DIVERSITY MAPPING AND CHARACTERIZATION OF LANDRACES OF MANGO [*Mangifera indica*. L]

by

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(2012-22-103)

THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Diversity mapping and characterization of landraces of mango [*Mangifera indica*. L]"** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that this thesis, entitled **"Diversity mapping and characterization of landraces of mango [*Mangifera indica*. L]"** is a record of research work done independently by **Mr. Hari Kumar V., (2012-22-103)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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LIST OF ABBREVIATIONS

IPGRI	:	International Plant Genetic Resources Institute
GIS	:	Geographic Information System
GPS	:	Global Positioning System
LRIS	:	Land Resources Information System
IBPGR	:	International Board for Plant Genetic Resources
PGR	:	Plant Genetic Resources
TFT	:	Tropical Fruit Tree
Acc	:	Accession
LR	:	Landrace
FGD	:	Focal Group Discussion
FCA	:	Four Cell Analysis
ITK	:	Indigenous Traditional Knowledge
FRM	:	Final round up meetings
PPB	:	Participatory Plant Breeding
TSS	:	Total soluble solids
PCA	:	Principal component analysis
cm	:	centimetre
m	:	metre
%		Per cent
g	:	gram
Kg	:	Kilo gram
y	:	years
i.e.	:	that is
Fig.	:	Figure
HH	:	Household
MHH	:	Many Households
FHH	:	Few Households
MT	:	Many trees
FT	:	Few trees
@	:	at the rate of
et al.,	:	and associated workers
viz.,	:	Namely

Chapter I

Introduction

1. INTRODUCTION

Conservation and maintenance of landraces (LR) as a part of the cultural heritage of a region or country is yet to be given a serious thought by crop breeders and horticulturists worldwide. LRs of a geographical region are the unique symbols which in many ways comparable with monuments, regional dresses, and folk songs - a few telling examples of the regional or local cultural heritage.

LRs of many crops have originated and developed together with agriculture and horticulture of a region and hence have probably been in existence for several years there (Zeven, 1998). Although LRs are commonly considered as endemic to a particular region, they have always been moved over short or even long distance, and thus brought into competition with native landraces if present. During the course of time they may disappear, or they may replace these native LRs or more likely, they may together form a new LR. For each site, their composition becomes adapted to the conditions of that site.

Humid tropic regions of Asian continent are endowed with a very rich diversity of many tropical fruit trees (TFT) which are the major components of a poly crop farming system including home gardens. The most noted example of such a rich tree fruit biodiversity in Asia is the genus *Mangifera* comprising 58 species naturally distributed in southeast and East Asia.

Kerala has a typical humid tropical condition and the natural mango gene pool consists mainly of the seedling races of local types, predominantly grown in homesteads and as avenue trees. Homestead with rich crop diversity is the salient feature of Kerala villages. Local LRs of mango are one among the components of such a poly crop system. These are the seedling mangoes and many are poly embryonic also. But the rapid development of industrialization, urbanization, changes in land and crop use patterns, large scale deforestation, accompanied by other social and cultural pressures have resulted in large scale degradation of natural habitats and loss of native diversity. Conduct of village level diversity analysis of local mango LRs of Kerala and preparation of germplasm catalogues and diversity registers are

supposed to be the basic steps in locating useful LRs and their conservation and subsequent use as parental material for future crop improvement programmes. Indiscriminate tree felling for conversion of the land into residential purposes and shifting crop priorities to commercial crops like rubber have all resulted in an unprecedented rate of gene pool erosion of tree fruit crops in Kerala. It has reached such an alarming proportion in mango to the extent that much of the valuable LRs widely found in the village homesteads have been lost and what remaining are also in the brink of extinction. Hence it is high time to take some effective strategies for a village level diversity management / on farm management of these LRs for saving the valuable germplasm still surviving in many hamlets of the state.

Present studies were taken up as a furtherance to a preliminary project work undertaken at the department of Pomology and Floriculture, College of Horticulture sponsored by Bioversity International Wageningen during 2009-11. It comprised of assessment of the traditional mango biodiversity of two selected villages in the grampanchayats of Pazhayannur (Thrissur district) and Muthalamada (Palakkad district). The methodology standardized by Bioversity international involving snow ball sampling, focal group discussion (FGD) and four cell participatory analysis etc., were adopted for identifying the common and unique mango types in these villages and finally culminating in chalking out a conceptual model eliciting strategies for conserving different mango types present in these villages. Indigenous traditional knowledge (ITK) documentation was also attempted along with this. Results from these pioneer studies indicated the potential of Pazhayannur region as a rich repository of traditional mango landraces, which is to be explored further for documenting the unique ones.

Present project entitled **"Diversity mapping and characterization of landraces of mango (*Mangifera indica*. L)"** was hence taken up in this background with the objectives of a detailed diversity mapping and digitization of landraces of mango at the entire region level in Pazhayannur area of Thrissur district of Kerala, their characterization, preparation of diversity registers and descriptors, documentation of associated indigenous traditional knowledge (ITK) and evolving appropriate integrated conservation and improvement strategies for the rare LRs spotted in the region during the project implementation.

Chapter II

Review of Literature

2. REVIEW OF LITERATURE

Literature reviewed as related to the present set of investigations on "Diversity mapping and characterization of landraces of mango (*Mangifera indica*. L)" is presented below:

2.1 LANDRACE `

Conservation and maintenance of landraces as a part of the cultural heritage of a region or country is yet to be given serious thought by crop breeders and horticulturists worldwide. Zeven (1998) stated that 'landraces'of a geographical region are in many ways comparable with monuments, regional dresses, and folk songs - a few examples telling the regional or local cultural heritage.

During the domestication phase of wild plants, man developed plants which had phenotypes surviving not only natural selection but also artificial selection. The phenotypes and genotypes of the wild plant changed as man selected for plants with certain desirable characteristics, which either were already present or else arose during cultivation. He maintained and multiplied these desirable plants. In addition to man's selection activities, nature also selected phenotypes suitable to be cultivated on man-made land and gardens. These combined actions resulted, for some crops, in populations which we call landraces. The term landraces also includes garden-races. These were and still are grown, in remote areas or in small garden plots, as suggested interestingly by Hawkes (1983) that 'remote to those trying to collect landraces, but not for the growers themselves'.

Landraces have originated together with agriculture and horticulture, during the past 10,000 years or so. Hence, landraces of many crops have probably been grown for several millenia. Although landraces are commonly considered as endemic to a particular region, they have always been moved over short or even long distances and thus brought into competition with autochthonous landraces if present. They may disappear, or they may replace these autochthonous landraces or more likely, they may together form a new landrace. For each site and for each year their composition becomes adapted to the conditions of that site and that year. These adaptations have taken place by changing the frequencies of phenotypes and hence genotypes for self-

fertilizing and vegetatively propagated crops, and of alleles for outbreeding crops, and by absorbing new genotypes either introduced from elsewhere or else which have originated by mutation or by a low degree of interplant hybridization.

Zeven, (1975) while making review on landraces opined that the LR population in a particular region are likely to be disappeared due to different factors such as the economic importance of the crop, extent of national and regional breeding attempts, introduction of exotic cultivars etc. The traditional LRs of a crop are hence likely to be replaced by newly bred varieties of the crop, as they are evolved for attributes such as yield stability and high yield capacity under improved cultivation methods. Yield stability of landraces under traditional low input agricultural systems is due to the fact that whatever the varying biotic and abiotic stress for each plant one or more genotypes within the landrace population will yield satisfactorily. Landraces were and still are grown by farmers all over the world for this reason only.

What are landraces? During the last so many years various researchers have coined definitions of LRs. Some are too concise, whereas others are merely long descriptions. The term landrace is not mentioned in the International Code for Nomenclature for Cultivated Plants (ICNCP) (Trehane, 1995). The term landrace cannot be included in the term cultivar as the cultivar is described as 'a taxon that had been selected for a particular attribute or combination of attributes, and that is clearly distinct, uniform and stable in its characteristics and that, when propagated by appropriate means, retains those characteristics.' As only limited selection attempts are carried out to maintain a landrace, it may clearly be distinct from other landraces, but repeated cultivation especially under other circumstances, often results in a different appearance of the landrace. Hence, a landrace is not uniform and stable, and thus is different from a cultivar.

