

In the present study attempts were made to screen genotypes based on the anatomical characters of stem. It was found that bark percentage varied from 10.2 to 24.22 per cent with a coefficient of variation of 22.47 per cent.

Majumder *et al.* (1972) found that growth of stem was negatively correlated with bark percentage. According to Arora *et al.* (1978), bark percentage is a genetic character. Mukherjee and Doradas, (1980) reported that varieties with low growth potential had a thick bark. Similar results were reported in mango by Singh *et al.* (1986) and Majumder and Singh (1990). Hence genotypes with higher bark percentage obtained in this study can be suggested as a dwarfing rootstock. The results are to be confirmed by undertaking field planting.

5.3.1.3.3 Xylem/phloem ratio

Xylem/phloem ratio is also suggested as an indicator of the vigor of the tree. High xylem/phloem indicates vigorous growth potential and low xylem/phloem ratio indicates dwarfing. In the present study the xylem/phloem ratio ranged from 0.77 to 2.44. Classification of mango varieties into various vigor groups was made by Arora *et al.* (1978) and Mukherjee and Doradas (1980) on the basis of number of xylem vessels. Majumder and Singh (1990) reported that dwarfing is related to small area of xylem vessels. Iyer (1991) and Kurian and Iyer (1992) have reported that dwarfing with paclobutrazol is associated with higher phloem to xylem ratio. They suggested that xylem/phloem ratio could be employed for predicting of vigor of genotypes. A possible scale was also developed for predicting the vigor based on this ratio.

In the present study bark percentage had a significant negative correlation with the xylem/phloem ratio indicating that thick bark and higher phloem content are positively correlated. However the stomatal count had no significant relation with bark percentage and xylem/phloem ratio.

Grouping of trees was done based on the xylem/phloem ratio of stem at the seedling stage. Plants could be selected for their vigour characters based on the ratio. However predictions on the vigour could be made only after confirming the results by undertaking field planting.

SUMMARY

6. SUMMARY

The experiment entitled 'Variability and character association analysis of picking type mango' was taken up with an objective to identify pickle varieties of mango suited for tender mango pickling, to study their variability in relation to phenotypic and quality characters and to work out the relation between these different characters. Studies were also taken up on the early growth characters of seedling and to explore their use as rootstocks. The study was conducted during 1995-98 period. The survey was conducted in Thrissur and Palakkad districts. The experiment was conducted in three parts.

Salient results obtained are given below.

Part I - Preliminary survey

Preliminary survey was conducted in Thrissur and Palakkad districts and 530 types were located of which 349 were from Palakkad district. Except for the variety Chandrakaran, all the genotypes located were seedling progenies of either land races or primitive cultivar and were located mainly in homesteads. More than 40 per cent of these trees were above the age group of 50 years. Trees were in general healthy, but *Loranthes* infestation was noticed in around 40 per cent of the trees.

Fruits from all the trees were reported to be good for pickling and fruits from 20 per cent of the trees were reported to be good for both pickling and for dessert purpose. Fruits of around eighty per cent of the trees were sold which indicated the commercial possibilities of the pickling types.

Part II - Variability and character association analysis of selected trees

Detailed observations were collected from selected trees and the results are as given below:

Leaf characters

Variation was studied in the morphological characters of leaf which included both the descriptive characters and biometric characters. Lanceolate leaf shape, acuminate leaf tip and flat leaf margin were common among the trees studied. Dark green color, drooping leaf orientation and deep smell for crushed leaves was common for the pickling varieties studied. Texture of the leaves was either smooth or rough, which were almost evenly distributed among the genotypes. The colour of new flushes were either green or yellowish green.

Significant association was obtained for leaf shape and leaf tip characters.

Variation was noted for leaf size characters expressed in terms of length, breadth and petiole length. Variation was maximum for petiole length. Maximum values recorded for leaf length, leaf breadth, petiole length and length/breadth ratio were 48.0 cm, 8.0 cm, 11.9 cm and 6.61 cm respectively. There was significant positive correlation between the size characters of leaf. Lanceolate leaves recorded more length as well as more length by breadth ratio.

