

**CHARACTERIZATION OF KUTTIATTOOR
MANGO (*Mangifera indica* L.) CULTIVAR OF
KANNUR DISTRICT, KERALA**

by
RESHMA REGHU
(2015-11-085)

THESIS

**Submitted in partial fulfilment of the requirement
for the degree of**

**Master of Science in Agriculture
(PLANT BREEDING AND GENETICS)**

**Faculty of Agriculture
Kerala Agricultural University**



**DEPARTMENT OF PLANT BREEDING AND GENETICS
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA
2017**

DECLARATION

I, hereby declare that the thesis entitled “**CHARACTERIZATION OF KUTTIATTOOR MANGO (*Mangifera indica* L.) CULTIVAR OF KANNUR DISTRICT, KERALA**” is a bonafide record of research work done by me during the course of research and that this thesis has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara,
Date: 6-12-2017



RESHMA REGHU
(2015-11-085)

CERTIFICATE

Certified that this thesis entitled **“CHARACTERIZATION OF KUTTIATTOOR MANGO (*Mangifera indica* L.) CULTIVAR OF KANNUR DISTRICT, KERALA”** is a bonafide record of research work done independently by Ms. Reshma Reghu under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associate ship or fellowship to her.

Vellanikkara

Date 6/12/2017



Dr. C. R. Elsy

(Major Advisor)
Professor and Coordinator
IPR Cell, KAU
Agricultural Research Station
Mannuthy

CERTIFICATE

We, the undersigned members of the Advisory Committee of Ms. Reshma Reghu, a candidate for the degree of **Master of Science in Agriculture** with major field in Plant Breeding and Genetics, agree that the thesis entitled **“CHARACTERIZATION OF KUTTIATTOOR MANGO (*Mangifera indica* L.) CULTIVAR OF KANNUR DISTRICT, KERALA”** may be submitted by Ms. Reshma Reghu, in partial fulfilment of the requirement for the degree.



Dr. C. R. Elsy
(Major Advisor)
Professor and Coordinator, IPR Cell, KAU
Agricultural Research Station
Mannuthy



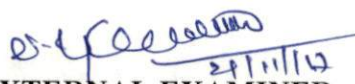
Dr. Jiji Joseph
(Member)
Professor and Head
Dept. of Plant Breeding and Genetics
College of Horticulture
Vellanikkara



Dr. S. Krishnan
(Member)
Professor and Head
Department of Agricultural Statistics
College of Horticulture, Vellanikkara



Dr. A. V. Meera Manjusha
(Member)
Assistant Professor (Horticulture)
RARS, Pilicode


EXTERNAL EXAMINER
N. MEENAKSHI GANESAN
Prof. (PBG), TPAU,
Coimbatore.

ACKNOWLEDGEMENT

*First and foremost I bow my head before the **Almighty God** for enlightening and making me confident and optimistic throughout my life and enabling me to successfully complete the thesis work in time.*

*It is with immense pleasure I avail this opportunity to express my deep sense of whole hearted gratitude and indebtedness to my major advisor **Dr. C. R. Elsy** for her expert advice, inspiring guidance, valuable suggestions, constructive criticisms, constant encouragement, affectionate advice and above all, the extreme patience, understanding and wholehearted co-operation rendered throughout the course of my study. I really consider it as my greatest fortune in having her guidance for my research work.*

*I express my gratitude to **Dr. Jiji Joseph**, Professor and Head, Department of Plant Breeding and Genetics for her immense help and assistance provided during the study.*

*I sincerely thank **Dr. S. Krishnan**, Professor and Head, Department of Agricultural Statistics, for his expert advice and relentless support in resolving the statistical intricacies of data analysis and constructive criticisms during my entire study which helped in successful completion of this work.*

*I express my sincere thanks to **Dr. Meera Manjusha A.V.**, Assistant Professor (Horticulture), RARS, Pilicode for her constructive criticism and critical scrutiny of manuscript.*

*I would like to specially thank **Professor, Dr. N. K. Parameshwaran** and **Assistant Professor, Dr. Saji Gomez**, of College of Horticulture, Vellanikkara, **Dr.***

Kunhamu, Dr. S. Gopakumar and Dr. E. V. Anoop and Dr. A. V. Santhoshkumar, Professors of College of Forestry, Vellanikkara and Dr. Jyothi M. L. Professor, RARS, Pattambi, for their timely help during the different phases of study.

*With deep reverence, I extend my sincere thanks to **Mr. Prabhakaran A.** from Kuttiaattoor for his unconditional support and valuable suggestions throughout the period of study. Without his timely help during the survey and observations, the completion of this research work would have been really difficult. I thank **Mr. Krishnan T. T. and Mr. V. O. Prabhakaran** from Kuttiaattoor for rendering help and support during the study. I also avail this opportunity to pay my sincere thanks to **Seena chechi** and her family members from Kuttiaattoor for providing me the accommodation during the period of data collection. I thank them for all the help and cooperation they have extended to me.*

*I duly acknowledge the encouragement, moral support, precious suggestions and timely persuasions by my dear seniors, **Mr. Ashish, Ms. Suma A, Ms. Asna Ajmal, Mr. Ajinkya Ambavane, Mr. Manjunatha, Mr. Prakash, Ms. Riya Antony, Ms. Tintumol Joseph and Ms. Neeraja Puthiyamathom,** for helping me not only in my research work but also throughout my PG programme. I express my sincere thanks to my classmates **Mr. Sunil R, Mr. Nikhil Narayanan and Mr. Veeresh S Akki** for their affection and kind help offered during my thesis work. I also thank my dear friends **Deepa and Alex** for their help and support.*

*I am in dearth of words to express my love towards **my beloved** parents and my loving brother for their boundless affection, moral support, eternal love, deep concern, prayers and personal sacrifices which sustains peace in my life.*

*I owe special thanks to Librarian, College of Horticulture, **Dr. A.T. Francis** and all other staff members of Library, who guided me in several ways, which immensely helped for collection of literature for writing my thesis. I am thankful for the service rendered by **Mr. Aravind** all along the academic period.*

I express my deep sense of gratitude to Kerala Agricultural University for financial and technical support for persuasion of my study and research work. It would be impossible to list out all those who have helped me in one way or another in the successful completion of this work. I once again express my heartfelt thanks to all those who helped me in completing this venture.



Reshma Reghu

CONTENTS

CHAPTER	TITLE	PAGE NO.
1.	INTRODUCTION	1-2
2.	REVIEW OF LITERATURE	3-16
3.	MATERIALS AND METHODS	17-36
4.	RESULTS	37-59
5.	DISCUSSION	60-74
6.	SUMMARY	75-78
.7	REFERENCES	i-ix
	ABSTRACT	

LIST OF TABLES

Table No.	Title	Page No.
1.	Methods for soil analysis	18
2.	Flowering and fruiting period of Kuttiaattoor mango cultivar (2016-2017)	38
3.	Percentage distribution of tree characters of Kuttiaattoor mango cultivar	39
4.	Quantitative tree characters of Kuttiaattoor mango cultivar	39
5.	Qualitative leaf characters of Kuttiaattoor mango cultivar	41
6.	Quantitative leaf characters of Kuttiaattoor mango cultivar	42
7.	Inflorescence characters of Kuttiaattoor mango cultivar	43
8.	Qualitative characters of mature fruit of Kuttiaattoor mango cultivar	46
9.	Quantitative characters of mature fruit of Kuttiaattoor mango cultivar	47
10.	Morphological characters of ripe fruit of Kuttiaattoor mango cultivar	49
11.	Stone and seed characters of Kuttiaattoor mango cultivar	50
12.	Number of nuts producing polyembryonic seedlings in different Panchayaths	51
13.	Biochemical characters of Kuttiaattoor mango cultivar	52
14.	Distribution of trees in clusters	54
15.	Mean inter-cluster and intra-cluster distances	54
16.	Cluster wise mean value for quantitative characters	55
17.	Soil parameters for Kuttiaattoor area	57
18.	Monthly mean weather data for Kannur district from April 2016 to March 2017	59

LIST OF FIGURES

Figure No.	Title	Page No.
1.	Crown shape	20
2.	Tree growth habit	21
3.	Leaf base	22
4.	Leaf apex	23
5.	Petiole attitude in relation to shoot	23
6.	Fruit length and width	25
7.	Shape in cross section	25
8.	Nature of stalk cavity	27
9.	Shape of shoulder	28
10.	Presence of neck	28
11.	Bulging on ventral shoulder	29
12.	Presence of sinus	29
13.	Bulging proximal of stylar scar	30
14.	Seed shape in lateral view	33
15.	Dendrogram depicting the distribution of trees into clusters	53
16.	Map of the study area	60
17.	Variation in inflorescence length and diameter across the Panchayaths	64
18.	Percentage distribution of polyembryonic seedlings	69
19.	Variation in total soluble solids across the Panchayaths	71
20.	Variation in crude fibre across the Panchayaths	71

LIST OF PLATES

Plate No.	TITLE	After Page No.
1.	Crown shape	61
2.	Tree growth habit	61
3.	Anthocyanin colouration in young leaves	63
4.	Twisting of leaf margin	63
5.	Shape of leaf apex	63
6.	Shape of leaf base	63
7.	Petiole attitude in relation to shoot	63
8.	Anthocyanin colouration	65
9.	Inflorescence	65
10.	Inflorescence with leafy bracts	65
11.	Mature fruit	67
12.	Shape in cross section	67
13.	Colour of skin	67
14.	Colour of flesh	67
15.	Seed embryony	69
16.	Seed shape	69
17.	Stone surface relief	69

Introduction

1. INTRODUCTION

Mango (*Mangifera indica* L.), the king of fruits, is the most relished, delicious and widely liked fruit of summer in most countries all round the world. For the rich, it is a delicacy on food table whereas, for the poor, it is the food. According to De Candolle (1884), mango is cultivated for the last 4,000 years.

The cultivation of mango in India is ancient and has intimate place in the life of people. The stupa of Sanchi, which dates back to 150 B.C., has patterns of mango tree and fruit. Mango grows well in tropical and subtropical conditions. The soil and climate of India are ideally suited to its cultivation. India is a leading producer of mango among the mango producing countries in the world. Presently, India harbours more than 1000 mango varieties in different diversity regions and represents the biggest mango germplasm in the world (Navprem *et al.*, 2012). Dusehri, Langra and Chousa of Uttar Pradesh, Gulab Khas of Bihar, Laxman Bhog, Himsagar and Fazli of West Bengal, Pairi and Alphonso of Maharashtra, Malgoa, Banganapalli and Suvarnarekha of Andhra Pradesh are some of the important varieties of mango in India.

In Kerala mango is cultivated in an area of 81,874 ha with a total production of 253.911 thousand tonnes. The districts of Kannur and Kozhikode leads in terms of area and production of mango in Kerala (*Maavum Maangayum*, 2016). In Kerala, mango is not grown in orchards, except in Palakkad district where large mango orchards are present in Muthalamada area. The first mango fruits of the season coming to Indian markets are from Muthalamada (Arun and Kamalavalli, 2016).

Kerala have typical humid tropical climate conditions and natural mango gene pool consists mainly of the seedling races of local types, predominantly grown in homesteads and as avenue trees (Harikumar and Parameshwaran, 2016). A large number of traditional cultivars are grown in Kerala and some of these cultivars are grown in specific regions only. Muvandan,

Puliyam, Chandrakaran, Priyur, Alphonso, Kilichundan, Mundappa, Karpooramanga, Neelum, *etc.* are the popular cultivars of mango grown in Kerala (Anila, 2002).

Kuttiattoor mango is a popular traditional mango cultivar found in Kuttiattoor and the nearby Grama Panchayaths of Kannur district. Each and every homestead in Kuttiattoor has atleast one tree of this cultivar. The distinctiveness of Kuttiattoor mango is aided by combination of the specific environmental conditions of the area of its cultivation. Padre (2015) reported that Kuttiattoor mango, mainly seen in Kuttiattoor Grama Panchayath has thin skin, is fibrous and is moderately sweet in taste. However, in-depth studies related to the cultivar is scanty, and hence the present study was undertaken.

Present study on “Characterization of Kuttiattoor mango (*Mangifera indica* L.) cultivar of Kannur district, Kerala” was undertaken to

- Characterize Kuttiattoor mango cultivar grown in Kuttiattoor Panchayath and the nearby Grama Panchayaths *viz.*, Kolachhery, Mayyil, Koodali, Munderi and Malappattam of Kannur district, Kerala
- Characterize the similar mango cultivars of the area

Review of literature

2. REVIEW OF LITERATURE

Cultivar is simply variation of a species, one that has been produced by man through breeding or deliberate selection, or it is a plant variety that has been produced in cultivation by selective breeding.

The cultivar as defined in Article 2 of the International Code of Nomenclature for Cultivated Plants (2009) is “an assemblage of plants that (a) has been selected for a particular character or combination of characters, (b) is distinct, uniform and stable in those characters, and (c) when propagated by appropriate means, retains those characters.” Most cultivars have arisen in cultivation, but a few are special selections from the wild.

Liberty Hyde Bailey, an American horticulturist, botanist and cofounder of the American Society for Horticultural Science coined the word *Cultigen* in 1918. He defined cultigens as “a species, or its equivalent, that has appeared under domestication”. Cultivars form a major part of Bailey's broader grouping, the cultigens, defined as a plant whose origin or selection is primarily due to intentional human activity.

2.1. Indigenous mango diversity in Kerala

Climate has a definite influence on the quality of the fruit. Consequently, each locality has its own choice varieties which may not do well in other places (Gangolly, 1957). The home gardens in Kerala provide an ideal set up for the conservation and maintenance of rare and unique varieties (Gautam *et al.*, 2008). Traditional cultivars of mangoes usually produce small and fibrous fruits unlike the medium to large and fleshy fruits of modern cultivars. But they are enriched with qualities like stable yield, low management requirements and good biotic and abiotic stress tolerance (Kehlenbeck *et al.*, 2012).

The humid tropical climatic situation of Kerala is ideal for mango due to which it has a rich indigenous mango germplasm. The germplasm mainly consists

of seedling races of local types, mostly grown in homesteads and as avenue trees. These seedlings are many a time polyembryonic also. The homesteads of Kerala are endowed with rich crop diversity in which mango is an important component (Harikumar, 2016).

The earliest description on mango in Kerala was made by Kannan (1982). Later, many surveys were conducted to locate and evaluate the mango types of various regions (Radha and Manjula, 1998; Radha and Nair, 2000; Jyothi, 2000; Simi, 2006; Pradeepkumar *et al.*, 2006). Chenska Varikka, Chandrakkaran, Koonan, Kalkandamanga, Chappikkudian and Kilichundan are some of the native mango varieties of Kerala (Simi *et al.*, 2013). Renisha *et al.* (2012) pointed out that the traditional mango types of Kerala like Muvandan, Gomanga, Chandrakaran, Swarnamookan, *etc.* faces serious threat of germplasm erosion due to the rapid urbanization and indiscriminate tree cutting in villages.

Padre (2015) reported that Kuttiattoor mango, mainly seen in Kuttiattoor Grama Panchayath has thin skin, is fibrous and is moderately sweet in taste.

2.2. Characterization

Mango has been cultivated in India for over 4000 years (Mukherjee, 1948) and there are at least 1000 named cultivars of mango all over India. Many workers have attempted to describe the mango types present in various regions of the country. The earliest descriptions of mango using scientific terminology were by Watt (1891). Maries (1902) collected about 500 varieties of Indian mango and described them with botanical terminology. The first attempt to suggest the distinguishing characters of varieties was made by Woodhouse (1909). He described 40 mango varieties of Bihar. A descriptive list of Indian mangoes was given by Wester (1920).

Naik and Gangolly (1950) characterized 335 South Indian mango varieties from the year 1936 to 1947 based on tree, leaf, inflorescence and fruit characters.

They found that the apex of the leaf and the inrolling of mature leaf are very important in the identification of varieties.

At the 12th International Horticultural Congress, held in Berlin in 1938, research workers from all over the world understood the importance of description and classification of varieties as a fundamental aspect of fruit research and it was decided that a permanent commission be set up in every country to encourage the undertaking of nomenclature work. This was affirmed at the Horticultural Workers' Conference organised by the Indian Council of Agricultural Research at New Delhi, in 1947. In 1948, a scheme for mango was taken up and complete morphological description using vegetative, floral, fruit and stone characters of 210 varieties was determined.

The International Plant Genetic Resources Institute has developed an elaborate descriptor for characterization of mango germplasm that consists of passport data for identifying the accession, characterization data and evaluation data to assess abiotic and biotic stress susceptibility (IPGRI, 2006).

2.3. Morphological characterization

It has been pointed out by previous workers engaged in the description of mango varieties that qualitative characters are much more constant and important than the quantitative characters. For example, the shape of fruit of a given variety is fairly constant, showing little response to changing environment, as compared to the size of the fruit. Similarly, the up curling of the leaf or its shape is much more constant and dependable than the size of the leaf (Gangolly, 1957).

Morphological characterization helps significantly in cultivar identification. It allows for identification and study of the plant variation using visual attributes. Hoojendijk and Williams (2001) suggested that the employment of morphological descriptor list is the easiest of the formal, approved, standardized, repeatable methods of assessing crop genetic diversity. The major advantages of using morphological characterization are that, published descriptor

lists are readily available for major crop species, it can be carried out *in situ*, is relatively low cost and easy to carry out. Morphological characterization is the key step that is recommended before the more in-depth biochemical or molecular studies.

The first key for the identification of mango varieties, based upon fruit characters only, was published in 1944 by Sturrock and Wolfe, who described 38 mango varieties from Florida. They studied the range in the variability of the following characters and has also given a key for the identification of these varieties.

Tree	:	Habit
Leaf	:	Colour at emergence, colour at maturity, margin and size
Inflorescence	:	Colour of panicle branches, pubescence of panicle, branches, length and presence or absence of bracts
Flower	:	Size, ridges on petals (colour and pattern)
Fruit	:	Detailed descriptions

According to the varying degree of importance, Gangolly (1957) grouped the different morphological characters under three categories, *viz.*, primary, secondary and tertiary.

I. *Primary characters*

- (1) Form of the fruit
- (2) Form of the beak

II. *Secondary characters*

- (1) Form of apices of leaves (leaf tip)
- (2) Folding of leaves

III. *Tertiary characters*

- (1) Shape of the inflorescence
- (2) Shape of the leaves
- (3) Nature of venation of stone
- (4) Fibre and nature of fibre on the stone
- (5) Shape of shoulders
- (6) Nature of sinus
- (7) Colouration of the emerging leaves

Morphological markers generally consist of those pivotal features that can be scored and distinguished by naked eye easily and which are easily expressed in all environmental conditions.

Ribeiro and Santos *et al.* (2013) opined that when associated with the studies of genetic divergence, the morphological information may be of assistance to the breeders in choosing the best parents to develop population with a large selection potential. Some of the drawbacks of morphological characterization includes the difficulty to take environmental influences into account, in case of quantitative characters.

2.4. Vegetative characters

2.4.1 Tree characters

Radha and Manjula (2000) while studying the characteristics of 12 polyembryonic mango types in northern Kerala classified the trees according to the tree habit into erect, intermediate and spreading types, based on tree habit.

Simi (2006) characterized 50 traditional mango types in southern Kerala from the districts of Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha

and reported that the trees showed the erect (38%), intermediate (30%) and spreading (32%) types of growth habits.

Kaur *et al.* (2007) after studying the 14 mango varieties present in the Punjab Government progeny orchard and nursery, Amritsar observed that a considerable variability exists for various tree characters like tree height, tree spread and trunk girth. Tree height varied from 4.24 m to 13.76 m and the tree spread (North – South and East – West) ranged from 4.43 m to 16.43 m and 5.10m to 17.50 m, respectively. The maximum trunk girth of 2.87 m was recorded in Kala gola and the minimum of 0.54 m in Amrapali.

Mango tree is aborescent evergreen in nature, which can attain a height of 40 meters or more and can live on for several hundred years. The canopy is normally oval, elongated or dome shaped (Litz, 2009).

Ribeiro *et al.*, (2013) characterized 103 mango accessions of the field germplasm collection of Embrapa semi arid region located in Brazil based on Brazilian descriptors for mango and reported vertical, vertical to semi vertical, semi vertical, semi vertical to open and open tree habits among which the semi vertical (60.1%) was predominant.

2.4.2. Leaf characters

Leaves are simple, alternate, irregularly placed along the branchlets, sometimes remote and at other times (especially at the tips of the flowering branches) crowded, rather long petioled, oblong ovate to oblong lanceolate, base acute to cuneate, narrowed, apex acute to acuminate, entire often with wavy margins, coreaceous, glabrous on both surfaces, leaf blade 10-32 cm long, 2-9.5 cm. wide with resinous smell when bruised, pinnate nerved, distinctly reticulate veined, lateral secondary nerves numerous (12-30 pairs), conspicuous, yellowish green, petiole is terete, slightly thickened or swollen at the base, round, smooth, glabrous; mature leaves dark green (Gangolly, 1957).