One of the early definitions was by Mansholt (1909) who pointed out that landraces have a high 'stability of their characteristics' and great 'resistance capacity to tolerate adverse influences'. Their production capacity, however, is less than that of cultivars and when grown outside their home region, their genetic composition will change.

Schindler (1918) stated that a landrace should not be compared with a cultivar, because yield stability is the major characteristic of a landrace, whereas a high yielding capacity under optimal conditions characterizes a cultivar. This statement was recently repeated by Falcinelli *et al.* (1994).

Harlan (1975) realized the complexity of a landrace. Hence, he did not define a landrace, but described it as follows 'While landrace populations are variable, diversity is far from random. They consist of mixture of genotypes all of which are reasonably well adapted to the region in which they evolved but which differ in detail as to specific adaptations to particular conditions within the environment. They differ in reaction to diseases and pests, some lines being resistant or tolerant to certain races of pathogens and some to other races. This is a fairly effective defense against serious epiphytotics. Some components of the population are susceptible to prevalent pathogenic races, but not all, and no particular race of pathogen is likely to build up to epiphytotic proportions because there are always resistant plants in the populations. Landraces tend to be rather low yielding but dependable. They are adapted to the rather crude land preparation, seeding, weeding and harvesting procedures of traditional agriculture. They are also adapted to low soil fertility; they are not very demanding, partly because they do not produce very much.

Harlan (1975) further continued that 'Landraces have a certain genetic integrity. They are recognizable morphologically; farmers have names for them and different landraces are understood to differ in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use and other properties. Most important, they are genetically diverse. Such balanced populations – variable, in equilibrium with both environment and pathogens, and genetically dynamic – are our heritage from past generations of cultivators. They are the result of millennia of natural and artificial selections and are the basic resources upon which future plant breeding must depend.

Brown (1978) also described landraces as geographically or ecologically distinctive populations, which are conspicuously diverse in their genetic composition both between populations [i.e. between landraces] and within them. They differ from their wild relatives because they have evolved under cultivation upon which most of them have come to rely for their survival. They differ from the cultivars developed by

modern scientific plant breeding in that they have not been deliberately intensively selected to a predetermined reduced level of genetic heterogeneity.

Frankel & Soule (1981) opined that the genetic diversity of a landrace has two dimensions: between site and population (the first dimension) and within site and population (the second dimension), the former mainly generated by heterogeneity in space, the latter by heterogeneity in space and time. They further continued that generally landraces have developed at low levels of cultivation, fertilization (i.e. inputs such as artificial fertilizers), and plant protection; they are subject to selection pressures for handiness and dependability rather than for productivity.' These two dimensions are not very distinct.

Jacquemart (1987) stated that for fruit trees a 'variété paysanne' (i.e. a farmer's variety) is a variety of which the origin is unknown. He further distinguished between a 'variété regionale' [regional variety], having an international distribution, and a 'variété locale' [local variety] with a restricted distribution. An example of the first kind of variety is the apple variety 'Cwastrèsse Double', which is grown around Namur in Belgium and in Luxemburg. An example of the second is the prune variety 'Wignon'. He called varieties with a known origin 'variétés anciennes' (ancient varieties). His example is the apple 'Golden Delicious'.

Louette *et al.* (1997) described a landrace as a farmers' variety which has not been improved by a formal breeding programme. Teshome *et al.* (1997) defined, or better described, landraces as 'variable plant populations adapted to local agroclimatic conditions which are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs.' They continue that 'In the absence of farmer's manipulations, landraces may not exist in the ecological dynamics that are known today. Thus landraces and farmers are interdependent, in need of each other for their survival.

Characteristics of mango landraces such as open pollination and outbreeding and high heterozygosity result in a great diversity to locally adapted mango landraces evolved and adapted to the diverse environmental conditions in those particular regions (Krishna and Singh, 2007; Bally *et al.*, 2009).

Such traditional mangoes / landraces generally produce small and fibrous fruits as compared to the modern varieties , but noted to have many - a - biological attribute such as stable yield, low management requirements, low susceptibility to pests and diseases and high drought tolerance (Kehlenbeck *et al.,* 2012).

2.2 FRUIT DIVERSITY IN THE TROPICS

The tropical region of the world is blessed with a great diversity of fruit tree species serving mankind with basic food and nourishment for a long time since the domestication of beneficial wild plants. Tropical continents possess a rich variety of fruit trees with about 1000 species located in America, 1200 species in Africa and 500 species in Asia (Paull and Duarte, 2011, Sthapit *et al.,* 2012). Although only relatively few are exploited worldwide for breeding potential, the diversities are nature's inestimable assets for the livelihoods of local people throughout the tropical regions.

2.2.1 Fruit diversity in Asia region

Asia is repository of tropical fruit tree genetic resources and about 500 species (Ramanantha Rao and Bhag Mal, 2002) are distributed in its diverse ecosystems (Verheij and Coronel, 1991; Ramanantha Rao and Bhag Mal, 2002). Natural diversity of fruit trees occurred in a wide range and well adapted to sub-humid, humid tropical and semi-arid conditions. In addition to the domesticated and diversified fruit species in this region, a large number of species of tropical American origin introduced in the distant past have developed agro-ecological niches and are well acclimatized (Verheij and Coronel, 1991; Arora and Ramanatha Rao, 1995). Nevertheless, only about 20 species are cultivated widely in the region comprising banana, citrus, mango, pineapple, papaya, durian, rambutan, jackfruit, litchi, longan, tamarind, chempedak, carambola, langsat, guava, soursop, custard apple, passion fruit and jujube (Verheij and Coronel, 1991; Singh, 1993; Arora and Ramanatha Rao, 1995), and the predominant ones being banana, pineapple, citrus, mango and papaya.

Humid tropics contain a very rich species diversity and tropical fruit trees formed a major component in multi-crop farming systems including home gardens (Verheij and Coronel, 1991). Such an example of rich fruit diversity in Asia is of the

genus *Mangifera* which comprises 58 species (Kostermans and Bompard, 1993) and is naturally distributed in south, southeast and east Asia. The Malay Peninsula, the Indonesian archipelago, Thailand, Indo-China and the Philippines are the seats of diversity for *Mangifera* species (Kostermans and Bompard, 1993). About 26 species have edible fruits, either eaten as fresh fruits or used to prepare jams, jellies or preserves, the most important of which is mango (*Mangifera indica*).The other important species, which produce edible fruits, are *M. caesia* Jack, *M. foetida* Lour, M. *kemanga* Bl., *M. laurina* Bl., *M. odorata Griff.* Lour. (Bompard 1992; Tanaka, 1976), *M. pajang* Kostermans (Bompard, 1992) and *M. sylvatica* Roxb. (Tanaka, 1976) which, with the exception of the later, are mostly distributed in Malaysia and Indonesia. Besides mango, the other *Mangifera* species reported from India include *M. khasiana, M. andmanica, M. sylvatica and M. camptosperma* (Mukherji, 1985). A large array of cultivated and wild types occur in India. Seedling races derived from monoembryonic mango · stones are the most important component of diversity available in India. Almost all commercial cultivars of mango have arisen as a result of seedling selection. Although, most other countries in Asia, Pacific and Oceania regions have two to ten commercial cultivated mango varieties, India has around 1000 distinct varieties and about thirty of them are commercially grown (Bhag Mal, 2004).

Tropical Fruit Tree (TFT) species were important components of stable ecosystems; provide a broad range of forest products to local people in the form of food supplements and better nutrition (Ramanatha Rao and Bhag Mal, 2002).

Angami *et al.* (2006) reported that 118 wild edible plant species from Arunachal Pradesh, most of which are fruits. The maximum concentration of wild species in Citrus and Musa occurs in north eastern India and the region has diversity in other wild fruits also (Bagra *et al.*, 2006).

Diverse native fruit trees maintained on farm may help farmers to have easy access for nutritionally rich food as well as to diversify their income sources in order to mitigate economic risks (Jarvis *et al.*, 2008).