Inflorescence characters

Pickling types had certain common characters for the inflorescence. In majority of the trees, inflorescence was borne terminally. Green colour of inflorescence axis and broadly pyramidal shape were common among the genotypes studied. Leafy bracts were rarely noted and the inflorescence axis was smooth in almost all the trees studied. More than 75 per cent of the trees were irregular bearers. Inflorescence of the genotypes was in general densely flowered giving a densely flowered bunch like appearance.

Variation in length and breadth of inflorescence was less than 20 per cent. However, wide variation was noted in sex ratio. There was significant influence for inflorescence shape on inflorescence size. Broadly pyramidal inflorescence had the maximum breadth.

Tender mango characters

Deep smell of fruits and high sap flow are considered important while selecting fruits for tender mango pickling. These two characters were noted in more than 85 per cent of the trees studied.

Variation was observed in the size characters of fruits at the tender mango stage. Maximum variation was noted for weight and volume of fruits. Mean values for length, breadth, stone width, stalk length, stalk thickness and specific gravity were 3.24 cm, 2.45 cm, 1.01cm, 1.4 cm, 2.6 mm and 0.99 respectively.

Fruits were generally borne in clusters and the number of fruits per bunch varied from 6.0 to 28.7. The shrinkage of fruits in brine was on an average 46.64 per cent.

There was significant positive correlation between length, breadth, weight and volume of tender fruits. Increase in length and breadth of tender fruits resulted in the increase in their weight and volume. Fruit length had a positive correlation with stalk length.

Ripe fruit characters

Among different characters studied, maximum variation was noted for ripe fruit characters. Shape of fruits were described as roundish, elliptic and oblong of which round fruits was noticed in 47.92 per cent of the trees followed by oblong and elliptic fruits. Straight and oblique stalk attachment were almost equally distributed. Variation was also noted in the other descriptive characters of fruits which included shoulder level, sinus of fruits, beak of fruits, fruit apex, flesh colour, skin colour and skin adherence. No generalisation was possible for these characters in the case of pickling types.

Skin surface was smooth in more than 80 per cent of the samples studied. Soft texture of flesh was noted in 69.38 per cent of the fruits followed by juicy texture. Hard texture was noted only rarely.

Association between fruit shape and stalk attachment, fruit shape and form of beak, and fruit shape and sinus were significant. Round fruits had more of straight stalk attachment while oblique attachment was common for oblong and elliptic fruits. In round fruits, sinus was either absent or shallow. Round fruits had the beak either absent or a point while the other two forms of fruit shape had the beak expressed as a point or pointed.

Skin was free in most of the fruits. There was a predominance of green and greenish yellow coloured fruits and orange and yellow colored flesh.

Length, breadth and thickness of ripe fruits showed comparatively lesser variation but high variation was recorded in the case of weight and volume of fruits.

Pulp content in the ripe fruits of pickling varieties was on an average 47.49 per cent, stone content 26.24 per cent and skin content 24.21 per cent. Pulp/peel ratio was 2.21 and pulp/stone ratio was 2.06 on an average.

There was significant positive correlation between the ripe fruit characters like length, breadth, thickness, weight, volume and also with skin weight, pulp weight and stone weight.

Influence of fruit shape on fruit size was studied and it was found that elliptic fruits had the maximum length and length/breadth ratio for both tender and ripe fruits

Stone characters

Stone venation was typical for each tree. Parallel and depressed venation on the stone was common for the pickling varieties. The stones had abundant fibre attachment in more than 90 per cent of the genotypes.

Variation was noted for length, breadth and thickness of stone and it was maximum for stone thickness. Coefficient of variation for stone weight and stone volume was almost similar. Length, breadth, weight and volume of stone had a significant positive correlation between each other and also with fruit characters.

Fruit quality characters

Quality characters were studied for both tender and ripe fruits. Wide variation was noted for tender fruit acidity (1.1-3.5%), ascorbic acid (16.7-191.5 mg/100), polyphenol (0.5-3.4 mg/g) and crude fibre (4.4-13.9%) content. Juice content of ripe fruits varied from 40-72.7 per cent, TSS from 5-22° and acidity from 0.3-3.5 per cent. TSS/acid ratio varied from 5.29-40.0.