Colour of the emerging leaves is a more constant character not subject to variation under the diverse conditions of mango culture. The colour shades are of varying degrees in the same plant at different stages of development of the leaf (Gangolly, 1957). Naik and Gangolly (1950) have described 335 varieties of South Indian mangoes. They have also laid great importance on the vegetative characters. They found that the apex of the leaf and the inrolling of mature leaf are very important in the identification of varieties with the shape of the leaf and colour of the emerging leaves ranking next in importance.

Davenport and Nunez-Elizea (1997) reported that in majority of the mango varieties, the newly emerging vegetative shoots are green in colour, but some cultivars also show colours like bronze, red or shades of red. After two to three months, when matured, the leaves attain dark green colour.

Majumdar and Sharma (1990) opined that the typical aroma of crushed leaf has very significant relation with the flavor of the fruit.

Radha and Manjula (2000) after characterizing 12 traditional polyembryonic mango types of Kerala observed that the leaf characters like shape, size, colour, *etc.* show large variation from cultivar to cultivar.

The lanceolate type of leaf shape, acuminate type of leaf tip and light green with brown tinge colour of young flush are principal features of traditional mango types of southern Kerala (Simi, 2006).

Fivaz (2008) reported that the colour of young flushes vary from copper red to purplish red which changes to dark green at maturity with a turpentine aroma when crushed.

Litz (2009) observed that the leaf morphology is highly variable and depending upon the cultivar, shape of the leaves could be lanceolate, oblong, ovate and intermediate types. Leaf length and width range from 12 to 38 cm and 2 to 13 cm, respectively. The length of the petioles of the leaves ranged from 1 to 12.5 cm.

Ribeiro *et al.* (2013) evaluated 103 mango accessions based on 50 morphological descriptors published by Brazil and reported that the young flushes showed light green to light brown or purplish colourations and in majority of the accessions, leaf length was between 16 and 21 cm and the average width was 4 cm.

CISH, Lucknow is conserving 726 accessions of mango from mango growing regions of India, Srilanka, Brazil and Australia. Among these 150 accessions are from North and East, 26 accessions from South and 72 accessions from West of India. These were documented based on 56 descriptors in the form of catalogue. The highest mean leaf length of 19.6 cm and mean leaf width of 5.6 cm was observed in case of North Indian accessions while the smallest mean leaf length of 18.56 cm and mean leaf width of 5.05 cm was recorded from the South and West Indian accessions.

2.4.3. Inflorescence characters

The inflorescence in mango is a large terminal panicle (axillary panicles or mixed panicles are also observed), which can be 6 to 40 cm long, rigid, erect or ascending, widely branched, rachis sometimes pink or purple, but often in different shades of green, terete, bracts oval to elliptic, bracteoles ovate and small. Flowers are small, polygamous, monoecious, yellowish green, in dense cymes on the ultimate branchlets, 4-5 merous, nearly sessile, male and female on the same panicle. Sepals are 4-5, deciduous, shorter than petals. Petals are 4-5, deciduous, spreading, with recurved tips, imbricate, yellowish white with purplish veins at the base of inner side. Stamens 4-5, very unequal, 1 or 2 of them longer and fertile, the rest reduced to sterile or abortive staminodes, inserted inside or on the disc, slender tipped with a small gland. Ovary in the bisexual flowers is conspicuous, globose, glabrous, citrine or yellowish white, sessile, one-celled, usually obliquely ovoid; style lateral, curved upwards, glabrous, citrine or yellowish white, 0.15-0.2 cm long; stigma simple, small and terminal; ovule

solitary, one-celled, usually pendulous from the basal or lateral or sub-basal funicle (Gangolly, 1957).

Flowering season of mango predominantly depends on the climatic condition of the region.

The blossom bud differentiation begins in October-November (Musahib-ud-din, 1946; Sen and Malik, 1940). Majumdar and Sharma (1990) opined that the time of flowering in mango is very closely associated to the time of flower bud initiation which differs with the cultivars as well as the climate of the region where it is grown. They also observed that the flowering period usually extends for two to three weeks. A lower temperature may extend the flowering period and a higher temperature may shorten it.

Gandhi (1955) reported that flowering commences in November or early December in West coast of India and Andhra Pradesh. Gangolly (1957) reported that wide variation was noted in the time of flowering among the different varieties of mango grown in same as well as different environment. Early, mid and late flowering varieties were recognized in each region. Relative date of flowering is a distinguishing feature of varieties. South Indian mangoes were noted to flower earlier when compared to North Indian varieties because of the low temperature conditions prevailing in the latter (Yadav and Singh, 1985).

Radha and Nair (2000) reported that flowering in mango varieties of Kerala starts by November –December. A similar observation was made by Anila (2002) while studying the various inflorescence and fruit characters of selected varieties and hybrids of mango viz., Neelum, Alphonso, Priyur, Kalappady, Ratna. According to Balakrishnan and Vijayarahavan (2009), November-December was the peak flowering season in South India while in North India it was February-March.

Mukherjee (1948) has described 72 varieties of mango in Bengal, Bihar and Uttar Pradesh. He has studied the range in the variability of the vegetative and

reproductive characters and has also reported that inflorescence characters like colour of panicle branches, pubescence of panicle branches, length of panicle and presence or absence of bracts are key characters for the identification of these varieties. In an attempt to classify the South Indian mangoes, Naik and Gangolly (1950) included the floral characters like shape, hairiness and sex ratio in the descriptor. According to Naarayanawami (1982) the length of inflorescence in five varieties of mango varied from 21.33 cm to 34.036 cm whereas the variation in breadth ranged from 18.11 to 32.083 cm.

A large variation was observed in length of the inflorescence from few centimeters to 60 cm. It varied from cultivar to cultivar (Chadha and Pal, 1986). Thimmappaiah and Suman (1987) reported that the inflorescence length ranged from 11.25 to 42.20 cm.

Radha and Manjula (2000) studied individual flower characters as well as inflorescence characters which includes the position of inflorescence, shape and size of inflorescence and sex ratio. Anila (2002) while studying the performance of selected varieties and hybrids of mango in Kerala, recorded length and breadth of inflorescence, colour of rachis, shape of inflorescence, density of flowers, percentage of hermaphrodite flowers and flower characters like diameter of inflorescence, flower type, nature of disc and number of stamens. The inflorescence length ranged from 15 to 30 cm

The colour of rachis of Banganappilly and Vellaikolumban was light green while that of Muvandan was dark red. It was light red in case of Neelum and Alphonso (Renisha, 2012).

2.4.5. Fruit characters

Mango fruit is a drupe, which follows a single sigmoid growth pattern. Drupe is fleshy, resinous, very variable in respect of shape and dimensions, yellowish green or yellow to reddish when ripe, fruit size 4-25 cm long and 1.5-10 cm wide, very unequalled, ovoid oblong, obliquely oblong, pyriform, sub-ovoid,

rounded or obtuse, peel rather thick, coreaceous, flesh yellow or orange coloured, juicy, savoury; stone solitary, rather thick, woody, with fibrous outer layer containing one flat seed. Seeds are large, ovoid oblong, compressed, testa thin, papery, cotyledons: plano-convex, often unequal and lobed, radicle slightly curved upwards (Gangolly, 1957).

Among the fruit characters, Naik and Gangolly (1950) found the shape of the fruit including the presence or absence of the beak as the most important. The nature and distribution of the fibre and the nature of the veins in the stone were also found to be varietal characteristics.

Fruits Among the number of morphological characters for fruit, it was found that fruit shape was the most reliable, relevant, and stable character for identification of varieties. Fruit size, presence of beak, sinus and cavity of stalk insertion are the characters which are significant while assessing the variability in mango germplasm (Ram and Rajan, 2003).

Simi (2006) characterized traditional mango varieties of southern Kerala and observed four types of fruit shapes viz., round, oblong, ellipsoid and oblong ellipsoid. She also reported that the fruit length and width ranged from 4.4 to 18.1 cm and 3.9 to 12 cm, respectively.

Bhuyan and Kobra (2007) observed that the skin colour of unripe fruits were green, light green, greenish, greenish yellow and light green whereas, the skin colour of ripe fruits were observed to be green, light green, greenish yellow, yellowish green, light yellow and yellow.

According to Jyothi *et al.* (2009) round and oblong was the most commonly observed fruit shape in mango. Navprem *et al.* (2011) characterized nine sucking mango genotypes in the sub tropics of Punjab and reported that the length and width of fruits ranged from 4.63 to 12.52 cm and 3.83 to 7.77 cm, respectively and the length to breadth ratio ranged from 1.02 to 1.84. He also recorded fruit shapes such as ovate, oblong and ovate oblong.

Navprem *et al.* (2012) reported that the colour of the pulp varied from yellow to orange. A range of pulp colours such as yellow, creamish yellow, light yellow and orange was reported by Navprem *et al.* (2012). In Amrapali, dark orange colour of pulp was reported by Riberio *et al.* (2013).

2.4.6. Polyembryony

Occurance of more than one embryo in a seed is known as polyembryony. In the genus *Mangifera*, it is from the integuments and nucellus from which the embryos are developed. They are widely known as nucellar seedlings. Carabac of Philippiens, important varieties of Malaya and majority of the Hawaiian mango varieties are polyembryonic. In mango, besides the embryo resulting from sexual union, three to eight seedlings per stone are observed. The nucellar seedlings are similar to the vegetatively propagated seedlings since they are identical to the female parents (ICAR, 1967).

When polyembryonic cultivars were examined in India, the number of embryos per stone ranged from 2 to 5 to 2 to 11, giving rise to an average of 3.1 seedling (Prasad and Prasad, 1972). According to Singh *et al.* (1967) majority of the Indian cultivars are monoembryonic except for the few polyembryonic ones found in Malabar coast. Radha (1997) reported that ten varieties of Kerala viz., Bappakkai, Chandrakkan, Olour, Kurukkan, Mylepelian, Goa, Pahutan and Bellari were polyembryonic.

Singh *et al.* (1983) reported that the number of embryos per stone ranged from 2 to 10 and seedlings ranged from 1 to 7. Percentage of germination is higher in polyembryonic varieties (Singh and Reddy, 1990). According to Iyer (1991), easiness in propagation, presence of tap root system and deeper root system that permits strong establishment and better adaptability in water deficit areas and the enormous variability that can be produced by using polyembryonic cultivars as male parents in breeding programs as the major advantages of polyembryonic varieties. These benefits of polyembryonic varieties suggests that there is wide scope for study in India in this aspect. Polyembryonic varieties are

high yielding but poor in quality. Selection is to be done for quality, early bearing, dwarf framework and high degree of polyembryony.

2.5. Biochemical characters

Teotia *et al.* (1972) studied the physico-chemical properties of Nisar Pasand, Neelum, Anupam, Bride of Russia Langra and Kesar. They reported highest TSS and sugar content in Nisar Pasand. Vitamin C was observed to be maximum in Neelum. Bride of Russia exhibited the minimum acidity (0.243%).

Satyavati *et al.* (1972) observed that TSS of ripe fruits of native mango types of Kerala ranged from 10 and 24 °brix. In 31 North Kerala mango varieties, the TSS ranged between 12.7 and 25.2 °brix (Pradeepkumar *et al.*, 2006). Bhuyan and Kobra (2007) opined that physico-chemical characters were very significant factors deciding the quality of fruits for fresh consumption. Lakshminarayana *et al.* (1970) reported that the ascorbic acid was highest in fifth week of fruit development whereas, it was least in the eighth week.

2.6. Traditional Knowledge (TK)

Madisa (1998) defined indigenous knowledge as knowledge of the people living together in an area, generated by their own and their ancestor’s experience, including knowledge originating from elsewhere which has to be internalized by the local people.

The concept of indigenous knowledge (IK) is as old as human civilization but the term was coined by John Hashburger in 1896. Indigenous knowledge is the traditional knowledge of indigenous communities about the existing plant diversity in their region. It also studies how the people of the region or locality utilize this IK.

In Sri Lanka, Maharouf (2003) attempted collecting indigenous knowledge on mango by meeting priests, village leaders, Ayurvedic doctors and ethnic communities. The information gathered indicated the existence of native

traditional mango types that were used for preparing particular food items and also for treatment of various ailments.

Renisha (2012) attempted biodiversity analysis of traditional mango types of Kerala and documented IK about the processing of mango in Pazhayannur village of Thrissur district. She reported that for the preparation of a particular product, the house maids always chose the typical variety.

Vasugi *et al.* (2012) reported about the unique aromatic pickle mango called the Appemedi mango identified by the farmers based on the aroma and taste from the forests of Western Ghats. Ashine *et al.* (2015) reported that because of the deep cultural attachment, the people of the area could identify a number of pickle mango types from wild habits. Traditionally these fruits are used in household preparations like Gojju, Sasve, Thambuli and chutney. Information were pooled from farmers, fruit collectors and sellers in the nearby market.

Materials and Methods

3. MATERIALS AND METHODS

The present study on 'Characterization of Kuttiaattoor mango (*Mangifera indica* L.) cultivar of Kannur district, Kerala' was undertaken to characterize Kuttiaattoor and similar mango cultivars grown in Kuttiaattoor and the nearby Grama Panchayaths of Kannur district in Kerala.

The materials used and the methodologies followed in the present investigation are detailed below.

3.1. Preliminary survey and selection of trees

A preliminary survey was conducted in Kuttiaattoor, Kolachhery, Mayyil, Koodali, Munderi and Malappattam Grama Panchayaths of Kannur district to locate and select the trees of Kuttiaattoor mango cultivars. Trees falling under the age group of 25 to 30 were located with the help of personnels of Kuttiaattoor Krishi Bhavan and local farmers. Twenty-five trees were selected from Kuttiaattoor Panchayath. Five trees each were tagged from Kolachhery, Mayyil, Koodali, Munderi and Malappattam. As the survey revealed that Kunjimangalam cultivar, mainly grown in Kunjimangalam Grama Panchayath is a similar cultivar to Kuttiaattoor, five trees of this cultivar were also selected and labelled for the present study. The history and indigenous technical knowledge associated with the cultivar were also collected.

3.2. Characterization

3.2.1. Site environment and age

For characterizing site environment, the soil samples were collected from all the Panchayaths under study and the pH, electrical conductivity (dSm^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorous (kg ha^{-1}) and available potassium (kg ha^{-1}) were estimated according to the protocols given in Table 1. The information related to the site environment of Kuttiaattoor area and Kunjimangalam Panchayath were also collected from Soil Survey Officer, Department of Soil Survey and Soil Conservation, Kannur and Pepper Research Station, Panniyur.

The approximate age of the trees selected for the study were determined by enquiry with the farmers.

Table 1. Methods for soil analysis

Soil property	Method used
pH (1:2.5)	1 : 2. 5 soil water ratio Beckman glass electrode (Jackson, 1973)
Electrical conductivity (dS m ⁻¹)	Conductometry (Jackson, 1973)
Organic carbon (%)	Wet oxidation method (Walkley and Black, 1934)
Available N (kg ha ⁻¹)	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P(kg ha ⁻¹)	Bray's method (Jackson, 1973)
Available K (kg ha ⁻¹)	Flame photometry method (Page <i>et al.</i> , 1982)

3.2.2. Morphological characterization

The standard descriptors for mango prescribed by IPGRI (2006) and DUS test guidelines by PPV & FRA (2008) were used to depict the tree, leaf, floral, fruit and seed characters of the selected trees.

3.2.2.1. General characterization

1. Time of flowering

The date of commencement of flowering and peak period of flowering was recorded from selected trees.

2. Time of fruit maturity

The period of fruit maturity was recorded from selected trees.

3. Pest and disease incidence

Information regarding the pest and disease infestation were collected.

3.2.2.2. Tree characters

The observations on the following characters were recorded from the trees.

1. Height of mature tree (m)

The height of mature tree was measured from ground level to the top of the tree using hypsometer and was expressed in the metre.

2. Trunk circumference (cm)

The trunk circumference was measured at 50 cm above the ground level of the tree and expressed in centimetre.

3. Crown diameter (m)

The diameter was measured using calibrated bamboo stick at the broadest part of the tree canopy and expressed in metre.

4. Crown shape

The visual appearance of crown was recorded and classified (Fig. 1) as

Code	Guide
1	Oblong
2	Broadly pyramidal
3	Semi-circular
4	Spherical
99	Other

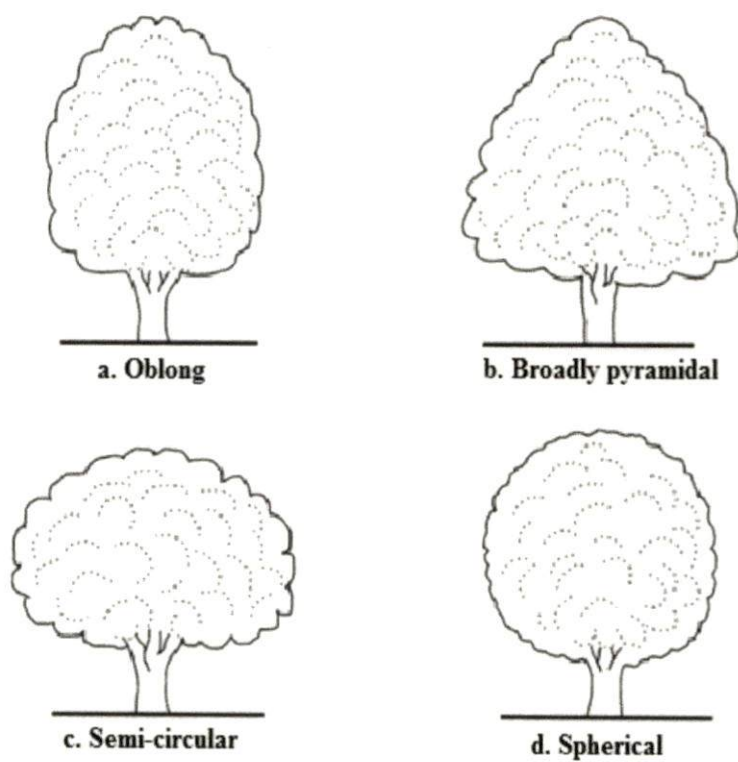


Fig. 1. Crown shape

5. Tree growth habit

Tree growth habit was recorded and classified (Fig. 2) as

Code	Guide
1	Erect
2	Spreading
3	Semi-circular
4	Drooping
99	Other

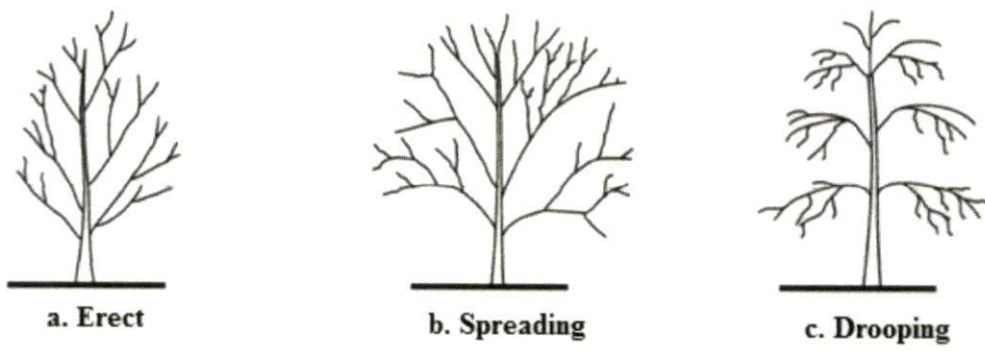


Fig. 2. Tree growth habit

3.2.2.3. Leaf characters

Observations on intensity of anthocyanin colouration was recorded from young leaves and other leaf characters were made from mature leaves in the middle third of the youngest shoots, not showing signs of active growth.

1. Intensity of anthocyanin colouration in young leaves

The intensity of anthocyanin colouration in young leaves were recorded and classified as

Code	Guide
a	Absent
b	Weak
c	Medium
d	Strong

2. Length (cm)

The length of the leaf blade was measured from the base of the leaf blade to the tip and expressed in centimetre.

3. Width (cm)

The breadth of leaf was measured at the broadest part of the lamina using digital Vernier caliper and expressed in centimetre.

4. Ratio

The ratio was obtained by dividing the leaf length with the corresponding leaf width.