Jeeva (2009) reported about 151 wild edible fruit species from Meghalaya, from Kalsubai-Harishchandragad wildlife sanctuary and Kolhapur district of

Maharashtra 29 and 30 species of wild edible fruits were documented (Deshmukh and Shinde, 2010; Valvi *et al.*, 2011)

A total of 123 fruit species (52 families and 82 genera) with edible fruits used by inhabitants in southern Yunnan in China have been recorded. Thirty three wild edible fruit species were reported from Paroha VDC of Rupandehi district, Nepal (Jin *et al.*, 1999; Acharya and Acharya, 2010).

Kasturi mango *(Mangifera casturi)* was identified as a rare variety in Kalimantan, Indonesia. (Ayala-silva *et al.*, 2013)

In India, central western ghats are endowed with a rich repository of tropical fruit trees housing hundreds of a native species such as *Mangefera indica*, *Artocarpus heterophyllus*, *Garcinia indica etc.* (Vanishree *et al.*, 2015; Vasudeva *et al.*, 2015). As a part of central western ghats, Utther Kannada district, Karnataka state has high diversity of TFTs spread in several production systems such as home gardens, farmlands.

2.2.2 The status and characteristic features of mango diversity in India

In India, Mango is considered as "The King of Fruits", (Singh, 1996). It is domesticated in the Indian sub-continent since 4000 years (Mukherjee, 1953; Condole, 1984).

The main causes for the diversity of mango in India were the presence of high heterozygosity, cross pollination, seed propagation, absence of vegetative propagation in the earlier days and indiscriminate multiplication. The five species *M.sylvatica*, *M. khasiana*, *M. andamanica*, *M. camptosperma* and *M. indica* reported to be found in India are distinctly different from each other. *M. indica* is the most important species of the genus, as a producer of the most delicious fruits (Mukherjee, 1985). Mango has rich germplasm diversity and there are about 1600 varieties in the world (Pandey, 1998).

Mango seedlings provide a wealth of variability (Navprem *et al.*, 2012) for carrying out choice selections of desirable strains and ensure continuous supply of

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novel genetic material for future crop improvement programmes (Singh and Jawanda, 1963: Vasugi *et al.*, 2012).

Majority of the cultivars belongs to a single species, *Mangifera indica*. The widest and well-characterized diversity with around 1000 local varieties in India, while in other Asian countries, the reported number of local cultivars varies from 10-106 (Litz, 1997). These cultivars are mostly direct selections of desirable trees found in natural habitats and recognized by fruit qualities and in some cases, adaptation to specific growing conditions.

India is supposed to have the biggest germplasm center for mango (Kostermans and Bompard, 1993; Ravisankhar *et al.*, 2000; Navprem *et* al., 2012; Ravishankar *et al.*, 2015). More than 1000 varieties were said to exist in the different agro climatic zones of our country (Yadav and Rajan, 1993: Karihaloo *et al.*, 2003; Begum *et al.*, 2014).

India has three main mango growing belts, Rathnagiri in the coastal area of the south-west, which has a major focus on the variety Alphonso, the major export variety, one in the north stretching the states of Uttar Pradesh and Bihar with Dasheri as the main variety, and the third in the area around Chittoor towards the coast in the south-east, which is the main belt for Totapuri (IPGRI, 1996).

Ravishankar *et al.* (2000) reported that knowledge of a diverse genetic gene pool is essential in designing future breeding strategies for sustainability in mango production. It is therefore, germplasm act as basis of variation for new assortment and necessary to conserve these precious genetic resources through collection of local indigenous germplasm.

The size of the geographical area and the climatic diversity in the country has brought a rich diversity of mango in India. A few wild relatives; *M. zeylanica* and *M. sylvatica* were mostly found in the north-east, while *M. andamanica, M. camptosperma* and *M. griffitii* are found in the Andamans. (Kruijssen and Mysore, 2010).

The diversity in mango comprises native land races, local selections and elite cultivars. The improvement in mango was started in olden days by locating the

varietal diversity, which was basically from selection of chance seedling. Presence of high heterozygosity nature of trees, seed propagation and absence of vegetative propagation in earlier days, indiscriminate selections were main causes for diversity in India (Reddy and Dinesh, 2010).

In Punjab province of India, old mango plantation predominantly from seedling origin are established naturally or propagated through selected stones from meritorious indigenous mango plants on the basis of fruit quality characteristics by local fruit lover during 19th and early 20th century. These are at present mostly growing along a strip of roads, riverbanks, undulated terrain in mountainous tracts, government revenue lands, mango groves etc., exhibit a wide range of variability in desirable horticultural traits like fruit shape, size, juice consistency, bearing regularity, fruit yield, tolerance/ resistance to various biotic and abiotic stresses etc. (Navprem *et al.*, 2011).

Andhra Pradesh is also a the major center of diversity of mango in the country. The germplasm largely confined to the districts of Krishna, East Godavari and West Godavari, Khammam, Vizianagaram, etc., and broadly grouped under table, juicy and pickle types. They are characterized on the basis of a set of agro-botanic traits. Those fruits which could be sliced easily and are almost free of fiber come under table type. Banaganapalle (Beneshan), Himayat, Jahangir, Mulgoa, Dashehari, Alphonso, Banglora, etc., were some of the popular table varieties. Juicy varieties popularly known as 'Rasaalu' are characterized by high fiber content and abundant juice. Peddarasam, Cherukurasam, Chinnarasam, Panchdarakalasa, Nuziveedu rasalu are some of the popular varieties of this group. The third category is pickle type, wherein fruits in raw unripened stage are used for preparation of pickles. Tellagulabi, Royal Special, etc., belong to pickle types. Some are dual types categorisable as juicy or table type. Nawab Pasand, Rumani, kumkum are some of the dual types (Malati *et al.*, 2013). Several indigenous mango landracs were reported in the Chittoor region of the state (Dinesh *et al.*, 2012).

2.2.3 Centers of diversity and distribution of mango

In India, seven centers of mango diversity has been recognized, one being a sub center (Yadav and Rajan, 1993). These are the places where maximum diversity

has been noticed for species as well as varietal diversity. They are 1. Humid tropical region- Manipur, Tripura, Mizoram and South Assam. 2. Chota nagapur plateau-trijunction of Orissa, Bihar and Madhya Pradesh. 3. Santal paragnas in Bihar. 4. South Madhya Pradesh adjoining Orissa and Andhra Pradesh. 5. Dhar plateau of Madhya Pradesh adjoining Gujarat and Maharastra. 6. Humid tropical and south peninsular India. 7. Andaman and Nicobar Islands.

2.2.4 The status of indigenous mango diversity in Kerala

Kerala, having a typical humid tropical climatic situation is endowed with a indigenous mango germplasm consisting mainly of the seedling races of local types, predominantly grown in homesteads and as avenue trees. Homesteads having rich crop diversity is the salient feature of Kerala villages. Local landraces of mango are one among the components of such a polycrop system. Such seedling mangoes are polyembryonic also frequently.

In Kerala, early description on mango types was made by Kannan, (1982) and later surveys and evaluation to locate the types of different regions were also attempted (KAU, 1998; Radha and Nair, 2000; Jyothi, 2000; Simi, 2006 and Pradeep kumar *et al.*, 2006).

Radha and Manjula (1998) located 12 distinct polyembryonic types of mango in a survey conducted in the central part of Kerala. The vegetative characters (leaf shape, size, colour *etc.*) and floral characters (inflorescence position, shape, size, colour, flower characters *etc.*) exhibited by these types showed great variation.

The native mango types of Kerala such as Muvandan, Gomanga, Vellari, Chandrakaran, Kalepad, Mundappa, Olour, Swarnamookan and many other local types are at present under the serious threat of germplasm loss due to rapid urbanization and indiscriminate tree felling in the villages (Renisha, 2012; Renisha *et al.*, 2015).

2.3 EXPLORATION AND DIVERSITY MAPPING WITH GPS AND GEO INFORMATION SYSTEM

Ecogeographic studies provide critical information on plant genetic resources (PGR) to assess their current conservation status and prioritize areas for conservation.