Relations were worked out between physical characters and quality characters of ripe fruits. TSS of ripe fruits was negatively correlated to length of fruits. Juice content had a significant positive relation with breadth of fruits.

Pickling quality

Pickling quality of fruits was assessed on the basis of appearance, colour, aroma, texture, taste and overall acceptability of the pickled fruits. All these components of pickling quality showed more than 30 per cent variation.

Significant positive correlation was noted between the components of pickling quality.

Fruit size and quality characters of fruits were found to influence the pickling quality.

High acidity had a favourable influence on the appearance, aroma, texture, colour, taste and overall acceptability of pickled fruits. High crude fibre content also had a favourable influence on taste and texture of pickled fruits. Length, breadth and stone width of tender mangoes had a positive influence on appearance of pickled fruits.

Pickled fruits were subjected to studies on development of fungal colonies. It was observed that fruits with high polyphenol content and crude fibre content developed fungal infestation only in the later stages.

Clustering of genotypes was done based on the tender fruit characters and pickling quality and nine groups were obtained. Grouping was also done based on overall acceptability of pickled fruits and TSS: acid ratio. Seventyfive genotypes were identified which were having a score of 1 or 1-2 for the overall acceptability of pickled fruits. These genotypes are to be evaluated further and conserved as at present no varieties are identified as good pickling varieties.

Part III. Nursery studies

High variation was noted in germination of seeds. Variation was also noted among the trees on the polyembryonic nature. An average number of 2-3 seedlings were noted in the polyembryonic seedlings.

Light purple colour was predominant for the emerging flushes.

Variation was noted in the growth of seedlings recorded three months, six months and one year after sowing in terms of height and girth of seedlings. Variation was also recorded in the root growth recorded in terms of length of roots and number of roots, one year after planting. Graft take also varied among the genotypes when used as rootstock.

Early growth characters of seedlings recorded positive correlation. Germination percentage was positively correlated with seed length. Root length and number of secondary roots had only a weak relation. Root length was positively correlated with plant height and girth after one year.

Anatomical characters of stem at the seedling stage were studied in terms of stomatal count, xylem/phloem ratio and bark content. Stomatal count showed a coefficient of variation of 46.72 per cent and xylem/phloem ratio had a coefficient of variation of 43.79 per cent. Bark percentage showed a variation of 22.47 per cent.

Bark percentage had a significant negative relation with xylem/phloem ratio. High bark content and low xylem/phloem ratio are attributed to dwarfing nature in the earlier studies conducted in mango and temperate tree fruit crops.

Grouping of trees was done based on xylem/phloem ratio. Trees with high values for xylem/phloem ratio is considered vigorous and trees with low values for xylem/phloem ratio is considered good for using as dwarfing root stock. Hence based on these observations selection could be made. However confirmatory evaluations have to be undertaken after observing their performance in the field.

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* Originals not seen

APPENDICES

APPENDIX-I

PROFORMA FOR PRELIMINARY SURVEY

1. Name and address of the farmer :
2. Panchayat :
3. District :
4. Number of trees in the plot :
5. Local name of the variety :
6. Age of the tree (approx.) :
7. Status of the tree (wild/land race/ primitive cultivar/cultivated variety) :
8. Planting material (seedling/graft) :
9. Fruit quality (pickling/dessert/both) :
10. Marketing :
11. Whether infested with *Loranthes*
12. Condition of the tree (Healthy/ diseased and damaged)
13. Whether the tree will be retained or not :
14. Whether nuts are collected for root stock production :