5. Colour

The colour of mature leaf was observed and recorded as

Code	Guide
a	Light green
b	Medium green
c	Dark green

6. Twisting

Twisting of the leaf margin was observed and classified as

Code	Guide
a	Absent
b	Present

7. Spacing of secondary veins in leaf blade

The distance between two adjacent secondary veins at the broadest part of the lamina was measured using digital Vernier caliper and expressed in centimeters

8. Shape of base of leaf blade

The shape of leaf base was observed and classified (Fig. 3) as

Code	Guide
a	Acute
b	Obtuse
c	Rounded



Acute



Obtuse



Rounded

Fig. 3. Leaf base

9. Shape of apex of leaf blade

The shape of leaf apex was observed and classified (Fig. 4) as

Code	Guide
a	Attenuate
b	Acuminate
c	Acute

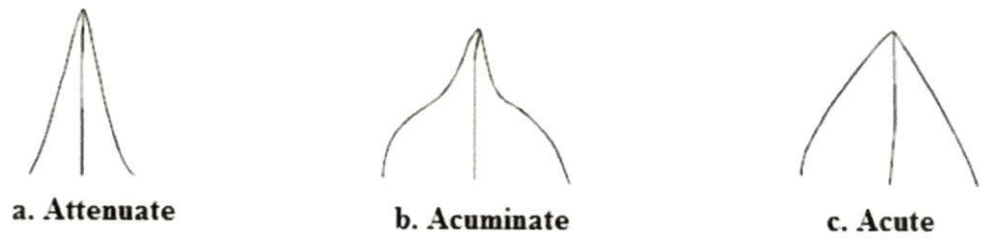


Fig. 4. Leaf apex

10. Petiole attitude in relation to shoot

The attitude of the petiole in relation to the branch was observed in upward growing shoots by breaking a small branch and holding it straight vertically. The attitude of petiole in relation to shoot was observed and classified (Fig. 5) as

Code	Guide
a	Erect
b	Perpendicular
c	Recurved

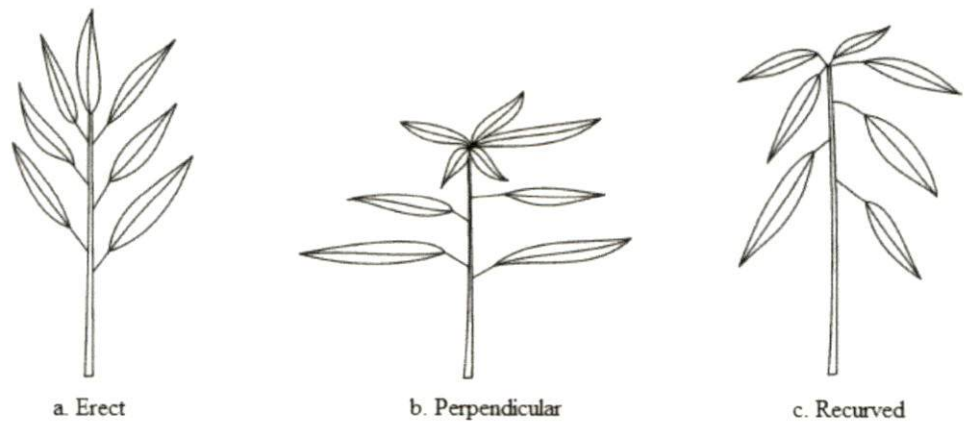


Fig. 5. Petiole attitude in relation to shoot

11. Petiole length (cm)

The length of the petiole was measured using digital Vernier caliper and expressed in centimeters.

3.2.2.4. Inflorescence characters

Five fully opened terminal panicles were selected from the exposed regions of every tree and the following observations were made

1. Length (cm)

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

2. Diameter (cm)

Diameter was measured at the broadest part of the inflorescence and expressed in centimetre.

3. Ratio

The ratio was obtained by dividing the inflorescence length by corresponding inflorescence diameter.

4. Anthocyanin colouration of axis and branches

The anthocyanin colouration of inflorescence axis and branches were observed and classified as

Code	Guide
a	Absent or weak
b	Medium
c	Strong

3.2.2.5. Mature fruit characters

Five fruits at appropriate stage of harvesting were selected from every tree and the following observations were made

1. Length (cm)

Fruit length was measured from base to apex (Fig. 6) using digital Vernier caliper and expressed in centimetre.

2. Width (cm)

The distance between two shoulders (Fig. 6) was measured using digital Vernier caliper and expressed in centimetre.

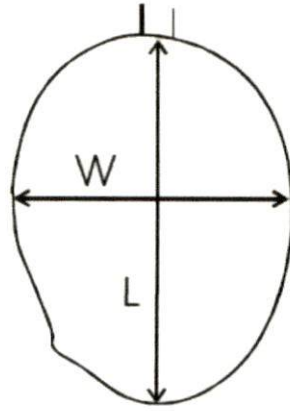


Fig. 6. Fruit length and width

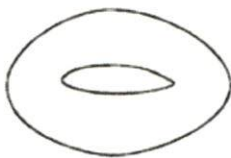
3. Ratio

The ratio was obtained by dividing the fruit length by corresponding fruit width.

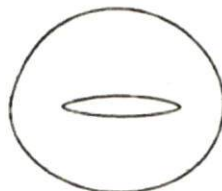
4. Shape in cross section

The shape in cross section was observed by cutting the fruit horizontally in the centre of mature fruit and was classified (Fig. 7) as

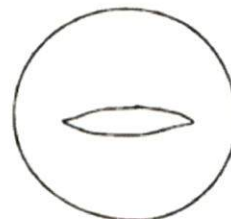
Code	Guide
a	Medium elliptic
b	Broad elliptic
c	Circular



a. Medium elliptic



b. Broad elliptic



c. Circular

Fig. 7. Shape in cross section

5. Colour of skin

The colour of skin was observed and classified as

Code	Guide
a	Only yellow
b	Only green
c	Green and yellow
d	Green and orange
e	Green and pink
f	Green and red
g	Green and purple

6. Density of lenticels

The number of lenticels in 1×1 cm square of fruit skin was counted by viewing through a hand-lens.

7. Colour contrast between lenticels and skin

The colour contrast between lenticels and skin was observed and classified as

Code	Guide
a	Weak
b	Medium
c	Strong

8. Size of lenticels

The size of the lenticels was measured using stereo microscope and expressed in micrometer

9. Roughness of surface caused by lenticels

The roughness of skin caused by lenticels was recorded by touching the skin surface by hand and was classified as

Code	Guide
a	Absent
b	Present

10. Nature of stalk cavity

The nature of stalk cavity was observed and classified (Fig. 8) as

Code	Guide
a	Absent or shallow
b	Medium
c	Deep

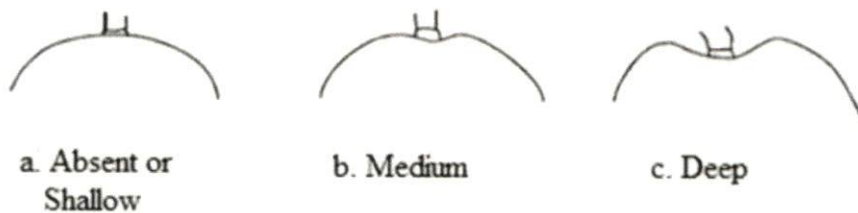


Fig. 8. Nature of stalk cavity

11. Shape of ventral shoulder

The shape of ventral shoulder of mango was observed and classified (Fig. 9) as

Code	Guide
a	Rounded upward
b	Rounded outward
c	Rounded downward
d	Sloping downwards
e	Falling abruptly

12. Shape of dorsal shoulder was observed and classified (Fig.9) as

Code	Guide
a	Rounded upward
b	Rounded outward
c	Rounded downward
d	Sloping downwards
e	Falling abruptly

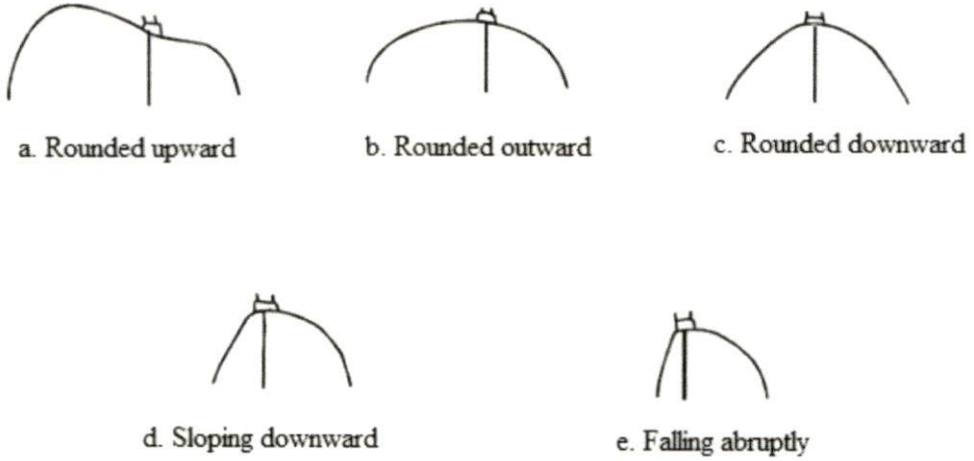


Fig. 9. Shape of shoulder

13. Presence of neck

Presence of neck was observed and classified (Fig. 10) as

Code	Guide
a	Absent
b	Present



Fig. 10. Presence of neck

14. Length of neck (cm)

The length of neck was measured and expressed in centimeters

15. Length of groove in ventral shoulder

The length of groove in ventral shoulder was observed and classified as

Code	Guide
a	Absent
b	Present

16. Bulging on ventral shoulder

The bulging on ventral shoulder was observed and classified (Fig. 11) as

Code	Guide
a	Absent
b	Present



Fig. 11. Bulging on ventral shoulder

17. Presence of sinus

The presence of sinus was observed and classified (Fig. 12) as

Code	Guide
a	Absent
b	Present

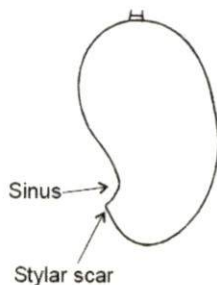


Fig. 12. Presence of sinus

18. Depth of sinus

Depth of sinus was observed and classified as

Code	Guide
a	Absent
b	Medium
c	Deep

19. Bulging proximal of stylar scar

Bulging proximal of stylar scar was observed and classified (Fig. 13) as

Code	Guide
a	Absent or weak
b	Medium
c	Strong

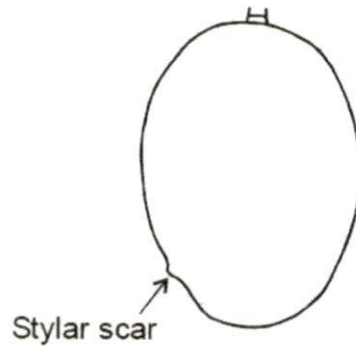


Fig. 13. Bulging proximal of stylar scar

20. Diameter of stalk attachment (mm)

Diameter of stalk attachment was measured using digital Vernier caliper and measured in millimetre.

3.2.2.6. Ripe fruit characters

Mature fruits from trees selected for study were harvested and allowed to ripen under room temperature for recording the observations on ripe fruit characters.

1. Predominant color of skin

Predominant color of skin was observed and classified as

Code	Guide
a	Green
b	Yellow green
c	Green and yellow

- d Yellow
- e Yellow-orange
- f Yellow and orange
- g Orange
- h Yellow and red
- i Orange and red
- j Red
- k Orange and purple
- l Purple

2. Speckling of skin

Speckling of skin was observed and classified as

Code	Guide
a	Absent
b	Weak
c	Strong

3. Thickness of skin

Thickness of skin was measured using digital Vernier caliper and expressed in millimeters.

4. Adherence of skin to flesh

Adherence of skin to flesh was determined manually by pulling the peel and was classified as

Code	Guide
a	Weak
b	Medium
c	Strong

5. Main colour of flesh

Main colour of flesh was recorded and classified as

Code	Guide
a	Greenish yellow

- b Light yellow
- c Medium yellow
- d Light orange
- e Medium orange
- f Dark orange

6. Firmness of flesh

Firmness of flesh was observed and recorded as

Code	Guide
a	Soft
b	Medium
c	Firm

7. Juiciness

Juiciness was observed and recorded as

Code	Guide
a	Low
b	Medium
c	High

8. Texture of flesh

Texture of flesh was recorded and classified as

Code	Guide
a	Fine
b	Medium
c	Coarse

9. Amount of fiber attached to stone

Amount of fiber attached to stone was observed and classified as

Code	Guide
a	Low
b	Medium
c	High

10. Amount of fiber attached to skin

Amount of fiber attached to skin was recorded and classified as

Code	Guide
a	Low
b	Medium
c	High

11. Turpentine flavor

Turpentine flavor for fruits were recorded and classified soon after harvesting as

Code	Guide
a	Absent
b	Present

3.2.2.7. Stone and seed characters

1. Relief of stone surface

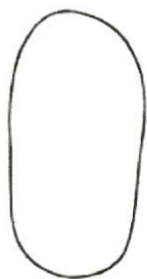
Relief of stone surface was observed and classified as

Code	Guide
a	Grooved
b	Smooth
c	Ridged

2. Shape of seed in lateral view

Shape of seed in lateral view was observed and classified (Fig. 14) as

Code	Guide
a	Oblong
b	Reniform



a. Oblong



b. Reniform

Fig. 14. Seed shape in lateral view

3. Seed embryony

The stone was cut open to obtain the seed and the seed was sown. Number of nuts producing different number of seedlings per nut was also calculated and expressed in percentage. The seed embryony was classified as

Code	Guide
a	Monoembryony
b	Polyembryony

3.2.3. Biochemical characterization

Uniformly ripened mangoes were chosen for biochemical characterization. Three mangoes were randomly selected from one tree.

3.2.3.1. Total soluble solids (TSS)

TSS of the juice extracted from the fruit was measured using a hand refractometer (range 0-32°brix) expressed in degree brix (AOAC, 1980).

3.2.3.2. Acidity

The titrable acidity was estimated by titrating with 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator and expressed as per cent of citric acid. A known weight of the sample was ground using distilled water and made upto 100 ml in a standard flask. An aliquot of 10 ml from this was titrated against 0.1 N NaOH (AOAC, 1998).

$$\text{Acidity} = \frac{\text{Normality} \times \text{titre value} \times \text{equivalent weight} \times \text{volume made up} \times 100}{\text{Weight of sample} \times \text{aliquot of sample} \times 1000}$$

3.2.3.3. Ascorbic acid

Five grams of the sample was taken and extracted with four per cent oxalic acid. Ascorbic acid was estimated by using standard indicator dye 2,6-dichlorophenol indophenol and expressed as mg/100g of fruit (Sadasivam and Manickam, 1996).

3.2.3.4. Carotenoids

A known weight of the sample was ground in a pestle and mortar with acetone. The extract was poured into a conical flask. Extraction was continued till the residue became colourless. The extract was transferred to a separating funnel and then 10-15 ml of petroleum ether, little amount of distilled water and a little amount of anhydrous sodium sulfate was added. Then it was shaken well. The upper layer was collected and the lower layer was re-extracted. Extraction of acetone phase was repeated with a small volume of petroleum ether till it became colourless. The extract was collected into a volumetric flask by passing through cotton containing a small amount of anhydrous sodium sulfate and then the volume was made up with petroleum ether. The colour was measured at 452 nm using petroleum ether as blank in a spectrophotometer. Results were expressed as $\mu\text{g}/100$ g of material (Ranganna, 1997).

$$\text{Total carotenoids } (\mu\text{g}/100 \text{ g}) = \frac{3.857 \times \text{optical density} \times \text{volume made up} \times 100}{\text{Weight of the sample}}$$

3.2.3.5. Crude fibre

Crude fibre content of the sample was estimated by acid alkali digestion method as suggested by Chopra and Kanwar (1978).

A known weight of the sample was first treated with acid and subsequently with alkali. The residue obtained after final titration was weighed, incinerated, cooled and weighed again. The crude fibre was given by the difference in weight and expressed as a percentage.

3.3. Statistical Analysis

Data collected with respect to all quantitative characters were tabulated and subjected to an analysis of variance for randomized block design using OPSTAT, a free online statistical software package for agricultural research workers, developed by the Department of Mathematics Statistics, Chaudhary Charan Singh Haryana Agricultural University, Hisar.

The treatments were compared using Duncans's multiple range test (DMRT).

3.3.1. Cluster Analysis

Clustering was done in the Minitab (<https://www.minitab.com/en-us/products/minitab/free-trial/>), following agglomerative hierarchical clustering method. Squared Euclidean distance, the most common distance measure and average linkage approach, widely used in continuous variables were considered for clustering. A dendrogram depicting grouping of accessions in various clusters at 65 per cent similarity level was also drawn. Both inter and intra-cluster distances were calculated.

Results

4. RESULTS

The present investigation deal with the characterization of Kuttiaattoor and similar mango cultivars of Kannur district, Kerala. Mango trees, falling under the age group of 25 to 30 years, which were identified by the local people as 'Kuttiaattoor mavu' where located and tagged through a preliminary survey from Kuttiaattoor, Kolachhery, Mayyil, Koodali, Munderi and Malappattam Grama Panchayaths. Being the core area of study, from Kuttiaattoor 25 trees were selected. From the remaining Grama Panchayaths, five trees each were selected for characterization. While undertaking the preliminary survey, it was learned from the local people of Kuttiaattoor that the 'Kunjimangalam mavu' found in Kunjimangalam Grama Panchayath is very similar to the Kuttiaattoor cultivar. So five trees from Kunjimangalam Grama Panchayath were also included for detailed study. Characterization was done according to the quantitative and qualitative characters vide mango descriptor (IPGRI, 2006) and DUS test guidelines (PPV and FRA, 2008).

4.1. Flowering and fruiting period

In Kerala, mango starts flowering by November – December. In the present study, the period of commencement of flowering, period of peak flowering and period of fruit maturity for Kuttiaattoor cultivar from the seven Panchayaths during 2016-2017 were studied and the results are presented in Table 2. Flowering commenced in the second week of November at Kolachhery, Mayyil, Koodali, Munderi and Malappattam. It started in third and fourth week of November at Kuttiaattoor and Kunjimangalam, respectively.

The peak flowering period was noted to be fourth week of December at Kuttiaattoor, Mayyil and Munderi, third week of December in Kolachhery, Koodali and Malappattam, and second week of January in Kunjimangalam.

Mature fruits of Kuttiaattoor mango were available in plenty from second week of March to May. In Kuttiaattoor, Kolachhery and Mayyil, fruits matured by

fourth week of March. Time of fruit maturity was noted to be first week of April in Koodali and Munderi and second week of April in Kunjimangalam.

Table 2. Flowering and fruiting period of Kuttiattoor mango cultivar (2016-2017)

Sl. No.	Grama Panchayaths	Commencement of flowering	Peak flowering	Time of fruit maturity
1	Kuttiattoor	Third week of November	Fourth week of December	Fourth week of March
2	Kolachhery	Second week of November	Third week of December	Fourth week of March
3	Mayyil	Second week of November	Fourth week of December	Fourth week of March
4	Koodali	Second week of November	Third week of December	First week of April
5	Munderi	Second week of November	Fourth week of December	First week of April
6	Malappattam	Second week of November	Third week of December	First week of April
7	Kunjimangalam	Fourth week of November	Second week of January	Second week of April

4.2. Tree characters

As per the IPGRI descriptor, the tree characters *viz.*, crown shape, tree growth habit, tree height, trunk circumference and crown diameter were considered for the study.

4.2.1. Qualitative tree characters

The qualitative characters and the percentage distribution pertaining to tree characters *viz.*, crown shape and tree growth habit are presented in Table 3. The crown shape in 73 per cent of the trees was semicircular, while that of 27 per cent were spherical.

Table 3. Percentage distribution of tree characters of Kuttiattoor mango cultivar

Morphological characters	Class	Per cent (%)
Crown shape	Oblong	-
	Broadly pyramidal	-
	Semi-circular	73
	Spherical	27
Tree growth habit	Erect	-
	Spreading	100
	Drooping	-

4.2.2. Quantitative tree characters

Quantitative tree characters considered for the study included tree height, trunk circumference and crown diameter. The mean values of the same are presented in Table 4.

Table 4. Quantitative tree characters of Kuttiattoor mango cultivar

Sl. No.	Grama Panchayaths	Tree height (m)	Trunk circumference (cm)	Crown diameter (m)
1	Kuttiattoor	16.10	152.40	13.25
2	Kolachhery	15.30	148.80	15.90
3	Mayyil	13.70	136.20	11.80
4	Koodali	14.80	158.80	13.20
5	Munderi	13.50	120.20	10.90
6	Malappattam	15.80	164.20	13.80
7	Kunjimangalam	14.60	129.00	13.00
Mean		14.82	144.22	13.12
C.D. (0.05)		NS	NS	NS

In the present study, no significant difference was observed between the trees from different Panchayaths for all the tree characters. Tree height ranged from 13.50 m (Munderi) to 16.10 m (Kuttiattoor) with an overall mean of 14.82

m. Trunk circumference ranged from 120.20 cm (Munderi) to 164.20 cm (Malappattam) with an overall mean of 144.22 cm. The crown diameter ranged from 10.90 m in Munderi to 15.90 m Kolachhery. The overall mean was 13.12 m.

4.3. Qualitative leaf characters

The qualitative characters for the leaf of Kuttiaattoor mango cultivar viz., intensity of anthocyanin colouration in young leaves, colour, twisting, leaf base shape, leaf apex shape and petiole attitude in relation to shoot for the mature leaves were observed and recorded and results of the same are presented in Table 5. It is interesting to note that the leaf qualitative characters did not show any kind of variation between trees from different Panchayaths.

The intensity of anthocyanin colouration was medium for newly emerged leaves in trees from all Panchayaths. The newly emerged leaves showed light green with brownish tinge colour. Mature leaves were of green colour in trees of all Panchayaths.