They have also proven useful for effective gene bank management, such as the definition of core collections and identification of collection gaps.

Apan (1999) had observed that the primary objective of most tree resource assessment and monitoring is to know and map what exist in a forest area. GIS has plenty of applications in this field and this includes; a) Assessing deforestation, degradation and land use/cover change, b) Assessing forest types, age classes and succession stages and c) Assessing forest resources at various spatial scales. Proper forest management and monitoring can only be achieved by using remote sensing techniques and creating spatial representations such as maps to know the exact locations and extent of forest resources (Kokolwin *et al.*, 1998).

In crop species, GIS-based analyses have been used to predict yields of different cultivars in various geographic areas (Jeutong *et al.*, 2000; Caldiz *et al.*, 2002), to explore the distributions of wild relatives of crop species (Greene *et al.*, 1999a, b; Hijmans and Spooner, 2001; Jarvis *et al.*, 2008), and to model future distributions of crop pests and diseases (Bernardi, 2001).

Geographical Information System was successful in determining information, collection and arrangement of data, mapping the area, assessing the problem and decision-making. GIS technologies are only a means to identify and solve problems, and need proper planning and basic resources to allow their potential to be realized (Bassole *et al.*, 2001 and Pradhan, 2008).

GIS is a database management system with specific functions to handle spatial data, *i.e.* latitude and longitude for mapping of biodiversity of natural resources. (Reddy and Dinesh, 2010). Global Positioning Systems (GPS) is a powerful tool for acquiring accurate locations and areas. The relatively recent development of GPS and GIS technologies appear ideally suited to conservation effort because they empower ecologists to expeditiously acquire, store, analyze, and display spatial data on organisms and their environment (Johnston, 1998; Wadsworth and Treweek, 1999).

Sanyong and Amarakul (2001) introduced GIS to study the diseases distribution of 338 Jack fruit trees (*Artocarpus heterophyllus* Lamk.), 126 bael fruit trees (*Aegle marmelos* Corr.) and 36 ma kiang trees (*Eugenia paniala* Roxb.) at lower

Northern part of Thailand which consisted of 50 districts and 81 sub-district in Kamphaengphet, Nakhonsawan, Phitsanulok, Phichit, Sukhothai, Tak and Uttaradit provinces. The percentage of plant diseases distribution on Jack fruit showed the leaf spot disease and die back disease were 85.8 % and 60.7 %, respectively, and bael showed dieback disease was s 28.6%, and Ma kiang showed lichen on their stem, sooty mold and agal disease which were 11.1%, 5.6% and 2.8%, respectively. All database were input to GIS for query and display. GIS program is a best tool for disease forecasting. In case of plant disease control, the data of soil suitability index and rainfall are important information for disease prevention and control. Bael fruit is grown well in dry area especially in the forest in Thailand. Unfortunately, the disease of the bael fruit is not studied so much in Thailand. GIS could create the mathematical model for distribution and showed as a map.

Ecogeographic surveys carried out based on the ecological and climatic parameters of major distribution areas of six TFT species in different countries provided information on the distribution patterns, and agroecosystems of TFT species. A total of 2184 accessions of six target TFT species were collected which included 1003 accessions of mango, 555 of citrus, 288 of rambutan, 180 of jackfruit, 60 of litchi, and 98 of mangosteen (IPGRI, 2003a). Twenty eight ecogeographic surveys were conducted and also mapped collected accessions and the areas with high diversity of TFT, predict their possible distribution in other similar agroclimatic areas and identify gaps in existing collections. The countries were able to produce the distribution maps for their respective TFT collections with the geographic information system (GIS) tools such as DIVA-GIS and FloraMap. The 42 diversity maps were produced for six crops, namely, citrus, jackfruit, litchi, mango, mangosteen and rambutan showing overlapping distribution of several species. These distribution maps, which represent a first major attempt by national programmes to use GIS technologies for germplasm management, were very useful in identifying diversity rich areas for further collecting and *in situ* conservation and also predicting new areas with similar climatic conditions for cultivation of these TFT (IPGRI, 2003).

Subedi *et al.* (2005) identified the eastern terai (Siraha district) and western mid hill (Baglung and Parbat districts) regions of Nepal with a rich in mango diversity representing a total of 62 farmer named varieties. The flora map was used to map the

distribution of diversity of mango genetic resources. Lower central and eastern tarai regions of Nepal and most of Indian region and East Asian countries have shown an affinity with Nepalese mango.Miller and Knouft (2006) used a geographical information system (GIS)-based approach to investigate differences in the environmental factors characterizing the geographic distributions of cultivated and wild populations of the Mesoamerican fruit tree *Spondias purpurea*. Locality data for 86 cultivated and 28 wild *S. purpurea* populations were used in conjunction with environmental data layers and a maximum entropy application for predicting species distributions. Interpredictivity analyses and principal components analysis revealed that the predicted distribution of wild *S. purpurea* is nested within the cultivated distribution and that the ecological niche (defined by environmental characteristics) of cultivated *S. purpurea* has expanded relative to that of wild populations. Significant differences between wild and cultivated populations were detected for five environmental variables, corresponding to the expansion of *S. purpurea* during the domestication process from its native habitat in the Mesoamerican tropical dry forests into less seasonal habitats. These data suggest that humans have altered the range of habitats occupied by cultivated *S. purpurea* populations relative to their wild progenitors.

Geographic information systems (GIS) are useful tools for mapping ecogeographic distributions of biodiversity. GIS allow complex analyses to be performed, as well as clearly visualizing results in maps, which facilitates decision making and implementation of conservation policies by authorities. (Jarvis *et al.*, 2010).

Rajan, (2012) has used Geo information system (GIS) and identified potential areas for the production of the popular Alphonso variety of mango.

Qayum *et al.* (2014) carried out inter-disciplinary work by integrating ethno-medicinal findings with Geographical Information System (GIS) tools to develop spatio-temporal maps covering antimalarial plants prevalent in three rural districts of Eastern Uttar Pradesh (UP), India. GPS coordinates were recorded for marked locations and under GIS environment maps of antimalarials are generated to highlight geographical distribution of such plants. Further, these are analysed with respect to

various natural plant habitats. 48 plants belonging to 25 families were found and its geographical distribution is illustrated through series of GIS maps. The developed map highlights the geographical location of antimalarial plants and facilitates easy access of plant's natural habitat. It is believed that the work would help researchers to find out the novel antimalarials towards open source drug discovery projects. Studies had shown that with the advent of availability of GPS, recent phytosociological surveys had provided enormous information on species distribution with specific locations. These include the endemic atlas of Western Ghats (Ramesh and Pascal, 1997) and mapping of sandal wood in Karnataka (Ganeshaiah *et al.*, 2000).

The geographic area of India lied between 8°4' N and 37° 6' N latitudes and 68° 7' E and 97° 25' E longitudes and total geographical area of 32,87,263 sq.km. The size of the geographical area and the climatic diversity in India, resulted a rich diversity of mango. A wide variability of climate and soils and variable geological and geographical conditions existing in India were very much favourable for growing a large array of horticultural crops throughout the country (Kruijssen and Mysore, 2010; Aravind and Pandey, 2016).

2.4. EVALUATION AND UTILIZATION OF DIVERSITY

The International Plant Genetic Resources Institute (IPGRI) has developed a descriptor list to assist with the identification of cultivars. The list contains passport data for identifying the accession and information recorded by collectors, characterisation data include recorded characters, marked as being highly heritable that
can be easily seen in the field and expressed in all environments; and evaluation data to help assess abiotic and biotic stress susceptibility (IPGRI, 2006).

A total of 3359 accessions of target fruit species, namely, mango, citrus, rambutan, jackfruit, litchi and mangosteen held in the field genebanks in different countries were characterized (IPGRI, 2003).These included 1804 accessions of mango, 983 of citrus, 285 of rambutan, 152 of jackfruit, 40 of litchi and 95 of mangosteen. These extensive characterization and evaluation studies helped to identify elite germplasm lines that could be used in crop specific breeding programmes or directly for cultivation by farmers. IPGRI (2003) evaluated and

identified four elite lines of mango possessing year-round bearing and nine lines of off-season bearing and one possessing sweetness at green stage in Bangladesh.