APPENDIX-II

LIST OF TREES SELECTED FOR STUDY

Tree Number	Location	District
1.	Dr.Mohandas, Pazhuvil	Thrissur
2.	K.K.Mohanan, Inchamudi	Thrissur
3.	Sunny, Inchamudi	Trissur
4.	Chemmappillimana, Karanchira	Trissur
5.	Govt. High School, Pattambi	Palakkad
6.	Maingate (Sales counter), RARS, Pattambi	Palakkad
7.	Thekkeppat Variyam, Manisseri	Palakkad
8.	T 14, State Seed Farm, Kongad	Palakkad
9.	Kunjuman, Thallaparambil, Engineer Road, Anakkara	Palakkad
10.	Anithanivas, Thonoorkkara	Trissur
11.	Pappu's gate, PWD, Attoor	Trissur
12.	Chitran Master, Attoor	Trissur
13.	Neelakantan Master, Kolannur Mana, Chelakkara	Trissur
14.	Attoor Variyam, Attoor	Trissur
15.	Thomas, Manalithara, Vazhani	Trissur
16.	Chitran Master, Attoor	Trissur
17.	Kuttettan, Peruvancherry, Attoor	Trissur
18.	Appukkuttan Nair, Treeno.2, Thonnoorkara	Trissur
19.	Alavi, Thonnoorkara	Trissur
20.	Anakkara Vadakkath	Palakkad
21.	Kumbidikadavu, Roadside, Kumbidi	Palakkad
22.	Abu, PWD, Attoor	Thrissur
23.	Tree No.V/37, State Seed Farm, Parakkad, Chelakkara	Trissur
24.	Tree No. 450, State seed farm, Parakkad, Chelakkara	Trissur
25.	Variyath Parambu, Chunangad	Palakkad

26. Vadakkedath Mana, Mannmpatta, Sreekrishnapuram	Palakkad
27. Mannazhiveedu, Sreekrishnapuram	Palakkad
28. Vadakkedath mana, Back of house, Sreekrishnapuram	Palakkad
29. V.Kuttaguptan, Vettayilveedu, Mannampatta	Palakkad
30. Sekharamenon, Near Sreekrishnapuram rice mill	Palakkad
31. Nedumpallimana, Easwaramangalam, S.K. Puram	Palakkad
32. Venugopal, S/o Sridevi Antharjanam, Perumangode	Palakkad
33. Kaladi Mana, Perumangode, S.K. puram	Palakkad
34. Govindan, Paramel, Vellnizhi, Thiruvazhiyode	Palakkad
35. Ammini Amma, Kalappurakkal house, Chazhur	Trissur
36. Govindan Paramel, Vellinezhi	Palakkad
37. Road side, near Manaladi Rubber society , Attoor	Trissur
38. Nedungad Haridas, Triprayar.	Trissur
39. Iratta mavu, Oomamapilli Mana, Palazhi	Trissur
40. Idakkunni Variyam, Chazhur	Trissur
41. Medical College Campus(1), Mulankunnathukavu	Trissur
42. *Vazhiyan*, Oomampilli mana, Palazhi	Trissur
43. Achuthan Nair, Kondor, Chazhur	Trissur
44. Narayanan Bhattathirippad, Chazhur	Trissur
45. Veluthedath, Kitta menon Road,Irinjalakkuda	Trissur
46. Kallingal Janardhanan(1), Chazhur	Trissur
47. Gopalakrishnan, Kottam Road, Chazhur	Trissur
48. Kamini bai meneon, Ambatane, Irinjalakkuda	Trissur
49. *Puliyan*, Oomampilli Mana, Palazhi	Trissur
50. Kallingal Janardhanan(2), Chazhur	Trissur
51. *Cheriya irattan*, Oomamapilli Mana, Chazhur	Trissur
52. *Iratta mavu*, Oomamapilli Mana, Chazhur	Trissur
53. Thekkekulavan, Mallisseri Mana, Vadasseri	Palakkad
54. Navabjan, Challikkal, Kongad	Palakkad
55. Mallissei mana(1), Kongad	Palakkad
56. Mallissei mana(2), Kongad	Palakkad