The leaves showed no signs of twisting of the leaf lamina. A partial twisting towards the apex portion of the leaf lamina was rarely observed in some leaves. However, it was clearly noticed that the leaf margin was entire and not wavy. The leaf base shape of the cultivar was found to be obtuse and rarely acute type in trees from all the Grama Panchayaths. Acuminate type of leaf tip was generally observed in the cultivar and very rarely acute type of leaf was also found. The petiole attitude was observed to be perpendicular with respect to the shoot.

Table 5. Qualitative leaf characters of Kuttiattoor mango cultivar

Sl. No.	Morphological character	Grama Panchayaths						
		Kuttiattoor	Kolachhery	Mayyil	Koodali	Munderi	Malappattam	Kunjimangalam
1	Intensity of anthocyanin colouration in young leaves	Medium	Medium	Medium	Medium	Medium	Medium	Medium
2	Colour	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green	Dark green
3	Twisting	Absent; rarely twisted towards apex	Absent; rarely twisted towards apex	Absent; rarely twisted towards apex	Absent; rarely twisted towards apex	Absent; rarely twisted towards apex	Absent; rarely twisted towards apex	Absent; rarely twisted towards apex
4	Leaf base shape	Obtuse; rarely acute	Obtuse; rarely acute	Obtuse; rarely acute	Obtuse; rarely acute	Obtuse; rarely acute	Obtuse; rarely acute	Obtuse; rarely acute
5	Leaf apex shape	Acuminate; rarely acute	Acuminate; rarely acute	Acuminate; rarely acute	Acuminate; rarely acute	Acuminate; rarely acute	Acuminate; rarely acute	Acuminate; rarely acute
6	Petiole attitude relation to shoot	Perpendicular	Perpendicular	Perpendicular	Perpendicular	Perpendicular	Perpendicular	Perpendicular

4.4. Quantitative leaf characters

The quantitative characters for leaf of Kuttiaattoor mango cultivar *viz.*, leaf blade length, leaf blade width, spacing of secondary veins and petiole length were observed and recorded from Kuttiaattoor, Kolachhery, Mayyil, Koodali, Munderi, Malappattam and Kunjimangalam Grama Panchayaths and the results of the same are presented in Table 6.

Table 6. Quantitative leaf characters of Kuttiaattoor mango cultivar

Sl. No.	Grama Panchayaths	Leaf blade length (cm)	Leaf blade width (cm)	Ratio (length/width)	Spacing of secondary veins (cm)	Petiole length (cm)
1	Kuttiaattoor	22.13	6.15	3.59	1.48	3.39 ^c
2	Kolachhery	21.90	6.11	3.58	1.38	4.01 ^a
3	Mayyil	22.46	6.33	3.54	1.40	3.88 ^{ab}
4	Koodali	22.23	6.19	3.59	1.43	3.90 ^{ab}
5	Munderi	21.89	6.11	3.58	1.49	3.81 ^{ab}
6	Malappattam	21.85	6.08	3.59	1.45	3.60 ^b
7	Kunjimangalam	21.83	6.16	3.54	1.31	4.02 ^a
Mean		22.04	6.16	3.57	1.42	3.80
C.D. (0.05)		NS	NS	NS	NS	0.341

The mean leaf blade length, width, ratio (length/width) and spacing of secondary veins did not show a significant variation from Panchayath to Panchayath. Leaf blade length ranged from 21.83 cm in Kunjimangalam to 22.46 cm in Mayyil with an overall mean of 22.04 cm. Leaf blade width ranged from 6.08 cm in Malappattam to 6.33 cm in Mayyil with an overall mean of 6.16 cm.

The ratio between leaf length and width recorded an overall mean of 3.57. The spacing of secondary veins in leaf blade ranged from 1.31 cm (Kunjimangalam)

to 1.49 cm (Munderi) with an overall mean of 1.42 cm. The petiole length varied slightly across the Panchayaths. It ranged from 3.39 cm in Kuttiaattoor to 4.02 cm in Kunjimangalam with an overall mean of 3.80 cm. The petiole length was slightly higher in trees of Kunjimangalam and Kolachhery (4.02 cm and 4.01 cm, respectively) and slightly lower in trees of Kuttiaattoor (3.39 cm).

4.5. Inflorescence characters

The inflorescence characters considered for the study included anthocyanin colouration, inflorescence length, inflorescence diameter and ratio and the results are presented in Table 7.

Table 7. Inflorescence characters of Kuttiaattoor mango cultivar

Sl. No.	Grama Panchayaths	Anthocyanin colouration	Inflorescence length (cm)	Inflorescence diameter (cm)	Ratio (length/diameter)
1	Kuttiaattoor	Absent; rarely slight pink tinge	22.90 ^{ab}	20.54 ^a	1.11
2	Kolachhery	Absent; rarely slight pink tinge	20.33 ^c	17.80 ^b	1.14
3	Mayyil	Absent; rarely slight pink tinge	22.05 ^{abc}	20.30 ^a	1.08
4	Koodali	Absent; rarely slight pink tinge	22.86 ^{ab}	20.36 ^a	1.12
5	Munderi	Absent; rarely slight pink tinge	21.64 ^{bc}	19.05 ^{ab}	1.13
6	Malappattam	Absent; rarely slight pink tinge	21.20 ^{bc}	18.66 ^{ab}	1.13
7	Kunjimangalam	Absent; rarely slight pink tinge	23.95 ^a	20.07 ^a	1.19
Mean			22.13	19.54	1.12
C.D. (0.05)			1.862	1.808	NS

The anthocyanin colouration of the inflorescence was generally absent or weak in the cultivar in all Panchayaths. Mostly, the floral axis and branches were pale green in colour. Very rarely a slight pink tinge was observed.

The mean inflorescence length of the cultivar showed slight variation in trees from Panchayath to Panchayath. It ranged from 20.33 cm in Kolachhery Panchayath to 23.95 cm in Kunjimangalam Panchayath with an overall mean of 22.13 cm. The mean values of inflorescence diameter also differed slightly across the Panchayaths similar to that of the inflorescence length. It ranged from 17.80 cm in Kolachhery to 20.54 cm in Kuttiattoor. The ratio obtained by dividing inflorescence length by the corresponding inflorescence width did not vary significantly from Panchayath to Panchayath. It ranged from 1.08 (Mayyil) to 1.19 (Kunjimangalam) with an overall mean of 1.12.

4.6. Mature fruit characters

The morphological characters for the mature fruit of the cultivar were recorded from all the Grama Panchayaths and the data are presented.

4.6.1. Qualitative mature fruit characters

The qualitative mature fruit characters considered for the study included shape in cross section, colour of skin, colour contrast between lenticels and skin, roughness of surface caused by lenticels, nature of stalk cavity, shape of dorsal shoulder, shape of ventral shoulder, presence of neck, bulging on ventral shoulder, presence of sinus and bulging of proximal stylar scar. The results obtained are presented in Table 8.

It was noticed that the fruits from all the seven Grama Panchayaths showed broad elliptical shape and shape. The colour of skin of mature fruits was only green in all the Panchayaths. The cultivar showed a medium colour contrast between lenticels and skin. On examining the fruit surface by touching, it was noticed that the skin was smooth and there was no corkiness or roughness caused by the lenticels. The result was similar in all the seven Grama Panchayaths. With regard to the stalk cavity, a

medium sized depression was recorded in Kuttiattoor mango cultivar in all the Grama Panchayaths.

The dorsal fruit shoulder was rounded outward in trees of all the Panchayaths whereas the ventral fruit shoulder showed the rounded upward shape. Neck was not observed in the cultivar and bulging on the ventral shoulder was also absent for the mangoes in all of the Panchayaths under study. Sinus is a small curvy depression present on the ventral side of the apex of the fruit. There was no such prominent depression or sinus present in Kuttiattoor mango cultivar in all Panchayaths. Similarly, bulging of proximal stylar scar was also absent.

Table 8. Qualitative characters of mature fruit of Kuttiattoor mango cultivar

Sl. No.	Morphological characters	Grama Panchayaths								
		Kuttiattoor	Kolachhery	Mayyil	Koodali	Munderi	Malappattam	Kunjimangalam		
1	Shape in cross section	Broad elliptic	Broad elliptic	Broad elliptic	Broad elliptic	Broad elliptic	Broad elliptic	Broad elliptic	Broad elliptic	Broad elliptic
2	Colour of skin	Only green	Only green	Only green	Only green	Only green	Only green	Only green	Only green	Only green
3	Colour contrast between lenticels and skin	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
4	Roughness of surface caused by lenticels	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
5	Nature of stalk cavity	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
6	Shape of dorsal shoulder	Rounded outward	Rounded outward	Rounded outward	Rounded outward	Rounded outward	Rounded outward	Rounded outward	Rounded outward	Rounded outward
7	Shape of ventral shoulder	Rounded upward	Rounded upward	Rounded upward	Rounded upward	Rounded upward	Rounded upward	Rounded upward	Rounded upward	Rounded upward
8	Presence of neck	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
9	Bulging on ventral shoulder	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
10	Presence of sinus	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
11	Bulging of proximal stylar scar	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

4.6.2. Quantitative mature fruit characters

The results of the quantitative matured fruit characters studied viz., fruit length, fruit width, density of lenticels, size of lenticels and diameter of stalk attachment are presented in Table 9.

Table 9. Quantitative characters of mature fruit of Kuttiaattoor mango cultivar

Sl. No.	Grama Panchayaths	Fruit length (cm)	Fruit width (cm)	Ratio (length /width)	Density of lenticels (per cm ²)	Size of lenticels (µm)	Diameter of stalk attachment (mm)
1	Kuttiaattoor	8.90	8.27	1.07	7.56 ^{ab}	136.98	4.49 ^{abc}
2	Kolachhery	8.83	8.11	1.08	6.88 ^{abc}	135.94	4.27 ^c
3	Mayyil	8.98	8.13	1.10	6.48 ^c	136.66	4.36 ^{bc}
4	Koodali	9.00	8.24	1.09	6.72 ^c	134.78	4.44 ^{bc}
5	Munderi	8.78	8.24	1.06	7.60 ^a	137.28	4.48 ^{abc}
6	Malappattam	9.18	8.30	1.10	6.36 ^c	136.30	4.53 ^{ab}
7	Kunjimangalam	8.91	8.18	1.08	6.76 ^{bc}	135.49	4.68 ^a
Mean		8.94	8.21	1.08	6.90	136.20	4.46
C.D. (0.05)		NS	NS	NS	0.818	NS	0.212

The variation in fruit length, fruit width, ratio (length/width) and size of lenticels across the Panchayaths were observed to be non-significant. The fruit length ranged from 8.78 cm (Munderi) to 9.18 cm (Malappattam) with an overall mean of 8.94 cm. The mean fruit width of the cultivar was 8.21 cm. It ranged from 8.11 cm in Kolachhery to 8.30 cm in Malappattam.

Fruit ratio ranged from 1.07 to 1.10 with an overall mean of 1.08. The density of lenticels ranged from 6.36/cm² (Malappattam) to 7.60/cm² (Munderi) with an overall mean value of 6.90/cm². It varied slightly in fruits across the Panchayaths.

Fruits from Munderi showed a slightly higher value ($7.60/\text{cm}^2$) for density of lenticels.

The size of lenticels ranged from $134.78\ \mu\text{m}$ in Koodali to $137.28\ \mu\text{m}$ in Munderi with an overall mean of $136.20\ \mu\text{m}$. Diameter of stalk attachment ranged from $4.27\ \text{mm}$ (Kolachhery) to $4.68\ \text{mm}$ (Kunjimagalam). The mean for diameter of stalk attachment was $4.46\ \text{mm}$. Diameter of stalk attachment also varied slightly across the Panchayaths.

4.7. Ripe fruit characters

The ripe fruit characters considered for the study included predominant colour of skin, speckling of skin, thickness of skin, adherence of skin to flesh, main colour of flesh, firmness of flesh, juiciness, texture of flesh, amount of fibre attached to stone, amount of fibre attached to skin and turpentine flavor. The results are presented in Table 10. The ripe fruit characters did not vary significantly in fruits from Panchayath to Panchayath.

The colour of skin of ripe fruits was yellow-orange in all the Grama Panchayaths. Ripe fruits from all the seven Panchayaths did not show speckling or patches on the skin. Thickness of skin ranged from $1.02\ \text{mm}$ to $1.09\ \text{mm}$. The mean thickness of skin was $1.06\ \text{mm}$. Skin thickness did not vary significantly across the Panchayaths.

The intensity of peel adherence to the flesh was recorded as 'medium'. The main colour of the flesh was recorded as medium orange in mature fruits from all the Grama Panchayaths.

The flesh was neither very soft nor too firm. A medium firmness of flesh was observed. The ripe fruits were observed to be medium juicy. The texture of the flesh was neither fine nor coarse. It was observed to be of medium texture. Medium

Table 10. Morphological characters of ripe fruit of Kuttiattoor mango cultivar

Sl. No.	Morphological characters	Grama Panchayaths							
		Kuttiattoor	Kolachhery	Mayyil	Koodali	Munderi	Malappattam	Kunjimangalam	
1	Predominant colour of skin	Yellow orange	Yellow orange	Yellow orange	Yellow orange	Yellow orange	Yellow orange	Yellow orange	
2	Speckling of skin	Absent	Absent	Absent	Absent	Absent	Absent	Absent	
3	Thickness of skin (mm)	1.02	1.09	1.05	1.05	1.09	1.08	1.09	
4	Adherence of skin to flesh	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
5	Main colour of flesh	Medium orange	Medium orange	Medium orange	Medium orange	Medium orange	Medium orange	Medium orange	
6	Firmness of flesh	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
7	Juiciness	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
8	Texture of flesh	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
9	Amount of fibre attached to stone	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
10	Amount of fibre attached to skin	Medium	Medium	Medium	Medium	Medium	Medium	Medium	
11	Turpentine flavor	Present	Present	Present	Present	Present	Present	Present	

amount of fibre was seen attached to stone and skin. Slight turpentine flavour was present for the fruits from all the Grama Panchayaths.

4.8. Stone and seed characters

The stone and seed characters considered for the study included relief of stone surface, seed shape in lateral view and seed embryony and the results are presented in Table 11. These characters did not vary significantly in fruits from Panchayath to Panchayath.

Table 11. Stone and seed characters of Kuttiaattoor mango cultivar

Sl. No	Grama Panchayaths	Relief of stone surface	Seed shape in lateral view	Seed embryony
1	Kuttiaattoor	Ridged	Reniform	Polyembryony
2	Kolachhery	Ridged	Reniform	Polyembryony
3	Mayyil	Ridged	Reniform	Polyembryony
4	Koodali	Ridged	Reniform	Polyembryony
5	Munderi	Ridged	Reniform	Polyembryony
6	Malappattam	Ridged	Reniform	Polyembryony
7	Kunjimangalam	Ridged	Reniform	Polyembryony

The relief of stone surface was observed to be ridged. Seed was reniform in shape in fruits of all Panchayaths. Kuttiaattoor mango showed polyembryonic nature in all the Panchayaths. Table 12 shows the number and percentage of nuts producing different number of seedlings in different Panchayaths.

In the present investigation, 10.34 per cent nuts produced monoembryonic seedlings whereas 89.66 per cent nuts produced polyembryonic seedlings. It was observed that 39.10 per cent of the nuts produced three seedlings per nut whereas, 31.00 per cent of the nuts produced four seedlings per nut. 2.28 per cent of the nuts produced five seedlings per nut while 1.14 per cent nuts produced even six and seven seedlings per nut.

Table. 12. Number of nuts producing polyembryonic seedlings in different Panchayaths

Number of seedlings	Number of nuts producing different number of seedlings in different Panchayaths								Total nuts (%)
	Kuttiattoor	Kolachhery	Mayyil	Koodali	Munderi	Malappattam	Kunjimangalam		
1	-	-	1	2	1	1	4		10.34
2	3	2	-	3	4	-	1		15.00
3	8	7	4	5	6	2	2		39.10
4	6	4	5	2	6	3	1		31.00
5	-	-	1	1	-	-	-		2.28
6	-	-	-	-	1	-	-		1.14
7	1	-	-	-	-	-	-		1.14



4.9. Biochemical characterization

Biochemical characters considered for the study included total soluble solids, titratable acidity, carotenoids, ascorbic acid and crude fibre. The mean values for these characters are illustrated in the Table 13.

Table 13. Biochemical characters of Kuttiattoor mango cultivar

Sl. No.	Grama Panchayath	Total Soluble Solids (°Brix)	Titratable Acidity (%)	Carotenoids (mg/100g)	Ascorbic acid (mg/100g)	Crude fibre (%)
1	Kuttiattoor	13.60 ^{ab}	0.21	6.40	38.43	3.69 ^{ab}
2	Kolachhery	15.40 ^a	0.15	7.66	44.70	3.48 ^{ab}
3	Mayyil	15.18 ^a	0.14	7.42	50.20	3.68 ^{ab}
4	Koodali	15.16 ^a	0.23	6.52	50.98	4.15 ^{ab}
5	Munderi	14.70 ^a	0.20	6.14	43.92	2.56 ^b
6	Malappattam	12.62 ^b	0.19	4.48	37.65	3.85 ^{ab}
7	Kunjimangalam	14.54 ^a	0.18	6.68	41.57	5.05 ^a
Mean		14.45	0.18	6.47	43.92	3.78
C.D. (0.05)		1.76	NS	NS	NS	1.24

Total soluble solids (TSS) ranged from 12.62 °Brix (Malappattam) to 15.40 °Brix (Kolachhery) with an overall mean of 14.45 °Brix. TSS varied slightly from Panchayath to Panchayath. The TSS of mangoes from Kolachhery, Mayyil, Koodali, Munderi and Kunjimangalam were on par with each other whereas Malappattam showed a slightly less TSS.

Titratable acidity ranged from 0.14 per cent (Kolachhery) to 0.23 per cent (Koodali) with an overall mean of 0.18 per cent. Carotenoids ranged from 4.48

mg/100g (Malappattam) to 7.66 mg/100g (Kolachhery) with an overall mean of 6.47 mg/100g. Ascorbic acid ranged from 37.65 mg/100g (Malappattam) to 50.98 mg/100g (Koodali) with an overall mean of 43.92 mg/100g . Crude fibre ranged from 2.56 per cent (Munderi) to 5.05 per cent (Kunjimangalam) with an overall mean of 3.78 per cent.

4.10. Cluster analysis

To examine the distinctness of Kuttiaattoor mango trees under study from the seven Grama Panchayaths and to find out whether the trees show any evident variation for morphological and biochemical characters from Panchayath to Panchayath, the 55 trees were subjected to cluster analysis. To determine the distinctness of trees within and between the clusters, the inter and intra-cluster distances were estimated. The result of cluster analysis is presented as in dendrogram (Fig. 15)

The cluster analysis grouped 55 trees into two clusters at 65 per cent similarity. The distribution of trees into clusters is given the Table 14. Cluster I and cluster II had 35 and 20 trees, respectively.

Cluster I was constituted by 14 trees from Kuttiaattoor (tree number 1, 2, 6, 7, 8, 10, 11, 13, 14, 17, 19, 20, 23 and 25), all the trees from Munderi, majority of the trees (4 nos.) from Mayyil (tree number 31, 32, 33 and 35), Kunjimangalam (tree number 52, 53, 54 and 55) and Kolachhery (tree number 26, 27, 28 and 29). Two trees each from Koodali and Malappattam were also grouped in cluster I.

Cluster II was constituted by 11 trees (tree number 3, 4, 5, 6, 9, 12, 15, 16, 18, 21 and 22) from Kuttiaattoor, one each from Mayyil (tree number 34) and Kunjimangalam (tree number 51) three trees each from Koodali (tree number 37, 38 and 39) and Malappattam (tree number 46, 48 and 49).