In India, IPGRI (2003) identified four mango elite lines for high yield, three for short height, five for high total soluble solids (TSS), eight for red peel with good consumer appeal, seven for pulp recovery, five for large fruits, five for regular bearing, four for early maturity, three for high tolerance to shoot borer and two hybrids for export possessing medium size fruits with high TSS and high pulp recovery.

In China, IPGRI (2003) identified four mango elite lines with dwarf growth habit, disease resistance, early bearing and large fruit size along with better quality.

In Malaysia, IPGRI (2003) identified three elite lines of Kuini (*Mangifera odorata*) possessing desirable traits and in Nepal, one of mango for earliness and very high TSS.

IPGRI (2003) identified two elite lines of mango for large fruit with small stone in Philippines and two elite lines of mango, one edible at green stage and the other for pickle and two of jackfruit for good fruit quality and attractiveness in Srilanka and two elite lines of mango for high fruit weight, firm and thick pulp texture, sweet, yellow peel, small stone and longer shelf life in Thailand.

2.4.1 Conservation of Tropical Fruit Tree Genetic Resources

Wild and cultivated fruit species diversity in Asia is being threatened by rapid genetic erosion due to natural habitat destruction and other economic and cultural pressures. All the countries have indicated the same threats such as 1) habitat destruction, 2) extension of agriculture, 3) filling up of wet lands, 4) conversion of biodiversity rich sites for human settlement and industrial development and 5) uncontrolled commercial exploitation. Land-use conversion results in significant loss of diversity, especially of woody species including wild fruits. In northeastern India, for example, the local tribal people practice shifting cultivation. Large-scale clearing of forests is done during winter months and burning is done during the summer. In India and Nepal, traditional mango varieties are maintained in communal lands in the

Terai. Mango diversity in such habitats is disappearing fast because these trees are often grown in communal land, and are harvested for quick income from alternate uses such as for fuel wood for the increasing number of brick factories. A number of factors related to use and management of tropical fruit tree species have placed additional pressure on the resources. Commercialization has increased the land area under a single variety and reduced species diversity in recent years (Trinh *et al.*, 2003). Propagation of orchards from single scion for monocultural commercial farming has increased uniformity and concurrently vulnerability to pests and diseases. These modern commercial cultivars tend to replace the traditional farmers' varieties, reducing available diversity and the many associated values. One result is loss of options to farmers for coping with change. An extreme example comes from India, where a survey undertaken under the National Agriculture Technology Project (NATP) on Plant Diversity by the National Research Centre for Citrus (NRCC), Nagpur, found that the "Mosaimbi" cultivar of sweet orange was completely replaced by the cash crop sugarcane in Ahmednagar area of Maharashtra State. Commercialization of home gardens has also increased the focus on preferred fruit trees while diminishing diversity of both species and cultivars (Trinh *et al.*, 2003).

Many tropical fruits are underutilized even though they are important sources of livelihood for large segments of the population. A number of these species occur in the wild or are sparsely grown; others are cultivated in medium to large-scale plantations or in home gardens. In addition, many are underutilized even though they are important livelihood assets for large segments of the population. Fruit trees often need long-term investment and security of tenure to merit investment in their maintenance.

Home gardens are dynamic in their evolution, composition and uses. They often serve as a place where farmers can experiment with, introduce and domesticate useful plants (Eyzaguirre and Linares, 2004). Gautham *et al.* (2008) while studying the home gardens in Nepal observed that home garden management of key species/ types is the ideal way to conserve the useful diversity from extinction. Four contrasting ecosites were selected based primarily on criteria *viz.* species diversity, uniqueness of species, status of home garden and importance of home garden and secondarily on criteria *viz.* accessibility, community interest and ethnic composition of community (Jarvis *et al.*, 2000; Suwal *et al.*, 2005). The criteria for the key species

identification in home garden was reported by different workers from studies conducted elsewhere (Watson and Eyzaguirre, 2002; Trinh *et al.*, 2003). Key species / types refers to the locally important species or plant types that are frequently and extensively grown in home gardens in the context of specific socio cultural and agro ecological considerations and primarily intended for household consumption. During their studies they organized focus group discussion (FGD) in each project site involving farmers. These participatory farmer groups discussed and shared information on the importance of key species/ types and their characteristics. The contribution of different key species/ types for food security, nutrition, and on farm management of biodiversity were highlighted. The groups were also asked during the process to define and prioritize their own criteria for selecting the key species/ types in their home gardens.

Genetic diversity available in the existing germplasm determines the success of any crop improvement programme (Harlan, 1976; Moose and Mumm, 2008).

Fruit characters have been the major descriptors for identification of different varieties of fruit crops (Sanjaykumar *et al.*, 2015). *In situ* on-farm conservation would be an ideal approach for conserving local natural selections, cultivars, and farmer's varieties (Malik *et al.*, 2010).

In Kerala, home-gardens would provide an ideal setting for the maintenance of rare and unique varieties (Gautam *et al.*, 2008; Watson and Eyzaguirre, 2002). The first step towards maintaining and enhancing mango diversity in local home-gardens would be to conduct of FGDs with target communities about the cultural, environmental, and economic importance of conserving rare landraces and varieties. Preparation of a village diversity registers that would record the different species and varieties maintained by the community could aid this campaign of raising local awareness on the importance of varietal diversity (Dinesh *et al.*, 2014).

2.4.2 *In situ* Conservation

IPGRI presently designated as Bioversity International (2003) has taken several initiatives aimed at conservation and use of native TFT Species diversity in Asia, the Pacific and Oceania (APO) region. Under the Asian Development Bank funded project on tropical fruits, Bioversity promoted the concept of on-farm

conservation of fruit genetic resources (Nares *et al.*, 2001). *In situ* conservation activities were initiated in a few countries, namely, Bangladesh, India, Nepal, Philippines, Sri Lanka and Vietnam and suitable *in situ* conservation sites were identified (IPGRI, 2003).

The principles of *in situ* conservation recognized that such efforts will be successful and sustainable only through the active participation of communities who depend and enjoy the fruits of the available resources. Hence, these efforts were made with an orientation to encourage the farmers and communities to participate in the conservation of tropical fruit trees genetic resource. In Nepal, farmer group meetings were organized with the help of Agriculture Development Department and awareness was created about the value of their fruit germplasm materials in terms of income generation, socio-economic aspects and conservation for future use. Fruit diversity fairs, fruit shows and fruit festivals were organized in Nepal, Bangladesh, Vietnam, Thailand and the Philippines during socio-economic surveys and germplasm collection. Close interaction with farmers and communities also motivated them to participate in the germplasm conservation efforts. The striking observations from these initiatives were that, although several farmers were carrying out *in situ* conservation (as they continue to grow traditional varieties over generations and practice some level of selection while planting new orchards or home gardens) in an unconscious manner, they became more aware of the value of what they have been doing from these interactions. Such efforts also indicated that different approaches (including agroforestry systems approach and community biodiversity management (CBM approach) are required to make *in situ*/on-farm conservation sustainable and beneficial to tropical fruit trees growers (IPGRI, 2003).

2.5. PREPARATION OF MANGO GERMPLASM CATALOGUES AND DIVERSITY REGISTERS IN THE VILLAGES

The International Plant Genetic Resources Institute (IPGRI) has developed a descriptor list to assist with the identification of cultivars. The list contains passport data for identifying the accession and information recorded by collectors, characterization data, include recorded characters, marked as being highly heritable,

that can be easily seen in the field and expressed in all environments; and evaluation data to help assess abiotic and biotic stress susceptibility (IPGRI, 2006).

Description of mango types prevalent in different regions of India has been attempted by a number of workers. The earliest description of mango varieties using scientific and botanical terminology was made by Maries (1902). Wester (1920) provided a descriptive list of Indian mangoes. Attributes of vegetative and reproductive organs such as tree habit, leaf colour both at emergence and maturity, panicle length, flower size, colour and pattern of veins on the petals and detailed descriptions of fruits were used as basis for varietal characterization by Mukherjee (1948). Naik and Gangolly (1950) described 335 varieties of south Indian mangoes. Although very large collections of diverse cultivated *Mangifera indica* are being conserved in gene banks at several centres in India, very less variability of wild forms is represented in these collections (Yadav and Rajan, 1993).