57. Seethalakshmi Amma, Margasseri veedu, Kongad	Palakkad
58. *Vadakkekulavan*, Mallisseri mana, Vadasseri	Palakkad
59. *Thai mavu*, Mallisseri mana, Vadasseri	Palakkad
60. Pooppulli Ramachandran, Challikkal, Kongad	Palakkad
61. Mallisseri mana(3), Vadasseri	Palakkad
62. Pallanchathanur Variyam, Kuzhalmannam(1)	Palakkad
63. Pallanchathanur Variyam, Kuzhalmannam(2)	Palakkad
64. Sankara Narayanan, Mudavannur(1), Trithala	Palakkad
65. Kariyannur Mana, Pulasseri	Palakkad
66. Sankaranarayana, Mudavannur(2), Trithala	Palakkad
67. K.P. Narayanan Namboodiri, Vadakkethil, Pulasseri	Palakkad
68. Nedungadi Master, Koppam	Palakkad
69. Sankaranarayana, Mudavannur(3), Trithala	Palakkad
70. Sankaranarayana, Mudavannur(4), Trithala	Palakkad
71. Ezhuthassanmarkalam, Puthunagaram	Palakkad
72. Vijayalaksmi, Opp.to High School, Anandapuram	Trissur
73. Pullanthody, Kottappuram, Karimpuzha	Palakkad
74. Chenapanthody, Kottappuram, Karimpuzha	Palakkad
75. Cherottur Variyam, Cherottur(1)	Palakkad
76. Soolapani Variar, Chittoor Variyam, Chittoor	Palakkad
77. Olappamanna Mana (1), Mundur	Palakkad
78. Olappamanna Mana (2), Mundur	Palakkad
79. Tree No. 28, Road side,Kanjikkulam	Palakkad
80. Mangode road side (opp. to T no.8)	Palakkad
81. Mangode road side (next to T no.25)	Palakkad
82. Tree no. 11, Pallippadi, Karimba	Palakkad
83. Tree No.12, Kanjikkkulam	Palakkad
84. Tree No. 5, Kalladikkode	Palakkad
85. Tree No. 33, Kanjikkulam	Palakkad
86. Opposite to Suhara Manzil, Mangode.	Palakkad
87. Adakkaputhur road side, Cherpulasseri	Palakkad

88. Mangode road side (after school)	Palakkad
89. Medical college campus (2), Mulankunnathukavu	Trissur
90. Medical college campus(3), Mulankunnathukavu	Trissur
91. Medical college campus(4), Mulankunnathukavu	Trissur
92. Medical college campus(5), Mulankunnathukavu	Trissur
93. Chitran Namboodiri, Mayannur	Trissur
94. Kavil Variyam, Mayannur	Trissur
95. Medical college campus(6), Mulankunnathukavu	Trissur
96. Medical college campus(7), Mulankunnathukavu	Trissur
97. Krishna Nivas, Mayannur	Trissur
98. Unnikrishnan, Mayannur	Trissur
99. Tree No.7, Thachampara,	Palakkad
100. Adakaputhur road, Cherpulasseri	Palakkad
101. Moideenkutty, Chakkutty, Mannangode, Koppam	Palakkad
102. Kaladi mana, Sreekrishnapuram	Palakkad
103. Chandrakaran, RARS, Pattambi	Palakkad
104. Moideenkutty, Chakkutty, Mannangode, Koppam	Palakkad
105. Erattakulam road side, Alathur	Palakkad
106. Dasan, Gramam, Pallanchathanur	Palakkad
107. Tree no. 3, road side, Vaniayamkulam	Palakkad
108. Unniyal, road side, Alanellur	Palakkad
109. James Harithavanam, RARS, Pattambi	Palakkad
110. T.No.151, 8 th block, RARS, Pattambi	Palakkad
111. Nursery, RARS, Pattambi	Palakkad
112. Koran, Karanappurath kunnu Harijan colony, Aloor	Palakkad
113. Ramakrishnan, Kottoppadam	Palakkad
114. M.E. Ezhuthassan, Perumattikalam, Chittoor	Palakkad
115. Ponnu, Madayankadu, Perumatti, Chittoor	Palakkad
116. Murali, Thayyil house, Vilayodi	Palakkad
117. Achutha Variyar, Near High school, Chunangad	Palakkad
118. Vamanan Namboodiri, Thrangali	Palakkad