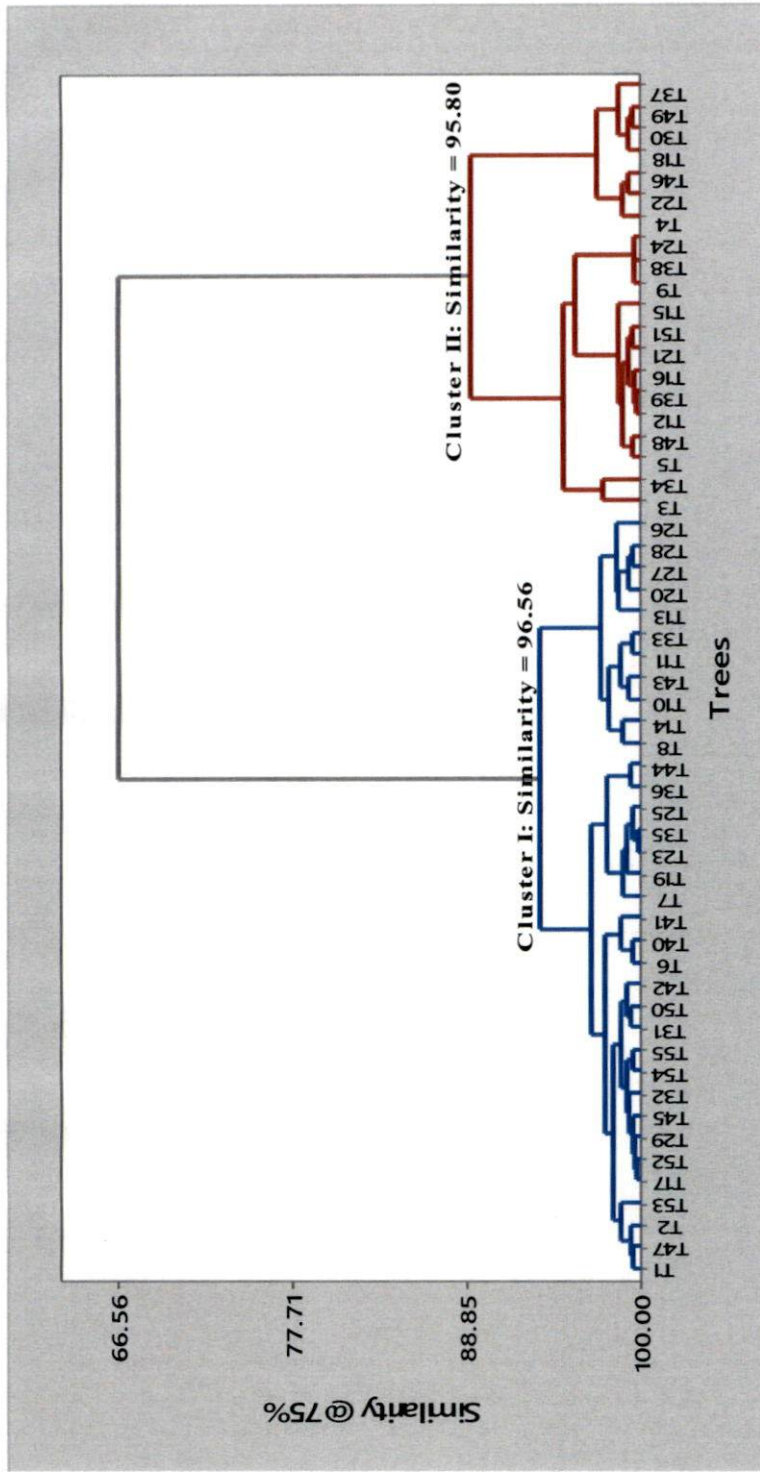


Fig. 15. Dendrogram depicting the distribution of trees in to clusters

Table 14. Distribution of trees in clusters

Clusters	Number of trees in the cluster	Tree Nos.
Cluster I	35	1, 47, 2, 53, 17, 52, 29, 45, 32, 54, 55, 31, 50, 42, 6, 40, 41, 7, 19, 23, 35, 25, 36, 44, 8, 14, 10, 43, 11, 33, 13, 20, 27, 28, 26
Cluster II	20	3, 34, 5, 48, 12, 39, 16, 21, 51, 15, 9, 38, 24, 4, 22, 46, 18, 30, 49, 37

4.10.1. Mean inter and intra-cluster distances

The mean inter-cluster and intra-cluster distance for the two clusters obtained were estimated and is presented in Table 15.

Table 15. Mean inter cluster and intra cluster distances

	Cluster I	Cluster II
Cluster I	14.99	60.49
Cluster II	60.49	18.98

It was observed that the inter-cluster distance between the two clusters was 60.49. The intra-cluster distances for cluster I and cluster II were 14.99 and 18.98, respectively. It was significant to note that the inter-cluster distance was greater than the intra-cluster distance indicating a broader diversity of trees between the clusters than that of the trees within the cluster.

4.10.2. Mean cluster values

The mean values of each character for the two clusters obtained are presented in Table 16.

Table 16. Cluster wise mean value for quantitative characters

Sl. No.	Character	Cluster I	Cluster II
1	Height of mature tree(m)	13.67	16.86
2	Trunk circumference (cm)	125.68	185.90
3	Crown diameter (m)	12.16	15.42
4	Leaf length(cm)	22.11	22.07
5	Leaf width(cm)	6.10	6.17
6	Spacing of secondary veins in leaves (cm)	1.44	1.41
7	Petiole length (cm)	3.79	3.74
8	Inflorescence length (cm)	21.55	21.70
9	Inflorescence diameter (cm)	19.29	19.26
10	Mature fruit length (cm)	8.87	8.96
11	Mature fruit width (cm)	8.14	8.33
12	Density of lenticels	7.20	6.88
13	Size of lenticels(μ m)	136.53	136.13
14	Diameter of stalk attachment (mm)	4.46	4.45
15	Thickness of skin (mm)	1.06	1.04
16	Total soluble solids ($^{\circ}$ Brix)	14.78	13.82
17	Titrateable acidity (%)	0.16	0.19
18	Carotenoids (mg/100g)	6.27	6.00
19	Ascorbic acid (mg/100g)	46.05	42.75
20	Fibre content (%)	3.62	4.21

The mean values of cluster II were slightly higher than cluster I for all the tree characters. The height of mature tree showed a mean value of 16.86 m for cluster II whereas it was 13.67 m for cluster I. When cluster I recorded a mean value of 125.68

cm for trunk circumference, a higher value of 185.90 was recorded for cluster II. Mean values for crown diameter was 12.16 m and 15.42 m for cluster I and cluster II, respectively.

The mean value for leaf length was slightly higher for cluster I (22.11 cm) than cluster II (22.07 cm) whereas, the mean value for leaf width was slightly higher for cluster II (6.17 cm) than cluster I (6.10 cm). The mean value for spacing of secondary veins in leaf was 1.44 cm and 1.41 cm for cluster I and cluster II, respectively. The mean value for petiole length was slightly higher for cluster I (3.79 cm) than cluster II (3.74 cm).

The mean values for inflorescence length were slightly higher for cluster II (21.70 cm) than cluster I (21.55 cm) whereas, the inflorescence diameter was slightly higher for cluster I (19.29 cm) than cluster II (19.26 cm).

The mean values for fruit length as well as fruit width were slightly higher for cluster II (8.96 cm and 8.33 cm, respectively) than that of cluster I (8.87 cm and 8.14 cm, respectively). The mean values for other fruit characters *viz.* density of lenticels, size of lenticels, diameter of stalk attachment and thickness of skin was slightly higher for cluster I (7.20, 136.53 μm , 4.46 mm and 1.06 mm, respectively) than cluster II (6.88, 136.13 μm , 4.45 mm and 1.04 mm, respectively).

Cluster I showed slightly higher mean values for total soluble solids, carotenoids and ascorbic acid (14.789 °Brix, 6.27 mg/100g and 46.05mg/100g respectively) and cluster II showed slightly higher mean values for titratable acidity (0.19 %) and fibre content (4.21 %).

4.11. Pest and diseases

Mango hopper (*Idioscopus* sp.), leaf cutting weevil (*Deporaus marginatus*), mango stone weevil (*Sternochetus mangiferae*), red ant (*Oecophylla smaragdina*) and

fruit fly (*Bactrocera dorsalis*) were the pests noticed during the study. Anthracnose of mango caused by *Colletotrichum gloeosporioides* was also noticed.

Fruit fly traps are recently used by some farmers in Kuttiaattoor to control the fruit fly. It was noticed that farmers are generally not following control measures, especially chemical methods to overcome the pest infestation.

4.12. Site environment

4.12.1. Soil and Topography

Soil characters were analysed based on samples collected from Kuttiaattoor area and the results are provided in Table 17.

Soil pH ranged from 4.47 to 6.51. Electrical conductivity ranged from 0.021 dSm⁻¹ to 0.21 dSm⁻¹. Organic Carbon varied from 0.73 per cent to 2.10 per cent. Available Nitrogen ranged from 837.19 kg/ha to 1315.58 kg/ha. Available Phosphorous ranged from 11.07 kg/ha to 84.16 kg/ha. Available Potassium ranged from 126.5 kg/ha to 618.11 kg/ha.

Table. 17. Soil parameters for Kuttiaattoor area

Sl. No.	Soil parameter	Range
1.	pH	4.47 to 6.51
2.	Electrical conductivity (dSm ⁻¹)	0.021 to 0.21
3.	Organic carbon (%)	0.73 to 2.1
4.	Available Nitrogen (kg/ha)	837.19 to 1315.58
5.	Available Phosphorous (kg/ha)	11.07 to 84.16
6.	Available Potassium (kg/ha)	126.5 to 618.11

Information about site environment (soil and topography) was collected from Soil Survey Officer, Department of Soil Survey and Soil Conservation, Kannur and is given below.

The topography of Kuttiattoor area is rolling to hilly with 2 to 25 per cent slope. The slope aspect is towards West with trees and shrubs as the major type of vegetation. The soil is well drained and is not saline. Soil colour is noted to be yellowish red and reddish brown and the texture is gravely clay loam to gravely clay. Generally, the soil is acidic in nature. Soil erosion is moderate but is high in the hilly areas.

The topography of Kunjimangalam Panchayath is undulating with 2 to 16 per cent slope. The slope aspect is towards West with tropical trees and shrubs as the main vegetation. The soil is well drained. Soil salinity is below 0.2 dSm^{-1} and is acidic. The soil colour is brown and texture is sandy loam.

4.12.2. Climate

The weather data from April 2016 to March 2017 for Kannur district was collected from Pepper Research Station, Panniyur. The monthly mean for rainfall (mm), number of rainy days, relative humidity (%) and temperature ($^{\circ}\text{C}$) are given in Table 18 given below.

The maximum and minimum rainfall was observed in July 2016 (859.7 mm) and February 2017 (nil), respectively. Maximum number of rainy days was in July 2016 (28 days) whereas, it was none in February. The total rainfall received for the period was 2729.4 mm. The relative humidity was maximum in June 2016 (95.53 per cent) and minimum in April 2016 (86.53 per cent). The mean relative humidity was 92.78 per cent. The highest maximum temperature was 40.79°C in March 2017 and the lowest minimum temperature was 21.21°C in January 2017.

Table 18. Monthly mean weather data for Kannur district from April 2016 to March 2017

Month	Rainfall (mm)	No of rainy days	Relative humidity (%)	Temperature	
				Maximum (°C)	Minimum (°C)
April-2016	1.00	1	86.53	39.53	28.03
May-2016	176.40	18	91.96	36.94	26.30
June-2016	768.60	28	95.53	30.52	25.09
July-2016	859.70	26	94.80	32.74	25.13
August-2016	560.50	26	94.58	32.91	24.94
September-2016	172.00	24	93.76	33.59	24.29
October-2016	109.60	10	94.03	35.08	24.01
November-2016	45.50	7	94.13	35.45	24.25
December-2016	17.60	2	93.74	37.52	21.66
January-2017	4.50	2	92.03	38.57	21.21
February-2017	-	-	91.07	39.72	23.02
March-2017	14	2	91.25	40.79	24.23
Mean	227.45	13.66	92.78	36.66	24.34

Discussion

5. DISCUSSION

Characterization of varieties and genotypes of crops is important for protection of bio-wealth of our country (Preethy, 2014). Characterization of available germplasm is very crucial to identify desired traits or genes. Moreover, preservation of germplasm for future utilization in crop improvement needs accurate information (Khan *et al.*, 2015).

A large number of traditional mango cultivars are grown in Kerala and some of these cultivars are grown in homesteads of specific regions only. Muvandan, Puliyan, Chandrakaran, Priyur, Alphonso, Kilichundan, Mundappa, Karpooramanga, Neelum, *etc.* are the popular varieties of mango grown in Kerala (Anila, 2002).

Kuttiattoor mango cultivar is popular in Kuttiattoor and the nearby Grama Panchayaths in Kannur district. It is a traditional mango cultivar found in the area. Each and every homestead in Kuttiattoor has at least one tree of the cultivar. The distinctiveness of Kuttiattoor mango is aided by combination of the specific environmental conditions of areas of its cultivation. Conservation of mango genetic resources needs identification, characterization and evaluation of potential and unique germplasm for their utilization in various mango breeding programmes (Rajwana *et al.*, 2011). The current work attempts to characterize Kuttiattoor mango cultivar of Kannur district grown in Kuttiattoor and nearby Grama Panchayaths and also Kunjimangalam mango, a similar cultivar from Kunjimangalam Grama Panchayath. The map of the study area is provided in Fig. 16.

For obtaining precise and correct data for characterization of the cultivar, trees (raised from seedling) belonging to an age group of 25 to 30 years were selected for the study.

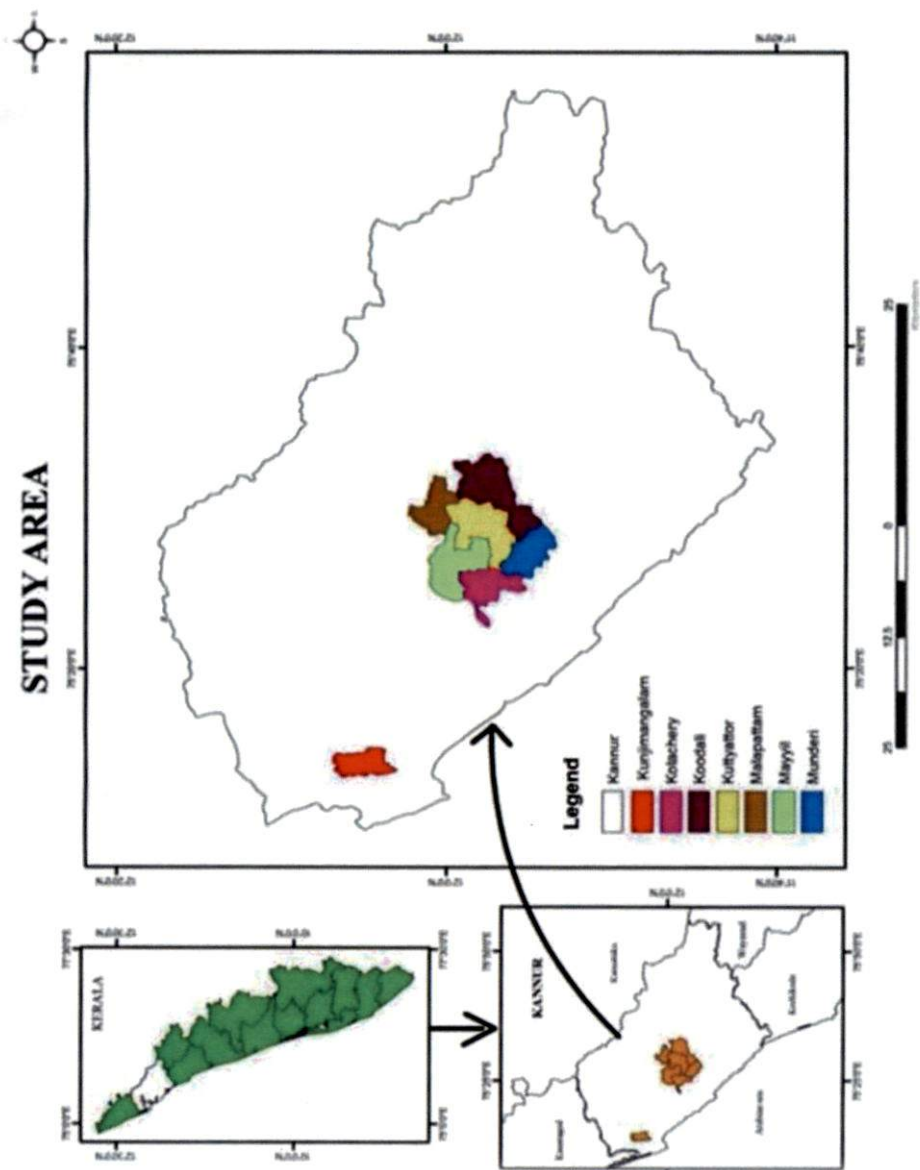


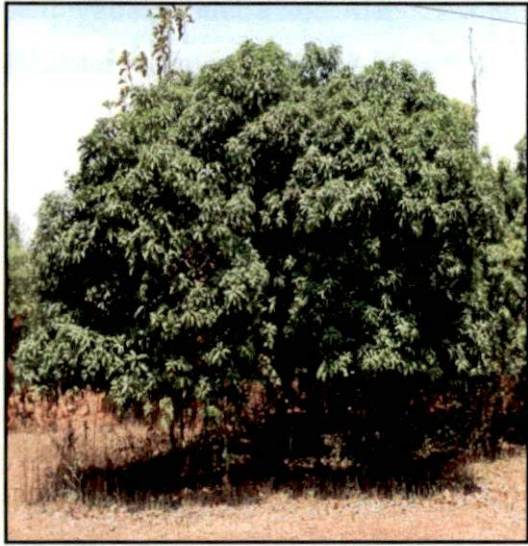
Fig. 16. Map of the study area

5.1. Time of flowering and fruit maturity

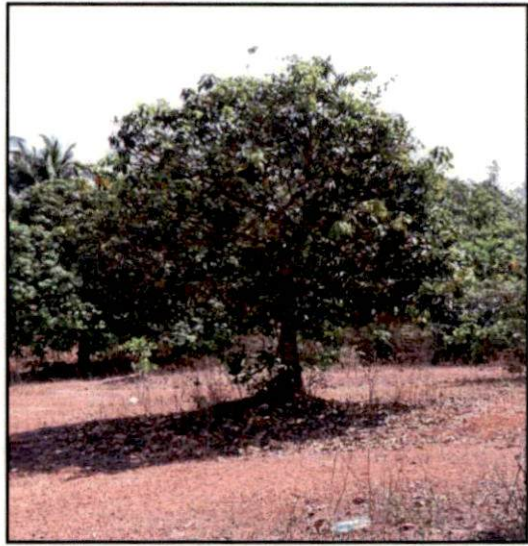
In Kerala, the flowering of mango commences during November-December (Radha and Nair, 2000; Anila, 2002). In the present study when flowering commenced in the second week of November in majority of the Panchayaths, a slight delay was noticed in Kuttiaattoor (third week of November) and Kunjimangalam (fourth week of November). The peak flowering was observed in third and fourth week of December in most of the Panchayaths while in Kunjimangalam Panchayath it was in the second week of January. The time of fruit maturity was during the fourth week of March and first week of April in most of the Panchayaths but in Kunjimangalam, a slight delay (second week of April) was noticed. The small differences in the time of flowering and fruit maturity may be due to the variations in environmental conditions of the areas.

5.2. Tree characters

The tree characters *viz.*, crown shape, tree growth habit, tree height, trunk circumference and crown diameter were considered for the study. Kuttiaattoor cultivar was noted to have an attractive semi-circular crown shape (Plate 1). The crown shape in 73 per cent of the trees was semicircular, while that of 27 per cent was spherical. This difference in crown shape for some trees from the general crown shape (semi-circular) of the cultivar was due to the space limitation the trees suffered. The trees which showed a different crown shape were restricted from expansion of branches either due to other surrounding trees or the nearby buildings like houses or shops. Trees found in open conditions exhibited comparatively lesser height and more spreading nature than the ones growing in backyards surrounded by other trees. A similar observation was made by Jyothi (2000) while studying the traditional pickling varieties of mango found in Thrissur and Palakkad districts of Kerala. Generally all the trees were found to have spreading type of tree growth habit (Plate 2). Radha and Manjula (2000) while studying the characteristics of 12 polyembryonic mango types in northern Kerala, classified the trees according to the tree habit into erect, intermediate and spreading types based on tree habit. Simi (2006) characterized 50 traditional



(A) Semi-circular



(B) Spherical

Plate 1. Crown shape



Plate 2. Tree growth habit

mango types in southern Kerala from the districts of Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha and reported that the trees showed erect (38%), intermediate (30%) and spreading (32%) types of growth habits.

Harikumar and Parameswaran (2016) reported that Pachha Moovandan and Vella Moovandan, two ecotypes of 'Moovandan' cultivar identified from Pazhayannur region of Thrissur district showed spreading type of tree habit.

In the present study, tree height ranged from 13.50 m (Munderi) to 16.10 m (Kuttiattoor) with an overall mean of 14.82 m. All the trees under study were tall. The trees from different Panchayaths including Kunjimangalam did not show significant variation in tree height. Radha and Manjula (2000) reported that in Thrissur and Palakkad districts of Kerala, the tree height ranged from 10 to 35 m, while Simi (2006) reported that it ranged from 4.5 to 30 m in different regions of the state. Harikumar and Parameswaran (2016) reported that height of the 'Moovandan' cultivar in Pazhayannur region showed a variation from 4 to 14 m.

In the present investigation it was observed that the crown diameter ranged from 10.90 m (Munderi) to 15.90 m (Kolachhery) with an overall mean of 13.12 m while the trunk circumference ranged from 120.20 cm (Munderi) to 164.20 cm (Malappattam) with an overall mean of 144.22 cm. The tree characters of Kuttiattoor cultivar was very similar to that of Kunjimangalam cultivar seen in Kunjimangalam Panchayath.

5.3. Leaf characters

Leaf characters are used as key factors in varietal identification. The leaf characters described include intensity of anthocyanin colouration (in young leaves) colour, twisting of leaf blade, leaf base shape, leaf apex shape, petiole attitude in relation to shoot, leaf blade length, leaf blade width, spacing of secondary veins and petiole length in mature leaves.