Renisha *et al.* (2015) undertook the evaluation of the traditional mango landraces and ITK documentation in selected villages of Thrissur and Palakkad districts of Kerala and worked out a conceptual model for the village level biodiversity management of the germplasm. Apart from the total variability of different mango landraces noted in these villages she also reported the occurrence of considerable variability within the landraces itself with respect to fruit shape, colour, fibre content, juicyness *etc.* Most striking was the prevalence of different Muvandan types *viz.*, green and white types; fleshy and juicy types.

The above study also showed that conduct of village level mango diversity analysis of local types of Kerala and preparation of germplasm catalogues and biodiversity registers is supposed to be the basic step in locating useful landraces for use as parental material for future hybridization programmes. At present regional field germplasm maintenance is undertaken to an extent at different research stations of Kerala Agricultural University and agricultural farms attached to the Department of Agriculture, Government of Kerala. But such *ex situ* conservation procedures in fruit trees like mango are expensive and labour intensive processes requiring considerable land and other resources.

2.5.1 Four cell participatory approach (FCA)

Participatory rural appraisal is the methodology for interacting with the mango growers and learning from them (Farrington and Martin, 1987). Chakraborti and Bandyopadhyay, (2003) conducted a survey on seedlings germplasm in mango undertaken in Gangetic West Bengal by involving the orchardist-folk pertaining to participatory plant breeding program. Thirty seedling germplasms collected from different orchards were measured on the basis of different physico-chemical characters during the'year 2001-2003 following participatory rural folk appraisal. Identified promising seedling germplasm were SG-26 and SG-12 for optimum presence of all physico-chemical traits under their consideration.

Sthapit *et al.* (2006) reported that participatory four cell analysis (FCA) can be effectively applied for assessing the local biodiversity based on their work on farm management of agricultural biodiversity in Nepal. Walter and Marja (2007) also recommended four cell analysis (FCA) as a participatory tool for identifying unique, common, rare varieties or crop species cultivated in a community.

Kuntoro *et al.*, (2013) attempted participatory four cell analysis method to assess on farm mango diversity and the study revealed that four species of *Mangifera* and twenty four local landraces of *M.indica* were identified by the community in Tiron, Kediri, and East Java. Three endangered species (*M foetida, M. Laijiwa,and M.indica*) and two rare species (*M. odorata,*and *M. indica*) were grown in the home garden by farmers in Tiron, Kediri, Java. Besides, four common varieties (Podang Urang, Podang Lumut, Golek, and Gadung), five endagered varieties (Madu, Lanang, Santok Kapur, Santok Buto, and Kopyor), and fifteen rare varieties of *Mangifera indica* were also found to be grown by farmers.

Renisha *et al.* (2015) attempted cataloguing of the local mango diversity in two villages ie., Maruthampadam of Thrissur district and Erippadam of Palakkad District of Kerala through four cell participatory approach and identified the common and rare mango varieties of the villages. Muvandan, Pulimanga and Gomanga are the common varieties in Maruthampadam village while the rare types included Karpuramanga, Ganapatimookan, Kilichundan, Chandrakaran, Kottamavu,

Sindhuram, Marathakam and Mundappa. Common mango varieties in Erippadam are Alphonso, Banganapalli, Kilichundan, Neelum, Sindhuram, Muvandan, Nadasala and the rare varieties being Chandrakaran, Kilimook, Mallika and Mundappa.

2.5.2 Diversity measures

Richness and evenness are two measures useful for judging the biodiversity of a given site (Jarvis *et al.*, 2008). Richness describes the total number of genotypes (in terms of this study, species or varieties) found within a specified area. Richness was determined at the household level and was calculated by counting the total number of different farmer-named mango varieties per household unit.

Evenness describes the frequency of given types within a total population (Jarvis *et al.*, 2008). For instance, a low evenness value indicates the dominance of an agricultural system by one or few species or varieties, whereas a high value indicates a more uniform distribution of types in a given unit area.

Gautham *et al.* (2008) adopted household surveys at two levels for understanding seed systems of home gardens in Nepal. The first level survey consisted of collecting information from the farmers surveyed through semi structured interviews. In the second level survey, nodal farmers were identified for collecting data through the sociometric method using a snowball sampling method (Subedi *et al.*, 2003).

Renisha *et al.*, (2015) reported lower evenness values in rare varieties like Mulgoa, Chandrakkaran, Mallika and Mundappa in Erippadam village., Ganapathimookan, Kottamavu, Kilichundan, Marathakam, Sindhuram and Mundappa in Maruthampadam village. High evenness values recorded in common varieties *viz.* Alphonso, Neelum, Sindhuram, Kilichundan etc in Erippadam village and Muvandan in Maruthampadam village.

2.6 CHRACTERIZATION OF MANGO GERMPLASM

IPGRI, Rome, Italy, has standardized a list of descriptors for mango that includes the morphological traits of plant, leaves, flowers, fruits and seeds providing a

universal format for the characterization of mango genetic resources (IBPGR, 1989; IPGRI, 2006).

The application of morphological markers is the simplest of the formal, standardised and repeatable methods of evaluating crop genetic diversity. Some of the most important advantages of using morphological characterisation are that published descriptor lists are readily obtainable for most major crop species, it can be carried out *in situ*, is relatively low-cost and easy to perform. Morphological characterisation is the first step that should be done before more profound biochemical or molecular studies are carried out (Hoogendijk and Williams, 2001).

Morphological characterization allows for the study of plant variation using visual attributes. Fruits have been the major descriptors for identification of different varieties of fruit crops (Toili *et al.*, 2013).

2.6.1 Vegetative characters

2.6.1.1 Tree Characters

Based on plant habit, the 12 polyembryonic mango varieties were described by Radha and Manjula (2000) and classified into erect, intermediate and spreading types. Accordingly, varieties, Kotta Manga was classified as erect and Puliyan and Nalla Nadan as intermediate and Kolambu manga, Muvandan, Chappikudiyan, Gomanga, Vatta manga and Kilichundan were classified as spreading types.

Simi (2006) characterized 50 mango types in southern Kerala observed that plant height varied from 4.5 m to 30 m and trees were showed growth habit of erect (38%), intermediate (30%) and spreading (32%).

Riberio *et al.*, (2013) characterized 103 mango accessions in Brazil and reported that growth habit of trees were predominantly semi vertical (60.1%) could simplify the orchard maintenance (Albuquerque *et al.*, 2002).

2.6.1.2 Leaf Characters

Davenport and Nunez-Elizea (1977) observed that colour of young flushes of emerging vegetative shoots are usually green but may be sometimes bronze red or

shades of red, which depends on cultivars. They are considered mature when they turn dark green, which occurs after two or three months. Radha and Manjula (2000) located 12 distinct polyembryonic types of mango in a survey conducted in the central part of Kerala. The vegetative characters (leaf shape, size, colour etc.) and floral characters (inflorescence position, shape, size, colour, flower characters etc.) exhibited by these types showed great variation.

Leaf characters form an important criterion in identification of varieties. Descriptors are provided for leaf shape, tip and margin (IBPGR, 1989). Aroma of crushed leaf has a direct correlation with fruit flavour (Majumder and Sharma, 1990).

Simi (2006) reported lanceolate type of leaf shape and acuminate character of leaf tip and light green with brown tinge colour of young flush predominantly appeared in traditional mango types of southern Kerala.

National active germplasm site, CISH, lucknow maintaining 726 accessions of mango from mango growing regions of India, Florida, Brazil, Australia and Sri Lanka (Rajan et al., 2013). Of these 248 accessions (North and East (150), south (26), and West (72)) were documented on 56 descriptors in the form of a catalogue (Rajan et al., 2002). North Indian accessions recorded the largest mean leaf length (19.6 cm) and width (5.6 cm) while the south and west indian accessions have the smallest leaf length (18.56 cm) and leaf width (5.05 cm), respectively.