119. T. Viswanathan, Thrangali	Palakkad
120. Thekkeppat Variyam, Manisseri(1)	Palakkad
121. Thekkeppat Variyam, Manisseri(2)	Palakkad
122. K.Narayanan Nair(1), Thekkeppat bhavan, SRK Nagar, Meetna	Palakkad
123. Ramakrishnan, Nezhukathodi, Manisseri	Palakkad
124. Chellappa Iyer, Thrikkangode	Palakkad
125. K.Narayanan Nair(2), Thekkeppat bhavan, SRK Nagar, Meetna	Palakkad
126. Chandran Master, Opp. to Ashramam, Meetna	Palakkad
127. Soolapani Variar, Meetna	Palakkad
128. Pratibha, Cherottur	Palakkad
129. Chakkiyath house, Palayoor	Trissur
130. Parunthirikkal,Pazhampalakode	Palakkad
131. Narayani. T., Kodalur, Pattambi	Palakkad
132. Karuthedath Mana, Pattambi	Palakkad
133. Kali, Kodalur, Pattambi	Palakkad
134. Roadside- opp. to Central Orchard(1), Pattambi	Palakkad
135. Roadside- opp. to Central Orchard(2), Pattambi	Palakkad
136. Palakkat Mana, Ongallur	Palakkad
137. RARS, Pattambi (near canteen)	Palakkad
138. Kurur Puthen Veetil Madhavi Amma, Melazhiyam	Palakkad
139. Palisseri Govindan Nair, Anakkara	Palakkad
140. Parameswaran Namboodiri, Palisseri Mana, Anakkara	Palakkad
141. Thekkepat Variyam, Manisseri(3)	Palakkad
142. Kuruppamveetil Kunjunni, Ummathoor	Palakkad
143. Cholayil Manu, Parathekkad, Kumbidi	Palakkad
144. Parathekkat Kamala Amma, Kumbidi	Palakkad
145. Kodur Puthen Veetil Sekhran Nair, Kumbidi	Palakkad
146. V.R. Rajan, Chhekode Kalam, Erattakkluam	Palakkad
147. Vesu, Eachan veedu, Vazhukakkode, Cheekode	Palakkad
148. Kalyani, Cheekode, Alathur	Palakkad

149. Cherottur Variyam, Manisseri(2)	Palakkad
150. Puthen Variyam, Attoor	Trissur

APPENDIX III

Table 52. Grouping of genotypes based TSS:acid ratio

TSS : Acid ratio	Tree number
Less than 10	6, 8, 26, 31, 36, 39, 43, 49, 54, 61, 63, 73, 74, 78, 79, 83, 84, 85, 87, 88, 91, 95, 114, 120, 133, 147, 150
10 - 20	9, 16, 25, 28, 29, 30, 38, 44, 50, 55, 60, 64, 68, 69, 77, 80, 82, 89, 92, 93, 94, 98, 109, 117, 119, 122, 125, 126, 131, 146, 148
20 - 30	2, 10, 11, 12, 13, 17, 27, 32, 33,42, 51, 52,62, 70, 71, 72, 86, 110, 128, 131
30 - 40	21, 41, 45, 67, 97, 113, 116, 121, 123, 129

Table 53 Grouping of genotypes based on overall acceptability of pickled fruits

Overall aceptability(score)	Tree number
Upto 1	53, 60, 87, 150
1 -2	2, 6, 10, 11, 12, 14, 15, 17, 19, 31, 32, 33, 34, 35, 38, 48, 51, 54, 55, 57, 58, 59, , 62, 63, 64, 67, 68, 70, 71, 74, 77, 78, 79, 80, 81, 83, 84, 85, 86, 88, 92, 96, 97, 99, 102, 103, 104, 107, 108, 109, 110, 111, 112, 113, 114, 116, 117, 118, 119, 120, 121, 123, 124, 125, 126, 128, 132, 134, 136, 142, 148,
2 -3	3, 8, 13, 16, 18, 20, 21, 22, 23, 24, 25, 28, 29 30, 36, 37, 39, 41, 42, 43, 45, 46, 52, 56, 65, 66, 69, 72, 89, 91, 93, 95, 98, 100, 101, 105, 106, 144, 143
3 –4	4, 26, 27, 40, 44, 49, 61, 147
4 –5	50, 90, 94, 115, 131, 133, 135, 138, 139, 140, 141, 145

Table 54. Grouping of genotypes based on xylem/phloem ratio

Xylem/phloem ratio	Tree number
Less than 1	15, 18, 21, 47, 51, 60, 64, 73, 77, 82, 85, 94, 103, 119, 116
1 -2	3, 4, 7, 8, 12, 16, 25, 27, 28, 32, 33, 34, 38, 39, 43, 49, 53, 55, 56, 57, 61, 62, 65, 71, 75, 79, 80, 84, 88, 91, 97, 125, 122
More than 2	6, 17, 19, 26, 48, 36, 41, 93, 110, 111, 147, 148