Leaf of Kuttiattoor cultivar recorded 'medium' intensity of anthocyanin colouration in young leaves. The young leaves were light green in colour with

brownish tinge (Plate 3). The mature leaves exhibited dark green colour, absence of leaf blade twisting (entire leaf margin), obtuse type of leaf base (rarely acute), acuminate type of leaf apex (rarely acute) and perpendicular or horizontal petiole attitude in relation to shoot (Plate 4, 5, 6 and 7). The qualitative leaf characters did not show considerable variation in trees from Panchayath to Panchayath.

Colour of the emerging leaves is a more constant character not subject to variation under the diverse conditions of mango culture (Gangolly, 1957). Davenport and Nunez-Elizea (1977) reported that in majority of the mango varieties, the newly emerging vegetative shoots were green in colour, but some cultivars also showed colours like bronze, red or shades of red. Simi (2006) reported that lanceolate leaf shape, acuminate leaf tip and light green with brown tinge colour of young flush were principal features of traditional mango types of Southern Kerala. A similar observation was made by Harikumar (2016) who studied the traditional mango cultivars found in Pazhayannur region of Kerala.

Harikumar and Parameshwaran (2016) after studying the five ecotypes of 'Moovandan' viz., Enna Moovandan, Cheriya Moovandan, Ezhikode Moovandan, Vella Moovandan and Pachha Moovandan found in Pazhayannur region reported that horizontal leaf orientation, acuminate type of leaf tip and entire leaf margin were the typical qualitative leaf characters of the cultivar. All ecotypes except Pachha Moovandan showed acute type of leaf base while Pachha Moovandan showed obtuse type of leaf base. The leaf characters of Kuttiattoor cultivar recorded in the present study revealed a similarity to the leaf characters of 'Moovandan', as recorded in the above study.

The mean leaf length, mean leaf width and petiole length observed for the cultivar were 22.04 cm, 6.16 cm and 3.80 cm, respectively. Litz (2009) reported that the leaf morphology varied highly depending upon the cultivar. Simi (2006) reported that in the traditional cultivars of mango found in southern Kerala, the leaf length and width ranged from 13.65 cm to 31.08 cm and 3.42 to 7.77 cm, respectively. The petiole length ranged from 1.8 cm to 11.9 cm in different



Plate 3. Anthocyanin colouration in young leaves



(A) Absent



(B) Twisted towards the apex

Plate 4. Twisting of leaf margin



(A) Acuminate



(B) Acute

Plate 5. Shape of leaf apex



(A) Obtuse



(B) Acute

Plate 6. Shape of leaf base



Plate 7. Petiole attitude in relation to shoot

cultivars. Harikumar (2016) while characterizing the mango landraces found in Pazhayannur region of Thrissur district observed that the leaf length of the different landraces varied from 18.95 cm to 36.50 cm and the leaf width ranged from 3.80 cm to 8.10 cm. Harikumar and Parameshwaran (2016) reported that in 'Moovandan' cultivar, the mean leaf length and width were 26.6 cm and 4.98 cm respectively.

5.4. Inflorescence characters

The inflorescence samples collected were terminal panicles from exposed regions of the tree and three characters viz., anthocyanin colouration of the inflorescence, inflorescence length and inflorescence diameter were observed.

The anthocyanin colouration was absent or weak in the inflorescence collected from all Panchayaths including Kunjimangalam. Mostly floral axis and branches were pale green in colour and very rarely a slight pink tinge was observed (Plate 8). Jyothi (2000) reported that the pickling varieties of mango found in Palakkad district of Kerala produced green coloured inflorescence axis. The colour of rachis of Banganappilly and Vellaikolumban was light green while that of Muvandan was dark red (Renisha, 2012). It was light red in Neelum and Alphonso.

The mean inflorescence length of the cultivar showed slight variation from Panchayath to Panchayath (Fig. 17). It ranged from 20.05 cm in trees of Mayyil Panchayath to 23.95 cm in trees of Kunjimangalam Panchayath. The overall mean for inflorescence length was 22.13 cm. The mean values of inflorescence diameter also differed slightly across the Panchayaths similar to that of the inflorescence length (Fig. 17). It ranged from 17.80 cm in trees of Kolachhery to 20.54 cm in trees of Kuttiattoor with an overall mean of 19.54 cm. The ratio obtained by dividing the inflorescence length by inflorescence diameter did not vary significantly across the Panchayaths or in other words it could be assumed that the inflorescence shape was similar in all Panchayaths. The inflorescence shape was observed to be mostly broadly pyramidal (Plate 9).

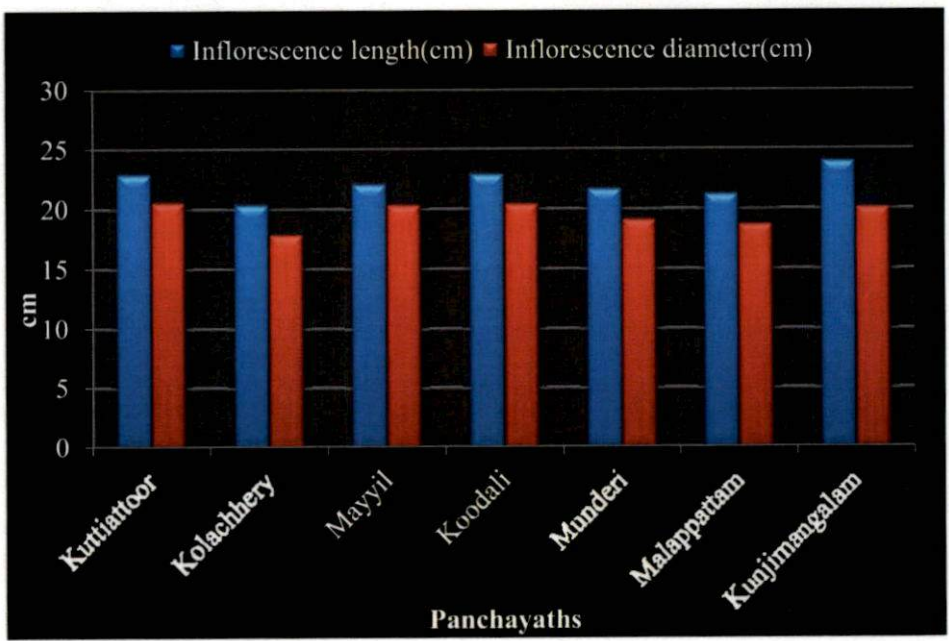


Fig. 17. Variation in inflorescence length and diameter in Kuttiaattoor mango across the Panchayaths

Chadha and Pal (1986) reported that a large variation could be observed in length of the inflorescence, from few centimeters to 60 cm. Jyothi (2000) reported that the inflorescence length ranged from 11.60 cm to 38.60 cm and the breadth ranged from 12.60 cm to 36.90 cm in the pickle varieties of mango available in Thrissur and Palakkad districts.

In mango, panicles with leafy bracts were reported by Bana *et al.* (1976). In the current study, inflorescence with leafy bracts was observed at random (Plate 10). Davenport and Nunez-Elisea (1997) reported that leafy bracts could emerge in the inflorescence under weak floral induction conditions.

5.5. Mature fruit characters

The mature fruit characters for the cultivar studied showed broad elliptic shape in cross section. Green colour of skin, medium colour contrast between lenticels and skin, absence of roughness of surface caused by lenticels, medium depth of stalk cavity, rounded outward shape of dorsal shoulder, rounded upward shape of ventral shoulder, absence of neck, absence of bulging on ventral shoulder, absence of sinus and absence of bulging of proximal stylar scar were the other characters recorded for mature fruits (Plate 11 and 12). The qualitative characters did not vary across the Panchayaths under study. In other words, the mature fruit characters of the cultivar from Kunjimangalam Panchayath were very similar to that from all other Panchayaths.

Among the fruit characters, Naik and Gangolly (1950) found the shape of the fruit including the presence or absence of the beak as the most important. Fruit size, presence of beak, sinus and cavity of stalk insertion are the characters that were significant while assessing the variability in mango germplasm (Ram and Rajan, 2003).

Simi (2006) characterized traditional mango varieties of southern Kerala and observed four types of fruit shape *viz.*, round, oblong, ellipsoid and oblong ellipsoid among which round was the prominent one. She also reported that round



(A) Pale green



(B) Slight pink tinge

Plate 8. Anthocyanin colouration



Plate 9. Inflorescence

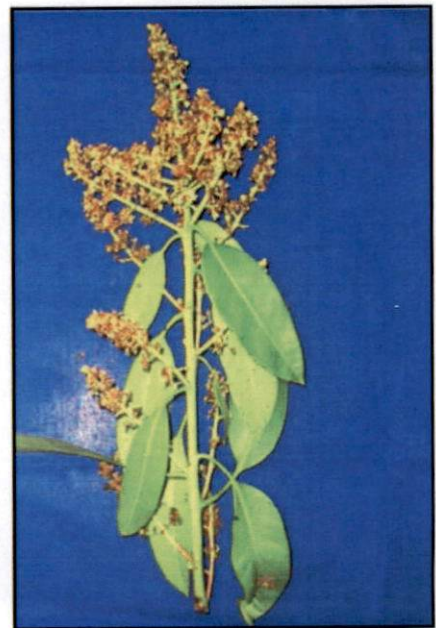


Plate 10. Inflorescence with leafy bracts

shape of fruit, absence of sinus, rising and then rounded slope of shoulders, smooth surface texture of skin and absence of neck were the predominant mature fruit characters observed in the various traditional cultivars of mango found in southern Kerala. It was very interesting to note that quite similar results were also obtained by Harikumar (2016) while characterizing traditional landraces of mango in Thrissur and Palakkad districts.

According to Jyothi *et al.* (2009) majority of the pickling type of mango cultivars found in Thrissur and Palakkad showed round and oblong fruit shape, smooth skin and green colour of mature fruit skin. Harikumar and Parameshwaran (2016) reported that Paccha Moovanadan and Ezhikode Moovandan showed a green colour for mature fruit, Enna Moovandan showed a yellow colour of peel whereas Vella Moovandan and Cheriya Moovandan showed greenish yellow colour of peel. They also reported absence of sinus in all the six Moovandan ecotypes.

The biometrical characters studied for mature fruits include fruit length, fruit width, ratio, density of lenticels, size of lenticels and diameter of stalk attachment. The fruit length ranged from 8.78 cm (Munderi) to 9.18 cm (Malappattam) with an overall mean of 8.94 cm. The fruit width ranged from 8.11 cm (Kolachhery) to 8.30 cm (Malappattam) with an overall mean of 8.21 cm. The ratio obtained by dividing the fruit length by fruit width ranged from 1.07 to 1.10 with an overall mean of 1.08. The fruit length and fruit width values were close to each other suggesting that the shape of the fruit is roundish. The density of lenticels ranged from 6.36/cm² (Malappattam) to 7.60/cm² (Munderi) with an overall mean value of 6.90/cm². The size of lenticels ranged from 134.78 µm in Koodali to 137.28 µm in Munderi with an overall mean of 136.20 µm. Diameter of stalk attachment ranged from 4.27 mm (Kolachhery) to 4.68 mm (Kunjimagalam) with an overall mean of 4.46 mm. Fruit length, fruit width, ratio and size of lenticels did not vary significantly in fruits from Panchayath to Panchayath including Kunjimangalam. Density of lenticels and diameter of stalk attachment varied slightly in fruits across the Panchayaths.

An evaluation of physical, morphological and biochemical characters of four varieties (Alphonso, Prior, Muvandan and Neelum) and two hybrids Ratna (Neelum x Alphonso) and H-151 (Kalapady x Neelum) of mango were made under Kerala conditions by Anila and Radha (2003) and they reported that the fruit length ranged from 8.50 cm to 10.50 cm and width ranged from 5.60 cm to 8.50 cm. Simi (2006) reported that the fruit length and width ranged from 4.4 cm to 18.1 cm and 3.9 cm to 12 cm, respectively. Navprem *et al.* (2011) characterized nine sucking mango genotypes in the sub tropics of Punjab and reported that the length and width of fruits ranged from 4.63 to 12.52 cm and 3.83 to 7.77 cm, respectively and the length to breadth ratio ranged from 1.02 to 1.84. Harikumar and Parameshwaran (2016) reported that fruit length and width ranged from 6.80 cm to 12.74 cm and 6.20 cm to 8.05 cm, respectively in different ecotypes of Moovandan.

5.6. Ripe fruit characters

Predominant colour of skin, speckling of skin, thickness of skin, adherence of skin to flesh, main colour of flesh, firmness of flesh, juiciness, texture of flesh, amount of fibre attached to stone, amount of fibre attached to skin and turpentine flavor were the ripe fruit characters considered for the study.

The predominant colour of skin of ripe fruits was yellow-orange and main colour of flesh was medium orange in fruits from all the Panchayaths including Kunjimangalam Panchayath (Plate 13 and 14). Speckling of skin was absent. Adherence of skin to flesh, firmness of flesh, juiciness, texture of flesh, amount of fibre attached to stone and amount of fibre attached to skin were recorded as 'medium' in fruits from all Panchayaths including Kunjimangalam. The thickness of skin ranged from 1.02 mm (Kuttiattoor) to 1.09 mm (Kunjimangalam) with an overall mean of 1.06 mm and did not show a significant variation across the Panchayaths.

Jyothi (2000) reported that rarely yellowish, reddish and green with red blotches were the skin colour of ripe fruit noted in the varieties. However, in the



Plate 11. Mature fruit



Plate 12. Shape in cross section



Plate 13. Colour of skin



Plate 14. Colour of flesh

present study, the skin colour was uniformly medium orange in the mangoes collected from all the Panchayaths without any blemishes or patches.

Roshan *et al.* (2007) reported that Moovandan showed roundish fruit shape, medium skin thickness, juicy flesh texture, smooth skin texture, presence of adherence of pulp to skin and absence of sinus.

Riberio *et al.* (2013) reported dark orange colour of fruit pulp in Amrapali. Navprem *et al.* (2012) reported that flesh colour in mango ranged from yellow to orange. Harikumar (2016) observed light yellow, yellow, yellow orange, light orange, dark orange and greenish yellow pulp colour. When Enna Moovandan, Vella Moovandan and Ezhikode Moovandan showed yellow orange colour of pulp, Cheriya Moovandan and Pachha Moovandan displayed yellow colour of pulp.

Anila and Radha (2003) reported soft flesh texture for Alphonso and Ratna varieties, firm texture for Priyur, Neelum and H-151 and juicy texture for Moovandan. They also reported the presence of adherence of skin to flesh in Alphonso, Priyur, Neelan, Moovandan and H-151, and absence of adherence in Ratna.

Harikumar (2016) reported that the peel thickness in different landraces of mango found in Pazhayannur ranged from 0.55 mm to 4.05 mm. Harikumar and Parameshwaran (2016) reported that the peel thickness in different ecotypes of Moovandan ranged from 1.4 mm to 3.10 mm.

5.7. Seed and stone characters

Emergence of multiple seedlings from a single seed or the presence of several embryos in single ovule is referred to as polyembryony. Mango cultivars are classified into two groups: monembryonic type or Indian type and polyembryonic type or Indo-Chinese type. In India, majority of the cultivated types are monoembryonic.

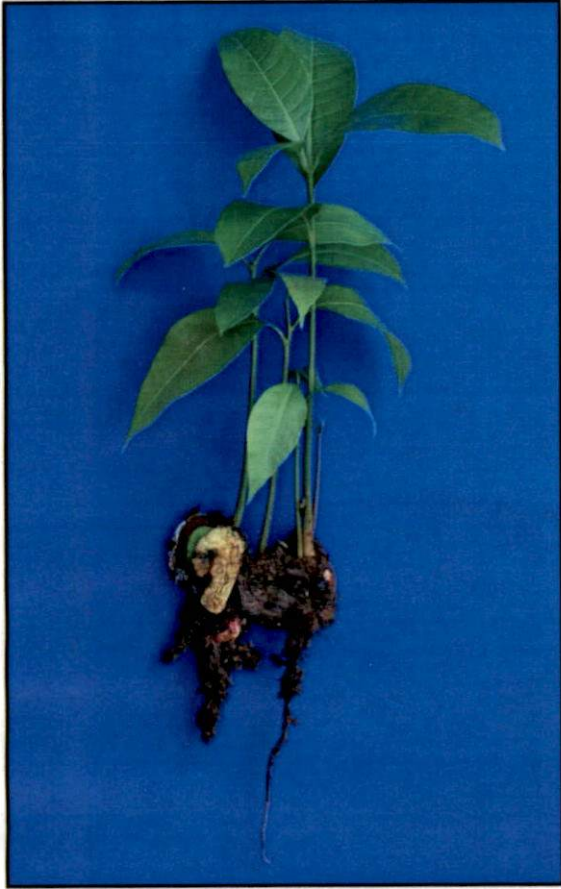
The plants developing from the vegetative or the nucellar embryos are clone of the mother plant, regardless of the pollen parent genotype. Cultivation of polyembryonic varieties is confined to the west coast adjacent to the Western Ghats. The polyembryonic types might have been introduced from other parts of Southeast Asia and are unlikely to have originated from India (Shukla *et al.*, 2004).

Kuttiattoor mango showed high level of polyembryony (89.66 per cent) nature in fruits from all the Panchayaths including Kunjimangalam (Plate 15). The percentage distribution of polyembryonic seedlings produced from a single nut is depicted in Fig. 18. It was observed that 39.10 per cent of the nuts produced three seedlings per nut whereas 31.00 per cent produced four seedlings per nut. 2.28 per cent of the nuts produced five seedlings per nut. It was interesting to note even six and seven seedlings per nut in 1.14 per cent nuts. 10.34 per cent nuts produced one seedling per nut. The relief of stone surface was observed to be ridged and seed was reniform in shape in mangoes from all Panchayaths (Plate 16 and 17).

5.8. Biochemical characterization

During ripening, the conversion of starch, acids and other insoluble substances into soluble form takes place resulting in sweetness of fruits. Biochemical characters considered for the study included total soluble solids, titratable acidity, carotenoids, ascorbic acid and crude fibre.

In the present study the TSS ranged from 12.62 to 15.40 °brix with an overall mean of 14.45 °brix. It varied slightly across the Panchayaths (Fig. 19). In mango, sugar concentrations are reported as total soluble solids content (Kapse *et al.*, 1988). Simi (2006) reported that TSS gives rough idea of sweetness of fruits. TSS determines the quality of juice and other canned products in mango (Bhuyan and Kobra, 2007). Kamiloglu (2011) reported that TSS of fruits is a major quality parameter, which is correlated to the texture and composition. Ellong *et al.* (2015) reported that palatability is more in ripe fruits because of the more sweetness and



(A) Polyembryony



(B) Monoembryony

Plate 15. Seed Embryony

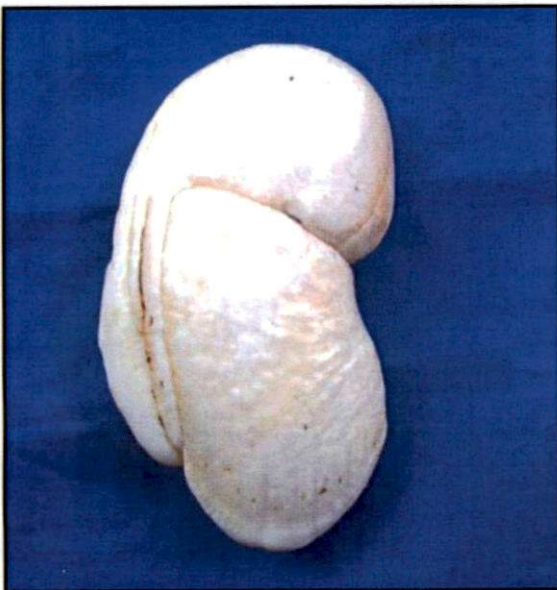


Plate 16. Seed shape



Plate 17. Stone surface relief

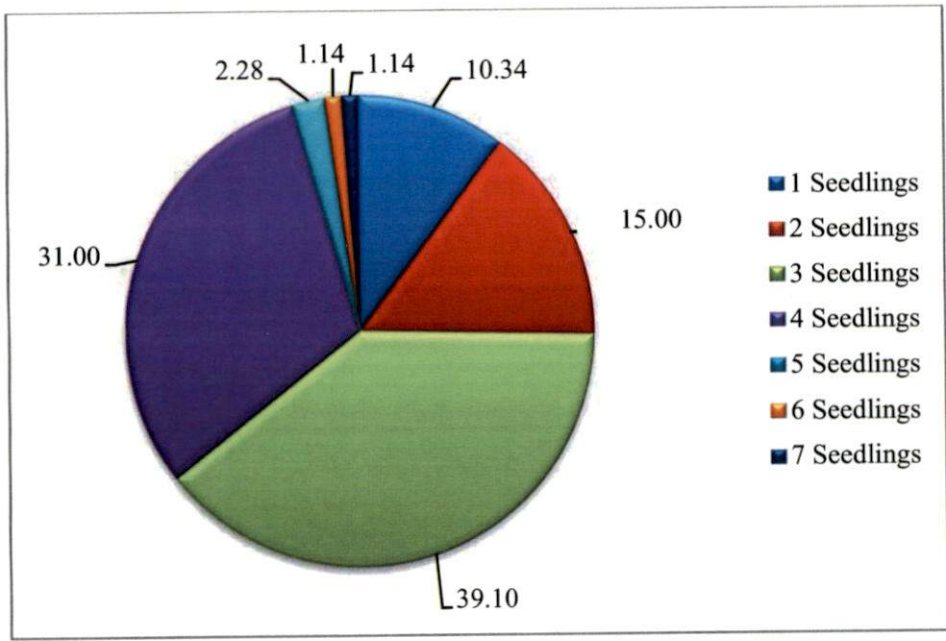


Fig. 18. Percentage distribution of polyembryonic seedlings

less acidity. They also reported that nutritional quality of the mango can be assessed from the fibre content, Vitamin C and carotenoids.