NavPrem et al, (2014) characterized nine sucking mango genotypes and observed the colour measurements of young emerging leaves with colour flex meter and it varied from brownish-green to purple brown.

2.6.2 Floral Characters

2.6.2.1 Flowering habit

In mango, flowering starts in November or early December in Andhra pradesh and West coast of India (Gandhi, 1955). Singh (1958) reported that flowering in mango is preceded by the differentiation of flower bud which occurs in October-December depending upon the local climatic conditions.

Gunjate et al. (1977) noted fruit bud differentiation started in August and continued till end of October and flowering starts by December under Konkan

condition. According to Yadav and Singh (1985) the south indian mango varieties attain physiological status of flowering earlier than north indian cultivars.

Radha and Nair (2000) reported that mango in Kerala commences flowering by November- December which was supported by Anila (2002) while studying flowering and fruit development in the varieties namely Alphonso, Neelum, Priyur, Kalapady and hybrids, Ratna and H-151 under Kerala conditions.

The time of flowering of mango varies in different regions of India is mainly influenced by local weather conditions, especially the temperature level. In India the flowering season becomes late progressively from South to North. In South India, the main mango flowering season is November-December-January whereas in North India peak flowering occurs during February-March. Accordingly the peak harvesting time also will be varying from April-May to June-August respectively (Balakrishnan and Vijayarahavan, 2009).

Navprem, (2014) reported initiation and end of flowering season under Punjab conditions was observed from the last week of February up to mid of March, respectively.

Duration of flowering is very short extending for about two-three weeks only. Mango inflorescence is primarily terminal but axillary ones are also produced frequently. Size of panicle, number of flowers and colour of the main axis and flowers show variation from variety to variety. Two types of flowers *i.e* male and bisexual are seen in a panicle. Total number of flowers varies from 1000-6000, primarily a varietal character and also influenced by climatic conditions and age of the tree (Balakrishnan and Vijayarahavan, 2009).

2.6.2.2 Inflorescence Characters

Radha and Manjula, (2000) studied inflorescence and flower characters including the position of inflorescence, shape, size, sex ratio and characters of individual flowers were studied.

Anila (2002) studied Inflorescence characters such as percentage of hermaphrodite flowers, length and breadth of inflorescence, density of flowers, colour of rachis, shape of inflorescence and hairiness and flower characters like type of

flower, diameter of flower, nature of disc and number of stamens of selected varieties and hybrids of mango in Kerala.

Asif *et al.* (2002) investigated the total flower number and proportion of male to female flowers in mango cultivars Anwar Rataul, Dashehari and Langra. The highest percentage of hermaphrodite flowers (37.7 %) was recorded in Zardalu (Hoda *et al.*, 2003).

Simi (2006) studied various inflorescence characters and reported that 84 % of mango trees showed terminal position of bearing, 52 % of panicles showed pyramidal shape and length varied from 3 to 41 cm.

Jyothi *et al.*, (2009) reported more than 70 percent of the mango trees had broadly pyramidal inflorescence and are densely flowered which give them a bunch like appearance.

Renisha (2012) reported that inflorescence rachis of Muvandan was dark red colour whereas in Neelum and Alphonso it was light red. Light green coloured inflorescence rachis was observed in Banganapalli and Vellaikolumban while in Priyur, it was with light green with red tinges.

2.6.2.3. Pollen characters

2.6.2.3.1 Pollen morphology

Simi (2006) reported pollen size of local mango types of southern Kerala varied from 19.18 to 34.18 microns.

Renisha (2012) observed that pollen shape was round in Neelum, Priyur, Alphonso and Vellaikolumban as well as oval and oblong shaped pollen was noted in Banganapalli and Muvandan respectively. The pollen size ranged in between 27.29µm - 33.34µm and the largest pollen noted in variety Muvandan under Kerala conditions.

2.6.2.3.2 Pollen viability

Simi (2006) observed that pollen fertility varied from 47.92 per cent to cent percent in local traditional varieties of south Kerala.

Renisha (2012) reported that significant variation in pollen fertility during the period of december to march. It was in the range of 80.70 -93.52 per cent in january and decreased to 40.70- 60.00 percent in march 2011 under Kerala conditions.

2.6.2.3.3 Pollen production

Ilgin (2007) determined number of pollen per flower in selected capri fig types by using haemacytometric method and reported pollen production ranged from 4355 to 7169 pollen grains and highest in 46 EI 03 and 46 EI 02 caprifig types.

Renisha (2012) reported highest pollen production in Vellaikolumban and Banganapalli (500) in January while in Priyur, Neelum, Alphonso, and Muvandan, the values were 400, 300, 250 and 250 respectively which declined to 188, 218, 70, 89, 223, 198 in Vellaikolumban, Banganapalli, Priyur, Neelum, Alphonso, Muvandan respectively in March.

2.6.2.3.4 Pollen storage

Carreno *et al*. (2009) stored the pollen of different cultivars of *Vitis vinifera* L. at temperature of -20^0c, -40^0 c and -80^0 c and observed good pollen germination at -80^0c.

Imani *et al*. (2011) recorded the viability of pollen of 4 apple cultivars, for three and seven months after keeping at 3 temperature levels (4°C, -20°C and -80°C). It showed that 3 months after storage, maximum germination was in Primgold Pollen stored at -80°C with 96.21% and the lowest germination (58.33%) in Northern Spy pollen stored at 4°C, but 7 months after storage, maximum germination was in Primgold Pollen stored at -80°C with 90.66% and the lowest germination (36.67%) in Northern Spy pollen stored at 4°C.

Storing the mango pollen under refrigerated conditions helped in retaining 67.64 per cent viability for 72 hours where as it was 70.93 per cent when kept on calcium chloride in a dessicator (Renisha, 2012).

Dutta *et al*. (2013) revealed that -196^0c cryostorage of mango pollen could be best long term storage strategy for efficient conservation of genetic resources.

2.6.2.3.4 Pollen germination

Singh (1954) reported the failure of pollen to germinate in 25 per cent sugar, 0.5 percent agar at temperature of 75^0 to 80^0 F and in other media concentrations.

Randhawa and Damodaran (1961) recorded highest pollen germination in 10 per cent sugar solution (28.2%) in mango var. Chausa.

Bolat and Pirlak (1997) noted highest pollen germination in 15% sucrose solution in hanging drop and agar plate test which varied between 49.77-72.90% and 57.83-84.42% in apricot, 47.92-57.38% and 52.40-66.60% in sweet cherry and 49.16% and 53.82% in sour cherry respectively.

Jutamanee *et al.* (2000) noted that germination of pollen ranged between 24.10% - 32.51% in Nam Dok Mai and Khiew Sawoey cultivars of mango. Almaguer *et al.* (2004) studied the pollen tube growth of Mandarin and found that pollen germination varied from 1 to 4%.

Ilgin *et al.* (2007) determined the germination of fig pollen using various concentration of sucrose supplemented with H_3Bo_3, KNO_3 or GA_3 in agar medium and found that germination was higher upto 74% in media containing 20% sucrose with addition of H_3Bo_3 or KNO_3 but not GA_3.

Khan and Perveen (2009) studied the pollen germination capacity of three mango cultivars *viz.*, Chausa, Dashehari and Langra by hanging drop technique in different concentrations of sucrose solution (5%- 50%) with 1% agar and 0.01% boric acid, of which Langra pollen showed better germination even when kept upto 48 weeks.

Prakash *et al.* (2010) studied *invitro* pollen germination of *Punica granatum* in different concentration of sucrose and found maximum percentage of germination upto 45.58% and 42.25% at 15% sucrose solution.

Artificial germination of mango pollen is reported to be difficult by different workers. Pollen storage at room temperature showed only 2.11, 1.80 and 1.03 percent pollen germination in Sensation, Tommy Atkins and Janardhan pasand respectively upto 4 weeks of storage (Dutta *et al.*, 2013).

2.6.3 Fruit characters

Variability in mango varieties showed that fruit shape was the most important and stable character for discriminating varieties from each other. Other fruit characters also have a degree of varying importance for the purpose of identification. Presence of beak, fruit size, sinus, cavity of stalk insertion are important for studying variability in mango germplasm (Ram and Rajan, 2003).