Table. 55 Clusters of genotypes

Cluster number	Genotypes
I	10, 16, 35, 44, 64, 78
II	21, 28, 71, 83, 142, 150
III	43, 49, 52, 67, 86, 136
IV	18, 53, 54, 75, 110
V	17, 36, 39, 45, 63, 72, 79
VI	42, 128, 148
VII	11, 55, 80, 91, 103
VIII	38, 60, 85, 125
IX	33, 77, 133

VARIABILITY AND CHARACTER ASSOCIATION ANALYSIS OF PICKLING TYPE MANGO

By
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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

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2000

ABSTRACT

The project entitled 'Variability and character association analysis of pickling type mango' was conducted at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara-680 656, Kerala during the period 1995-1998. Mango germplasm available in Palakkad and Trissur districts were selected for the study.

A preliminary survey was conducted to locate the pickling varieties and 530 trees were identified. Palakkad district has a good collection of pickling varieties when compared to Trissur district. These trees are potential sources of variation as they were all seedling progenies. There were no named pickling varieties available except for the variety Chandrakaran.

Variability and character association analysis was conducted on 150 selected trees. Characters pertaining to leaf, inflorescence, tender fruit, ripe fruit, pickling quality, seedling growth and stem anatomical characters were subjected for investigation.

Lanceolate leaf, acuminate leaf tip, flat leaf margin and drooping orientation of leaves were characteristic to the pickling varieties. The colour of new flushes was either green or yellowish green. Similarly the inflorescence had broadly pyramidal shape and green colour for inflorescence axis. Good sap flow and deep smell were noted from the tender fruits of the pickling types.

Variation for the morphological characters was maximum for ripe fruit characters when compared to leaf, inflorescence and stone characters. There was almost an equal distribution of the genotypes between the two fruit shape forms viz., roundish and oblong and the characters associated to fruit shape.

Stone venation had also a common pattern for the pickling varieties. Parallel and depressed venation was commonly noted. Abundant fibers were also noted on the stone.

Variation was noted in the leaf size, inflorescence size, tender fruit size, ripe fruit size and stone size characters. Correlation was also worked out between these characters. Significant association was noted between the different descriptive characters of leaf, descriptive characters of ripe fruit and descriptive characters of stone. Influence of descriptive characters on size was also noted for leaf, inflorescence and ripe fruits.

Quality characters were studied in terms of acidity, ascorbic acid, polyphenols and crude fibre content of tender fruits and juice content, total soluble solids and acidity of ripe fruits. There was significant variation in all these characters. Pickling varieties were in general juicy and had high acidity and had a low TSS:acid ratio.

Pickling quality was assessed based on appearance, colour, aroma, taste, texture and overall acceptability of pickled fruits. Based on the score given 75 genotypes were identified as good varieties for tender mango pickling. Pickling quality was found to be influenced by the fruit size, particularly the length and breadth of fruits at tender stage. Acidity and crude fibre content of tender fruits were found to influence pickling quality.

Trees were grouped into nine groups based on tender fruit characters and pickling quality. Grouping of the trees was also done based overall acceptability of pickled fruits and TSS:acid ratio of ripe fruits.

Early growth characters of seedlings were studied to explore the possibilities of using these genotypes as root stocks for graft production in mango. Around 40 per cent of the trees produced polyembryonic seedlings. Growth measured in terms of height and girth at different stages showed significant variation. Mutual correlation was also noted between the growth characters.

Stem anatomical characters of seedling were studied for early screening of trees for vigour characteristics. Xylem/phloem ratio, bark percentage and

stomatal count showed significant variation between the genotypes. Based on the xylem/phloem ratio trees were grouped into three groups (Group I - xylem/phloem < 1, Group II - xylem/phloem ratio 1-2 and Group III - xylem/phloem ratio > 2).

Trees with good pickling quality are to be conserved and evaluated further for developing good pickling varieties. Early screening in the nursery based on stem anatomical characters could be utilized for predicting the vigour of trees.