Satyavati *et al.* (1972) reported that TSS of ripe fruits of local varieties of Kerala ranged between 10 and 24⁰ brix. Pradeepkumar *et al.* (2006) reported that TSS of the 31 north Kerala mango genotypes ranged between 12.7⁰ brix and 25.20⁰ brix. Simi and Rajmohan (2013) reported that the TSS for traditional dual purpose mango varieties of Souther Kerala ranged from 12.18 to 20.66⁰ brix.

Roshan (2007) reported TSS of 15⁰ brix for Moovandan. Harikumar and Parameshwaran (2016) reported that TSS ranged between 10.60⁰ brix to 13.3⁰ brix in the five ecotypes of Moovandan. Kuttiattoor mango cultivar expressed similarity to TSS observed in Moovandan.

Titrateable acidity ranged from 0.14 per cent to 0.23 per cent with an overall mean of 0.18 per cent. Satyavati *et al.* (1972) reported that acidity ranged from 0.20 per cent to 0.48 per cent in local varieties of mango in Kerala. Pradeepkumar *et al.* (2006) reported acidity of 0.21 per cent and 0.28 per cent in 'Chinnarasam' and 'Himayuddin' varieties respectively grown in Northern Kerala. Harikumar and Parameshwaran (2016) reported that in ecotypes of Moovandan, titrateable acidity ranged from 0.23 per cent to 0.25 per cent. Simi and Rajmohan (2013) evaluated biochemical properties of traditional mango varieties of Southern Kerala and reported that varieties Nedungolan, Perakka manga, Chadayamangalam Local, Natumav Type-3, Mylapore manga, Kundara manga, and Cheriya Kilichundan are to be designated as varieties with lower acidity (< 0.19%). Hence it could be assumed that Kuttiattor mango is less acidic.

Mango fruit is an important source of Vitamin C (Manay and Shadaksharaswamy, 1995). Ascorbic acid gives the amount of vitamin C and in the present study, it ranged from 37.65 mg/100g to 50.98 mg/100g. Pradeepkumar *et al.*, (2006) reported an ascorbic acid content of 45.2 mg/100g in Banganappally, 33.9 mg/100g in Bangalora, 136.9 mg/100g in Gomanga, 41.8 mg/100g in Himayuddin x Kalapady, 45.5 mg/100g in Phirangiladuva and 28.5 mg/100g in

Mundappa. Simi and Rajmohan (2013) reported that traditional mango varieties with a high ascorbic acid content were, Chadayamangalam Local, Kalluketty, Kandiyoor Local, Vellayani Local, Thali manga, Mavelikkara Local and Kizhakkan Thali (>57.14mg/100g). They also reported that the average ascorbic acid in the traditional dual type mango varieties in Kerala was 32.76 mg/100g (range 12.31-71.43 mg/100g). Satyavati *et al.* (1972) reported that the ascorbic acid ranged from 19.84 to 54.72 mg/100g of fruits in local mango varieties of Kerala.

Mango is an excellent source of carotenoids among fruits. Yellow-orange flesh colour contributes more than just a beautiful hue to mango. The pigments that make up this colourful fruit, carotenoids, are known for their antioxidant qualities. Antioxidants help to repair damage to the body caused by free radicals, which can contribute to a range of health problems including cancer, diabetes and heart disease, just to name a few. Yahia *et al.* (2006) reported that carotenoids in fruits and vegetables are excellent sources for antioxidants and vitamin A. In the current study, carotenoids ranged from 4.48 to 7.66 mg/100g. Simi and Rajmohan (2013) reported the highest carotenoid content in Karpoora Varikka (7.97 mg/100g) and also reported that Perakka manga (3.84 mg/100g), Kolambi (2.69 mg/100g), Velutha Muvandan (2.65 mg/100g) and Manacaud Local-2 (2.00 mg/100g) were rich in carotenoid content. The mean carotenoid content of Kuttiattoor mango was 6.47 mg/100g indicating that it is an excellent source of carotenoids when compared with many traditional mango varieties of Kerala.

Crude fibre in Kuttiattoor cultivar ranged from 2.56 per cent to 5.05 per cent and it varied slightly across the Panchayaths (Fig. 20). Wide variation in crude fibre for mango was reported by Satyavati *et al.* (1972) and Srivastava *et al.* (1987). Radha and Nair (1998) reported that crude fibre showed wide variation ranging from 4.40 per cent to 13.90 per cent with an average of 8.76 per cent. The overall mean of crude fibre for Kuttiattoor cultivar is 3.78 per cent which was slightly higher than that reported for the traditional table varieties of mango in Southern Kerala by Simi and Rajmohan (2001).

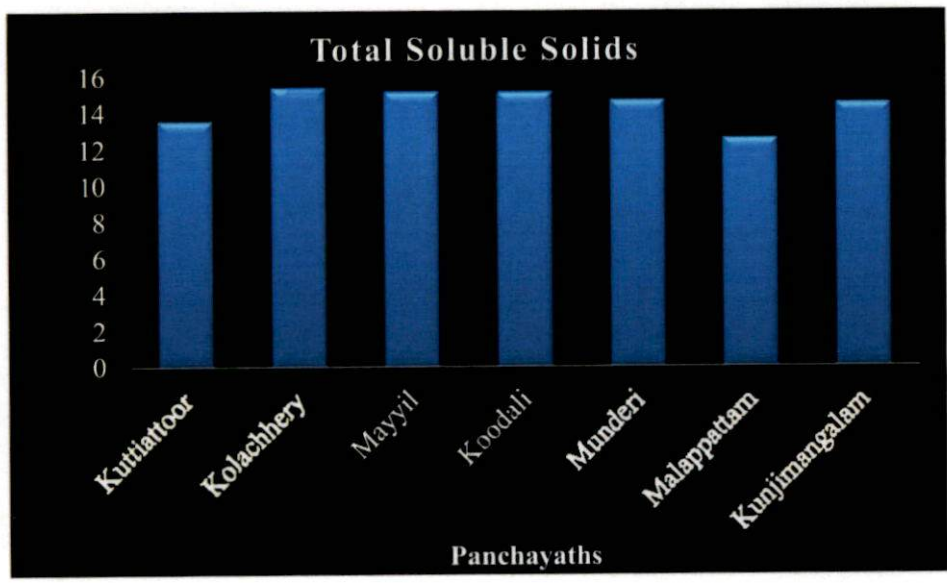


Fig. 19. Variation in total soluble solids in Kuttiattoor mango across the Panchayaths

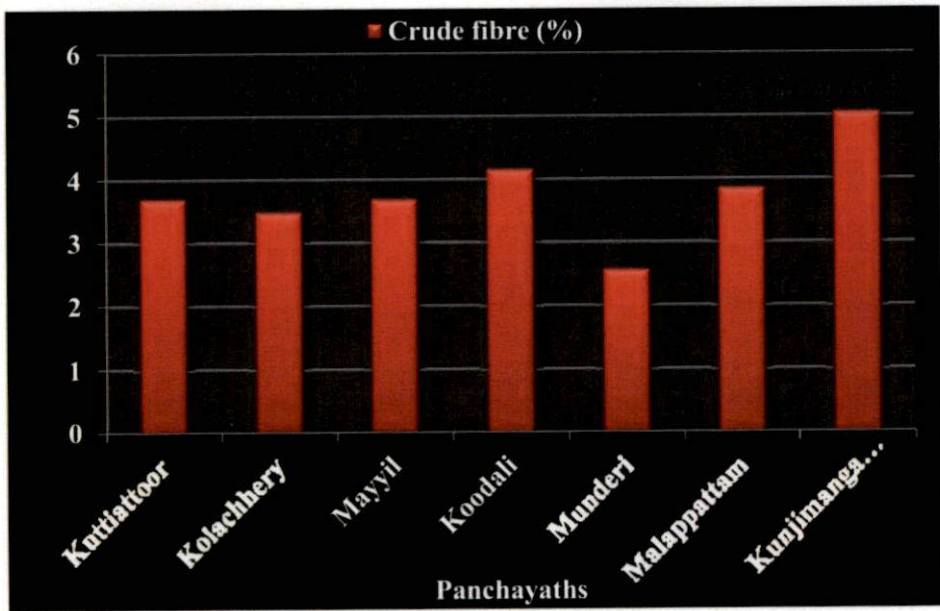


Fig. 20. Variation in crude fibre in Kuttiattoor mango across the Panchayaths

5.9. Cluster analysis

“Cluster analysis” refers to a group of multivariate techniques whose primary purpose is to group individuals or objects based on the characteristics they possess, so that individuals with similar descriptions are mathematically gathered into the same cluster. In the present investigation, cluster analysis was performed based on morphological and biochemical parameters.

Two clusters were obtained after performing the cluster analysis at 65 per cent similarity with Cluster I and Cluster II having 35 and 20 trees, respectively. It was observed that trees from same Panchayath were distributed to different clusters. It was noted that 14 trees from Kuttiattoor Panchayath were grouped in Cluster I whereas another 11 trees were grouped in Cluster II indicating variability for quantitative characters studied within the Panchayath. All the trees from Munderi were grouped in Cluster I indicating their close similarity with each other. Four out of five trees each from Mayyil and Kunjimangalam were grouped in Cluster I. From this it could be assumed that the trees identified from Kunjimangalam had close similarity to the trees of Kuttiattoor and nearby Panchayaths identified for the study. Two trees each from Koodali and Malappattam were in Cluster I whereas three each were grouped in Cluster II. This suggested that trees from Koodali and Malappattam showed a variability with respect to the quantitative characters than trees from other Panchayaths. It was interesting to note that Cluster II showed a slightly higher fruit length and width which could lead to higher fruit size. Majority of trees from Malappattam and Koodali were in Cluster II.

Cluster II which gave higher fruit size gave lesser values for majority of the biochemical characters like TSS, carotenoids and ascorbic acid. The reason for this might be the higher fruit size in cluster II and the inverse proportionality of these biochemical factors with fruit size. Fibre content was slightly more in Cluster II.

5.10. History and Indigenous Traditional Knowledge

The history and traditional knowledge related to Kuttiattoor mango, collected during study is provided below.

According to the oral literature prevalent in the area it is believed that, nearly 300 years back, the seedlings of Kuttiattoor mavu reached 'Chaathoth Tharavadu' of Kuttiattoor all the way from 'Allada swaroopam' or the 'Neeleshwaram royal family' of Neeleshwaram in Kasargode district. The people of Chathoth Tharavadu belonged to the Nambiar community. Later the cultivar found its way to other homesteads of Kuttiattoor area.

History also tells that, a mango seller reached the 'Irikkur' local market with the mango fruits harvested from the Nambiar Tharavadu and that mango got a wide acceptability in the market. When asked about the name of the mango, since it was harvested from 'Nambiar Tharavadu', the mango trader named it as 'Nambiar manga' or Nambiar mango. Eventually, the mango became popular as 'Nambiar manga'. In later years the number of trees in Kuttiattoor increased tremendously with the joint efforts of the localities and Grama Panchayath. It will not be an exaggeration to call Kuttiattoor as 'mango village' of Kannur given the quantity of Kuttiattoor mango produced there. At present in Kannur district, the mango of this particular cultivar is popularly known and marketed as 'Kuttiattoor' mango.

Kuttiattoor mango tree is a common sight in every homesteads, schools, public institutions and roadsides of Kuttiattoor village. The mango trees with large number of mangoes on them are a visual treat for anyone visiting Kuttiattoor during the months of March and April and May. A few trees which are believed to be 100 to 125 years can still be seen in Kuttiattoor today. Unfortunately, the very old Kuttiattoor mango tree (150-200 years old) which was the pride possession of

‘Chaathoth Tharavadu’ in Kuttiaattoor, lovingly called by the local people as ‘Muthassimavu’, was cut down almost 20 years back.

Mango is a fruit crop which is integral part of the traditional Kerala culture. The close association of the localities with the cultivar in their day to day is evident from the various local rhymes, games and traditional culinary preparations prevalent in the region. The young branches and ripe leaves were used for brushing teeth in olden days. The tender mangoes are used for making tender mango pickle. In olden days, the mashed mango seed was used to make sweet dishes like *Payasam* and *Appam*. ‘*Maangakkachu*’, made out of the sun dried pulp of mango, was popular in the area years back. It is very similar to the mango bar available in markets now a days. Another culinary preparation popular in the area is ‘*Mangapperakku*’ made by mixing the ripe mango pieces with ground mustard, salt and dried whole red chilli. Unripe mango is added in fish curry also. The traditional method of ripening is by keeping the mangoes in cardboard boxes or sacks with the leaves of *Kanjiram* (*Strychnos nux*), dried grass and hay. The harvesting of mature mangoes from the tall trees at correct maturity without falling down on the ground poses big problem before the villagers.

The local Panchayaths, Krishi Vigyan Kendra and local people are taking efforts to conserve and promote this unique cultivar of the area. The local people had requested Kerala Agricultural University to make study for the characterization of this unique cultivar for registration of it as Geographical Indication. The present study had brought out the unique characters of the cultivar including morphological and biochemical characters which are necessary for the registration of this cultivar as a geographical indication. In August 2016, ‘Kuttiaattoor Mango Producer Company Limited’ was formed and registered under the Companies Act, 2013 with the aim of production, harvesting, procurement, grading, pooling, handling, marketing and selling of the Kuttiaattoor mangoes.

Summary

6. SUMMARY

The present investigation was to characterize Kuttiaattoor mango cultivar found in Kuttiaattoor and nearby Grama Panchayaths of Kannur district, Kerala. The nearby Panchayaths selected for the study were Kuttiaattoor, Kolachhery, Mayyil, Koodali, Munderi, Malappattam and Kunjimangalam. Trees, raised from seedlings, belonging to an age of 20 to 30 years were identified and selected for the study based on a preliminary survey. The trees were characterized based on morphological and biochemical characters. The salient findings of the study are presented below.

1. The flowering in Kuttiaattoor cultivar is from November – January. The fruits become ready to harvest by March and the harvesting continues till the end of May.
2. Crown shape of 73 per cent of trees of the cultivar was semi-circular and that of 27 per cent were spherical. All of the trees exhibited spreading type of tree growth habit. Tree height ranged from 13.50 m to 16.10 m with an overall mean of 14.82 m. Trunk circumference ranged from 129.00 cm to 164.20 cm with an overall mean of 144.22 cm. The crown diameter ranged from 10.90 m to 15.90 with an overall mean of 13.12 m. The quantitative tree characters did not vary significantly in trees from the different Panchayaths.
3. Kuttiaattoor cultivar showed medium intensity of anthocyanin colouration in young leaves. The colour of young leaves was light green with brownish tinge. Mature leaves were dark green in colour without leaf blade twisting. Leaf base was obtuse (rarely acute) and leaf tip was acuminate (rarely acute). The petiole attitude in relation to shoot was perpendicular. The leaf characters except petiole length did not show significant variation from Panchayath to Panchayath including Kunjimangalam.
4. Leaf blade length ranged from 21.83 cm to 22.46 cm with an overall mean of 22.04 cm. Leaf blade width ranged from 6.08 cm to 6.33 cm with an

overall mean of 6.16 cm. The ratio ranged from 3.54 to 3.59 with an overall mean of 3.57. The spacing of secondary veins in leaf blade ranged from 1.31 cm to 1.49 cm with an overall mean of 1.42 cm. The petiole length ranged from 3.39 cm to 4.02 with an overall mean of 3.80 cm. Petiole length varied slightly across the Panchayaths.

5. The anthocyanin colouration of the inflorescence was absent or weak uniformly in trees of all the Panchayaths. Mostly floral axis and branches were pale green in colour and very rarely a slight pink tinge was observed. The inflorescence length ranged from 20.33 cm to 23.95 cm with an overall mean of 22.13 cm. The inflorescence diameter ranged from 17.80 cm to 20.54 cm with an overall mean of 19.54 cm. The inflorescence length and diameter varied slightly across the Panchayaths. The ratio of inflorescence length to diameter ranged from 1.08 to 1.19 with an overall mean of 1.12.
6. Observations on mature fruit characters of the cultivar revealed broad elliptic shape in cross section, green colour of skin, medium colour contrast between lenticels and skin, absence of roughness of surface, medium depth of stalk cavity, rounded outward shape of dorsal shoulder, rounded upward type of ventral shoulder, absence of neck, absence of bulging on ventral shoulder, absence of sinus and absence of bulging of proximal stylar scar. The qualitative characters did not vary in fruits across the Panchayaths including Kunjimangalam.
7. The fruit length ranged from 8.78 cm to 9.18 cm with an overall mean of 8.94 cm. The fruit width ranged from 8.11 cm to 8.30 cm with an overall mean of 8.21 cm. The ratio obtained by dividing the fruit length by fruit width ranged from 1.07 to 1.10 with an overall mean of 1.08. The fruits were round in shape. The density of lenticels ranged from 6.36/cm² to 7.60/cm² with an overall mean value of 6.90/cm². The size of lenticels ranged from 134.78 µm to 137.28 µm with an overall mean of 136.20 µm. Diameter of stalk attachment ranged from 4.27 mm to 4.68 mm with an overall mean of 4.46 mm. Two quantitative characters viz., density of

- lenticels and diameter of stalk attachment varied slightly in fruits across the Panchayaths.
8. The colour of skin of ripe fruits was yellow-orange and main colour of flesh was medium orange in all the Grama Panchayaths. Speckling of skin was absent. The characters *viz.*, adherence of skin to flesh, firmness of flesh, juiciness, texture of flesh, amount of fibre attached to stone and amount of fibre attached to skin were recorded as 'medium' in fruits from all the Panchayaths including Kunjimangalam. The thickness of skin ranged from 1.02 mm to 1.09 mm with an overall mean of 1.06 mm.
 9. The relief of stone surface was ridged and the seed shape was reniform. The cultivar was polyembryonic. 89.66 per cent of the nuts exhibited polyembryony whereas, 10.34 per cent exhibited monoembryony.
 10. Biochemical characterization revealed that TSS ranged from 12.62 °Brix to 15.40 °Brix with an overall mean of 14.45 °Brix. TSS was very similar to that obtained for Muvandan in earlier studies. Titratable acidity ranged from 0.14 per cent to 0.21 per cent with an overall mean of 0.18 per cent. Carotenoids ranged from 4.48 mg/100g to 7.66 mg/100g with an overall mean of 6.47 mg/100g. Ascorbic acid ranged from 37.65 mg/100g to 50.98 mg/100g with an overall mean of 43.92 mg/100g. Crude fibre ranged from 2.56 per cent to 5.05 per cent with an overall mean of 3.78 per cent. TSS and crude fibre showed slight variation across the Panchayaths.
 11. The cluster analysis grouped 55 trees into two clusters. It was observed that trees from same Panchayath were distributed to both the clusters. Fourteen trees from Kuttiaattoor Panchayath were distributed in Cluster I whereas, 11 trees were distributed in Cluster II. All the trees from Munderi were distributed in Cluster I indicating a close similarity with each other. Majority (four out of five trees) from Mayyil and Kunjimangalam were distributed in Cluster I, which had most of the trees of Kuttiaattoor and all of the trees from Munderi indicating that, the trees identified from Kunjimangalam had close similarity to the trees from Kuttiaattoor and

nearby Panchayaths. Cluster II was constituted by 11 trees from Kuttiaattoor, one each from Mayyil and Kunjimangalam three trees each from Koodali and Malappattam.

Suggested future line of work

- Registration of Kuttiaattoor mango as Geographical Indication.
- Molecular characterization of Kuttiaattoor mango cultivar.
- Studies on sex ratio and detailed studies on biochemical characters like total, reducing and non-reducing sugars.

References

7. REFERENCES

- Anila, R. 2002 Performance studies in selected varieties and hybrids of mango. M.Sc. thesis, Kerala Agricultural University, Thrissur, 161p.
- Anila, R. and Radha, T. 2003. Physico-chemical analysis of mango varieties under kerala conditions. *J. Trop. Agric.* 41: 20-22
- AOAC [Association of Official Analytical Chemists]. 1980. AOAC Home page [online]. Available: http://www.aoac.org/iMIS15_pROD/AOAC. [18 Jan 2017].
- Arun, S. and Kamalavalli, A. L. 2016. Opinion about organic mango farmers in Muthalamada Panchayath. *Int. J. Adv. Res. in Computer Studies*. Available: <http://www.ijarcsms.com/docs/paper/volume4/issue11/V4I11-0016.pdf>. [17 April 2017].
- Ashine, T., Vasudeva, R., Bhuwon, R. S., Parthasarathy, V. A., Reddy, B. M. C., and Ramanatha R. V. 2015. Domestication potential of aromatic pickle-mango (Appemidi) types in the Central Western Ghats, India. *Indian J. Plant Genet. Resour.* 28(1): 106-116.
- Balakrishnan, K. and Vijayarahavan, H. 2009. Flowering behavior and its chemical regulation in off season mango. In: *Proceedings of National seminar on Off-Season Mango Production*. 7-8 December, 2009, Tamil Nadu Agricultural University, Coimbatore. pp. 112-120.
- Bana, D. S., Singh R. D., and Upadhyay, N. P. 1976. Studies on floral biology of mango (*Mangifera indica*) var. Rataul. *Prog. Hortic.* 8(1): 29-40.
- Bhuyan, M. A. J. and Kobra, K. 2007. Fruit characteristics of some uncommon mango varieties grown under Joydebpur condition. *Bangladesh J. Agril. Res.* 32(3): 493-500.

- Candolle, A. D. 1884. *Origin of Cultivated Plants*. Hafner, London, 480p.
- Chadha, K. L. and Pal, R. N. 1986. *CRC Handbook of flowering Vol. V*. CRC Press, Florida, 340p.
- Chopra, S. L. and Kanwar, S. J. 1978. *Analytical Agricultural Chemistry*. Kalyani Publishers, Ludhiana, 331p.
- Davenport, T. L. and Nunez-Elizea, 1997. Reproductive physiology. In: Litz, R. E. (ed.), *The Mango, Botany Production and Uses*. CAB International, pp. 69-148.
- Elong, N. E., Adenet, S., and Rochefort, K. 2015. Physicochemical, nutritional, organoleptic characteristics and food applications of four mango (*Mangifera indica*) varieties. *Food Nutrition Sci.* 12: 242-253.
- Fivaz, J. 2008. Botanical Aspects. In: Villiers, D. and Joubert, E. A. (eds), *The Cultivation of Mango*. ARC-Institute for Tropical and Subtropical Crops, Florida, pp. 9-20.
- Gandhi, S. R. 1955. The mango in India. *Farm Bull.* Vol. 6.
- Gangolly, S. R. 1957. *The Mango*. Indian Council of Agricultural Research, 530p.
- Gautam, R., Sthapit, P., Subedi, A., Poudel, D., Shrestha, P., and Eyzaguirre, P. 2008. Home gardens management of key species in Nepal: a way to maximize the use of useful diversity for the well-being of poor farmers. *Plant Genet. Resour.* 7(2): 142-153.
- Harikumar, V. 2016. Diversity mapping and characterization of landraces of mango (*Mangifera indica* L.). Ph.D. thesis, Kerala Agricultural University, Thrissur, 188p.

Harikumar, V. and Parameswaran, N. K. 2016. Diversity mapping and characterization of mango ecotypes of Moovandan. *Adv. Life Sci.* 5(12): 5240-5245.

Hoogendijk, M. and Williams, D. 2001. Characterizing the genetic diversity of home garden crops: Some examples from Americas. 2nd International Home gardens workshop, Contribution of home gardens to in situ conservation of plant genetic resources in farming systems,

ICAR. 1967. *The Mango – A Hand Book*. Indian Council of Agricultural Research, New Delhi. 150p.

International Plant Genetic Resources Institute, Rome, Italy. pp 34-40

IPGRI, 2006. *Descriptors for Mango (Mangifera indica)*. International Plant Genetic Resources, Rome, Italy, 57p.

Iyer, C. P. A. 1991. Recent advances in varietal improvement in mango. *Acta Hort.* 291: 109-132.

Jackson, M. L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, 498p.

Jyothi, M. L. 2000. Variability and character association of pickling type mango. Ph.D. thesis, Kerala Agricultural University, Thrissur, 165p.

Jyothi, M. L., Narayanankutty, M. C., Radha, T., and Puthummal, B. 2009. Pickling suitable mango in Kerala. In: *Proceedings of National Level Seminar Cum Training on Off-season Mango Production*. 7-8, December, 2009. Tamilnadu Agricultural University, Coimbatore. pp. 26-28.

Kamiloglu, O. 2011. Influence of some cultural practices on yield, fruit quality and individual anthocyanins of table grape cv. ‘Horoz Karasi’. *J. Anim. Plant Sci.* 21(2): 240-245.

- Kannan, 1982. *Maavum Maangayum*. State Institute of Languages, Thiruvananthapuram, Kerala, 300p.
- Kapse, B. M., Rane, D. A., and Khedkar, D. M. 1988. Correlation between biochemical parameters and organoleptic evaluation in mango varieties. *Acta Hort.* 231:756-762.
- Kehlenbeck, K., Rhode, E., Njuguna, J. K., and Jamnadass, R. 2012. Mango production in Kenya. In: Valavi, S. G., Rajmohan K., Govil J. N., Peter, K. V., and Thottappilly G. (eds), *Mango, Vol 2: Cultivation in different countries*. Studium Press LLC, Houston, pp. 186-207.
- Khan, A. S., Ali, S., and Khan, I. K. 2015. Morphological and molecular characterization and evaluation of mango germplasm: An overview. *Sci. Hort.* 194: 353-366.
- Lakshminarayana, S., Subhadra, N. V., and Subramanyam, H. 1970. Some aspects of developmental physiology of the mango fruit. *J. Hort. Sci.* 45: 133-142.
- Litz, R. E. 2009. *The Mango: Botany, Production and Uses*. 2nd Ed. Cabi Series, CAB International, Wallingford, UK, 587p.
- Madisa, K. 1998. The proposal for strengthening indigenous fruit trees of Botswana in farming systems – Gaborone Agricultural Region. Final year B.Sc. thesis, Lareinstin International Agricultural College, Netherlands, 115p.
- Mahrouf, A. R. M. 2003. Socioeconomic Dimensions in Conservation and Use of Mango Species Biodiversity in Srilanka. Final reports on Socioeconomic Aspect studied under IPGRI-ADB-TFT Project – ‘Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia’. Socioeconomics

- and Planning Centre, Department of Agriculture, Peradeniya, Srilanka, 75p.
- Majumdar, P. K. and Sharma, D. K. 1990. Mango. In: Bose, T. K. and Mitra, S. K., (eds), *Fruits: Tropical and Subtropical*. Narayanprakash, Calcutta, pp. 1-62.
- Manay, S. and Shadaksharaswamy, M. 1995. *Foods- Facts and Principles*. New Age International (P.) Ltd., New Delhi, 155p.
- Maries, C. 1902. Indian mangoes. *J. Res. Hortic. Sci.* 26: 755.
- Mukherjee, S. K. 1948. The varieties of mango (*Mangifera indica* L.) and their classification. *Bull. Bot. Soc. Beng.* 2: 101-133.
- Musahib-ud-din, 1946. Fruit bud differentiation in mangoes in the Punjab. *Punjab Fruit J.* 10: 30-31.
- Naarayanaswamy, P. 1982. Studies on blossom biology, sex ratio and fruit set in certain cultivars of mango (*Mangifera indica* L.). M.Sc. thesis, University of Agricultural Sciences, Bangalore, 167p.
- Naik, K. C. and Gangolly, S. R. 1950. *A monograph on Classification and Nomenclature of South Indian Mangoes*. Madras, Superintendent, Government Press, 311p.
- Navprem, S., Jerath, N., and Singh, G. 2011. *In situ* conservation of seedling mango biodiversity in sub mountane region of Punjab. In: Sandhu, S. K., Pathak, D., Sidhu, N., Bharadwaj, R. and Rang, A (eds), *In Proceedings of International Conference on Preparing Agriculture for Climate Change*. February 6-8th 2011, Ludhiana, India, pp.89-90.

- Navprem, S., Jerath, N., Singh, G., and Gill, P. P. S. 2012. Physio-chemical characterization of unexploited mango diversity in sub-mountane zone of northern India. *Indian J. Plant. Genet. Res.* 25: 261-269.
- Padre, S. 2015. Ray of hope for Kuttiaattoor Mango, *Kerala Calling*. 35(9): 48-50.
- PPV & FRA, 2008. Guidelines for the conduct of tests for Distinctness, Uniformity and Stability. Mango (*Mangifera indica* L.), Protection of Plant Varieties and Farmers' Rights Authority, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi, 17p.
- Pradeepkumar, T., Philip, J., and Jhonkutty, I. 2006. Variability in physio-chemical characteristics of mango genotypes in northern Kerala. *J. Trop. Agric.* 44(1-2): 57-60.
- Prasad, A. M. and Prasad, A. Y. 1972. Performance studies on polembryonic varieties of *Mangifera indica* L. *Acta Hortic.* 24: 31-36.
- Preethy, T. T. 2012. Characterization of betel vine (piper betle L) types of Malappuram District. M.Sc. thesis, Kerala Agricultural University, Thrissur, 143p.
- Radha, T. 1997. *Mavukrishi Keralathil*. Kerala Agricultural University, Thrissur, 86p.
- Radha, T. and Manjula, C. 2000. Characteristics of some polyembryonic mango types grown under Kerala conditions. *Acta Hortic.* 509: 135-142.
- Radha, T. and Nair, S. R. 1998. Physiochemical analysis of some important mango varieties grown under Kerala conditions. In: *Proceedings of National Symposium on mango Production and Export*, June 25-27, 1998. Central Institute of Subtropical Horticulture, Lucknow, *Abstract*: 10.

- Radha, T. and Nair, S. R. 2000. Status of mango cultivation in Kerala. *Acta Hortic.* 509: 117-122.
- Rajwana, I. A., Khan A. S., Malik A. U., Saleem, B. A., Khan, Ziaf, K., Anwar R., and Amin. M. 2011. Morphological and biochemical markers for varietal characterization and quality assessment of potential indigenous mango (*Mangifera indica*) Germplasm. *Int. J. Agric. Biol.* 13(2): 151-158.
- Ram, S. and Rajan, S. 2003. Status report on genetic resources of mango in Asia-Pacific region. IPGRI Office for South Asia, New Delhi, India, pp. 64-68.
- Ranganna, S. 1997. *Handbook of Analysis and Quality Control for Fruits and Vegetable Products* (3rd Ed.). Tata McGraw and Hill Publication Co. Ltd., New Delhi, 634p.
- Renisha, M. 2012. Biodiversity analysis of traditional mango types of Kerala and studies on the reproductive biology of selected popular varieties. M.Sc. thesis, KAU, Thrissur, 89p.
- Ribeiro, S., Santos, C. A. F., and Neto, F. P. L. 2013. Morphological characterization of mango (*Mangifera indica*) accessions based on Brazilian adapted descriptors. *J. Agric. Sci. Technol.* 3: 798-806.
- Roshan, R. K, Pebam, N., and Singh, D. B. 2007. Physico-chemical analysis of polyembryonic mango cultivars under north india conditions. *Acta Hortic.* 975: 351-354.
- Sadasivam, S. and Manikam, A. 1996. *Biochemical Methods*, (2nd Ed.). New Age International Publishers, 256p.
- Sanjaykumar, S., Awtar, S., Vishal, N., Parthasarathy, V. A., Sthapit, B., Rajan, S., and Vinoth, S. 2015. Genetic diversity in seedling populations of mango. *Indian J. Plant Genet. Resour.* 28(1): 123-131.

- Satyavati, V. K., Bhatt, A. V., George, V. A., and Mukherjee, K. K. 1972. Studies on suitability of different varieties of Kerala for processing. *Indian Food Pack.* 26(4): 8-12.
- Sen, P. K. and Malik, P. C. 1940. The embryo of the Indian mangoes, *Mangifera indica*. *Indian J. Agric. Sci.* 10: 750-760.
- Shukla, M., Rupendra, V. K., and Mathur, D. K. 2004. Diverse genetic bases of Indian polyembryonic and monoembryonic mango (*Mangifera indica* L.) cultivars. *Curr. Sci.* 87: 870-871.
- Simi, S. 2006. Characterization of traditional mango varieties of Southern Kerala. Ph.D. thesis, Kerala Agricultural University, Thrissur, 171p.
- Simi, S. and Rajmohan, K. 2013. Evaluation of traditional mango (*Mangifera indica* L.) Varieties of Southern Kerala. *J. Hortic. Sci.* 892: 228-233.
- Singh, G. and Reddy, Y. T. N. 1990. A note on extend of polyembryony in mango. In: *Advances in Horticulture and Forestry Vol. I*. Scientific Publishers, Jodhpur, pp. 3-21.
- Singh, N. P., Chadha, K. L., and Srivastava, K. P. 1983. Nucellar seedlings from polyembryonic mango stones. *Curr. Sci.* 52(16): 782-784.
- Singh, S., Krishnamurthy, S., and Katyal, S. L. 1967. *Fruit Culture in India*. ICAR, New Delhi, 204p.
- Srivastava, S. S., Asali, K. P., Patel, M. P., Tiwari, B. L., and Bhaduria, U. P. S. 1987. Evaluation of mango varieties in Madhya Pradesh. *Indian J. Hortic.* 37: 10-15
- Subbiah, B. V. and Asija, G. L. 1956. A rapid method for the estimation of nitrogen in soils. *Curr. Sci.* 26: 259-260.

- Thimmappaiah, and Suman, C. L. 1987. Sex ratio in relation to fruit set and fruit yield in mango. *Punjab Hortic. J.* 27: 8-11.
- Toili, M. E. M., Rimberia, F. K., Nyende, A. B., Mutwiwa, U., Kaluli, J., and Sila, D. 2013. Assessing morphological diversity of mango germplasm from the upper Athi river region (UAR) of eastern Kenya. In: *Scientific Conference Proceedings*. 15th February 2013, pp. 602- 612.
- Vasugi, C., Dinesh, M. R., Sekar, K., Shivashankara, K. S., Padmakar, B., and Ravishankar, K. V. 2012. Genetic diversity in unique indigenous mango accessions (Appemidi) of the Western Ghats for certain fruit characteristics. *Curr. Sci.* 103: 199-207.
- Walkley, A. and Black, I. A. 1934. An examination of methods for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Sci.* 37(1): 29-38.
- Watt, G. 1891. *A Dictionary of Economic Products of India*. Calcutta Government Printing Press, 149p.
- Wester, P. J. 1920. The mango. *Philippine Bureau Agric. Bull.* 18: 3-70.
- Woodhouse, E. H. 1909. The mangoes of Bhagalpur. *Quart. J. Dept. Agric. Beng.* 2: 168.
- Yadav, I. S. and Singh, H. P. 1985. Evaluation of different ecological groups of mango cultivars for flowering and fruiting under sub tropics. *Prog. Hortic.* 17: 165-175.
- Yahia, E. M. 2006. Extraction, separation and partial identification of 'Ataulfo' mango fruit carotenoids. *Acta Hortic.* 712: 333-338.

115

**CHARACTERIZATION OF KUTTIATTOOR
MANGO (*Mangifera indica* L.) CULTIVAR OF
KANNUR DISTRICT, KERALA**

by
RESHMA REGHU
(2015-11-085)

ABSTRACT OF THE THESIS
Submitted in partial fulfilment of the requirement
for the degree of

Master of Science in Agriculture
(PLANT BREEDING AND GENETICS)
Faculty of Agriculture
Kerala Agricultural University



DEPARTMENT OF PLANT BREEDING AND GENETICS
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA
2017

ABSTRACT

The present investigation on 'Characterization of Kuttiaattoor mango (*Mangifera indica* L.) cultivar of Kannur district, Kerala' was undertaken to characterize Kuttiaattoor mango cultivar grown in Kuttiaattoor Panchayath and the nearby Grama Panchayaths viz., Kolachhery, Mayyil, Koodali, Munderi and Malappattam and to characterize the similar mango cultivar of the area. The preliminary survey revealed that Kunjimangalam mango cultivar found in Kunjimangalam Grama Panchayath was a similar cultivar to the Kuttiaattoor cultivar. Therefore, Kunjimangalam mango cultivar was also characterized.

In the present study it was noticed that flowering commenced in the second week of November in majority of the Panchayaths but a slight delay was noticed in Kuttiaattoor and Kunjimangalam Panchayat. The peak flowering was observed in third and fourth week of December in most of the Panchayaths while in Kunjimangalam Panchayath it was in the second week of January. The time of fruit maturity was during the fourth week of March and first week of April in trees from most of the Panchayaths but in Kunjimangalam Panchayath, a slight delay was noticed.

Kuttiaattoor cultivar was noted to have an attractive semi-circular crown shape. Generally, all the trees were tall and found to have spreading type of tree growth habit. Tree height ranged from 13.50 m to 16.10 m with an overall mean of 14.82 m. Trunk circumference ranged from 129.00 cm to 164.20 cm with an overall mean of 144.22 cm. The crown diameter ranged from 10.90 m to 15.90 with an overall mean of 13.12 m. The tree characters did not vary significantly in trees across the Panchayaths.

Kuttiaattoor cultivar showed medium intensity of anthocyanin colouration in young leaves. The colour of young leaves were light green with brownish tinge. Mature leaves were dark green in colour without leaf blade twisting. Leaf base was obtuse and leaf tip was acuminate. The petiole attitude in relation to shoot was perpendicular. The leaf characters except petiole length did not show

significant variation in tree from Panchayath to Panchayath including Kunjimangalam.

Leaf blade length ranged from 21.83 cm to 22.46 and leaf blade width ranged from 6.08 cm to 6.33 cm with an overall mean of 6.16 cm. The ratio ranged from 3.54 to 3.59. The spacing of secondary veins in leaf blade ranged from 1.31 cm to 1.49 cm with an overall mean of 1.42 cm. The petiole length ranged from 3.39 cm to 4.02. Petiole length varied slightly in leaves across the Panchayaths.

The anthocyanin colouration of the inflorescence was absent or weak uniformly in all the Panchayaths. The inflorescence length ranged from 20.33 cm to 23.95 cm with an overall mean of 22.13 cm. The inflorescence diameter ranged from 17.80 cm to 20.54 cm with an overall mean of 19.54 cm. The inflorescence length and diameter varied slightly across the Panchayaths.

Broad elliptic shape in cross section, green colour of skin, medium colour contrast between lenticels and skin, absence of roughness of surface, medium depth of stalk cavity, rounded outward shape of dorsal shoulder, rounded upward type of ventral shoulder, absence of neck, absence of bulging on ventral shoulder, absence of sinus and absence of bulging of proximal styler scar where the typical qualitative mature fruit characters. The qualitative characters did not vary across the Panchayaths including Kunjimangalam.

The fruit length ranged from 8.78 cm to 9.18 cm and the fruit width ranged from 8.11 cm to 8.30 cm. The ratio obtained by dividing the fruit length by fruit width ranged from 1.07 to 1.10 with an overall mean of 1.08. The size of lenticels ranged from 134.78 μm to 137.28 μm with an overall mean of 136.20 μm . Diameter of stalk attachment recorded an overall mean of 4.46 mm. Density of lenticels and diameter of stalk attachment of fruits varied slightly across the Panchayaths. The other fruit quantitative characters did not vary significantly across the Panchayaths.

Yellow-orange colour of skin, medium orange colour of flesh, absence of skin speckling were the characters shown by ripe fruits. The characters viz. adherence of skin to flesh, firmness of flesh, juiciness, texture of flesh, amount of

fibre attached to stone and amount of fibre attached to skin were recorded as 'medium' in fruits from all Panchayaths including Kunjimangalam. The thickness of skin ranged from 1.02 mm to 1.09 mm with an overall mean of 1.06 mm.

The relief of stone surface was ridged and the seed shape was reniform. The cultivar was highly polyembryonic. 89.66 per cent of the nuts exhibited polyembryony whereas 10.34 per cent exhibited monoembryony.

Biochemical characterization revealed that TSS ranged from 12.62 °Brix to 15.40 °Brix with an overall mean of 14.45 °Brix. TSS was very similar to that obtained for Muvandan in earlier studies. Titratable acidity ranged from 0.14 per cent to 0.21 per cent with an overall mean of 0.18 per cent and carotenoids ranged from 4.48 mg/100g to 7.66 mg/100g with an overall mean of 6.47 mg/100g. Ascorbic acid ranged from 37.65 mg/to 50.98 mg/100g and the crude fibre ranged from 2.56 per cent to 5.05 per cent. TSS and crude fibre showed slight variation in mangoes across the Panchayaths.

The cluster analysis grouped 55 trees into two clusters. It was observed that trees from same Panchayath were distributed to both the clusters. Majority of trees from Kunjimangalam were distributed in Cluster I, which had most of the trees of Kuttiattoor, indicating that, the trees identified from Kunjimangalam had close similarity to the trees from Kuttiattoor and nearby Panchayaths.

174204