Anila and Radha (2003) recorded the high total and reducing sugars in H-151 and Alphonso next to Ratna. Alphonso and Neelum fruits recorded higher acidity values.

Simi (2006) observed fruit size, length and width ranged from 37.5 g to 826 g, 4.4 cm to 18.1 cm and 3.9 to 12 cm respectively.

Pradeep kumar *et al.* (2006) reported TSS ranged between 12.7 and $25.2°$ brix among 31 North Kerala mango genotypes. Satyavati *et al.* (1972) reported that TSS of ripe fruits of local varieties of Kerala ranged between 10 and $24°$ brix. 'Heralappa' ($25.2°$ brix) and 'Kalapady' ($24.7°$ brix) were the two top genotypes in this respect. Fruits of 'Ratnagiri Alphonso' showed higher acidity and lower TSS than the popular variety 'Alphonso'. TSS of 'Alphonso' was $21.8°$ brix.The skin colours of unripe fruits of the varieties were green, light green, greenish, greenish yellow and light yellow, while the skin colours of ripe fruits were green, light green, greenish yellow, yellowish, yellowish green, light yellow and yellow (Bhuyan and Kobra, 2007).

Physicio-chemical characteristics are the important qualitative indexes of any fruit for fresh consumption. Total soluble solids determine the quality of juice and other canned products (Bhuyan and Kobra, 2007).

Fruits have been the major descriptors for identification of different varieties of fruit crops (Toili *et al.*, 2013). NavPrem, (2014) characterized nine sucking mango genotypes and observed fruit shapes such as ovate, oblong and ovate oblong. Round and oblong shapes of mango dominated among various shapes (Jyothi *et al.*, 2009). Simi (2006) observed four types of fruit shapes such as round, oblong, ellipsoid and oblong ellipsoid.

Navprem *et al.* (2012) studied 28 elite lines of mango and recorded fruit weight, fruit length and width ranged from 50.3 g to 380.4 g, 4.63 cm to 12.52 cm and 3.83 cm to 7.77 cm, respectively.

The highest fruit pulp weight of 267.5 g observed in the variety Jogiya Chhalli and lowest of 18.3 g noted in Ber amb (Navprem *et al.*, 2012).

Riberio *et al.* (2013) characterized 103 mango accessions based on brazilan adopted descriptor and a great diversity found in the colour of epidermis ranging from green to red.

Fruit pulp colour of mango ranged from yellow to orange (Navprem *et al.*, 2014). Various pulp colours reported such as yellow, creamish yellow, light yellow, lemon yellow and orange (Navprem *et al.*, 2012) and dark orange pulp in Amrapali (Riberio *et al.*, 2013).

Navprem *et al.*, 2014 reported fruit size indicated by weight ranged from 77.3 - 203.7 grams and fruit length to breadth ratio was observed 1.02 - 1.84 in Punjab. Radha and Manjula (2000) reported 70 to 425 grams in Kerala.

2.7. ASSOCIATED LOCAL KNOWLEDGE AND CULTURAL VALUE OF INDIGENOUS MANGO FRUITS

Indigenous knowledge can be defined as knowledge of the people living together in a certain area, generated by their own and their ancestor's experience including knowledge originating from elsewhere which has to be internalized by the local people (Madisa, 1998). Utilization of wild edible plants as a food source is an integral part of the culture of indigenous people (Medley and Kalibo, 2007) who gather and consume wild edible plants as snacks and at times of food scarcity (Addis, 2009). Knowledge of traditional foods is important for sustaining their development and utilization. It is important for people to know the prevailing traditional food in their areas and how they can be improved for better sustainable food security/nutrition (Ohiokpehai, 2003). This innumerable wealth of knowledge that creates the rich and complex production systems also affords people the adaptability and resourcefulness that is so critical at times of stress, such as drought or crop failure (Bell, 1995). They

are knowledgeable of traditional plant uses, one of which is the use of wild edible plants as a food source (Addis, 2009). Ethnobotanical studies conducted have indicated that wild plants are gathered and consumed by indigenous people (Asfaw, 2009). As a result, local people's knowledge has been a key element in several ethnobotanical studies to explore various aspects. Ethnobotany is study of how the people of a particular culture and region makes use of indigenous plants while ethnobotanist explores how plants are used for food, shelter, medicine, clothing, hunting and religious ceremonies (Qureshi et al., 2007). It is relationship between a given society and its environment and in particular the plant world (Aumeeruddy, 1996).

Indigenous knowledge is as old as human civilization but the term was first coined by an American botanist, John Harshburger (1896). Since then it has been defined as the traditional knowledge on indigenous communities about surrounding plant diversity and as the study of how the people of particular culture and region make use of indigenous plants. Ethnobotanical inventories of local knowledge of plants and their environment have a great value in identifying species for domestication and commercialization (Melnyk, 1998; Shrestha and Dhillion, 2006). This proves the diversification of knowledge among the indigenous people in region to region and nation to nation. For instance, Okafor (1999) has successfully used local people's knowledge for the conservation and evaluation of the use of non-wood forest products in Southeastern Nigeria.

In Sri Lanka, IK on mango and jackfruit documented with the help of different communities (Maharouf, 2003) indicated the existence of varieties that were used for a long time in specific food items and treatment of various diseases. IK on mango was gathered by interviewing the priests, village leaders, Ayurvedic doctors and the ethnic communities, namely, Singhalese and Tamils. Information pertaining to the use of mango and its plant parts in food, medicine and in festivities, weddings and other rituals was gathered.

In Nepal, IK was documented for citrus, which included varied types of information (Budathoki, 2003) such as: i) *in situ* manuring by keeping animals in the

orchards, ii) use of temporary 'mobile' toilets near the trees for manuring, iii) planting of whole fruits in the field after removing the peel, iv) smoking of trees in the evenings and nights to repel the insect pests, and v) spraying small seedlings with slurry of fresh cow dung and urine to repel animals. Such information could be very useful in increasing fruit production and thereby enhancing farmers' income and can be validated by formal and more controlled research.

In Malaysia, decoction of roots of pulasan has been reported to be used as vermifuge for fever and the roots are boiled and used for bathing patients inflicted with fever (Idris, 2003). The dried seed kernels with faintly sweet smell oil are suitable for use in food. In the Philippines, decoction of dried mangosteen rind is used to cure stomachache (Dela Cruz, 2003). In Vietnam, litchi has been reported to have medicinal value. It is traditionally used to treat stomach-ache and the pain in small intestine. The traditional uses included the use of litchi flesh to prevent tiredness and to treat bronchocele or growth on the neck, fruit skin to treat diarrhoea and leaves to treat animal bites. Litchi tree productivity was enhanced with the use of poultry manure. The other traditional practices included the cutting of trunk vertically in the middle to induce branching and slicing of trunk for inducing fruiting (Hue, 2003).

Indigenous Knowledge documentation (IK) is very important as it gives very useful information on growers' preferences and uses, indigenous production methods and on the role of growers in conservation and use, which could be used in developing appropriate research and development strategies on target fruit tree species.

Renisha (2012) attempted traditional knowledge documentation with respect to the processing of mango in two villages of Thrissur and Palakkad districts of Kerala as part of the biodiversity analysis of traditional mango types. In these studies, she noted a typical varietal specificity for each and every products prepared by the house maids of these regions and the simple traditional skills employed by them for making it unique.

Bhat *et al.* (2013) reported tropical fruit tree species form an important source of livelihood, medicine and income of local indigenous people. Several wild TFT genetic resourses partially domesticated and deployed into farming systems in tropical Fruits in the Farmlands of Central Western Ghats. Several varieties of wild aromatic

pickle mango popularly known as Appemidi an important commodity of commerce, have been identified by the farmers from the riverine habitats and have been deployed under various agro forestry systems from Central Western Ghats (Vasudeava and Rajeswari, 2014).

Chapter III

Materials and Methods

3. MATERIALS AND METHODS

Present investigations on "Diversity mapping and characterization of landraces of mango [*Mangifera indica.* L]" were implemented during November 2012 to March, 2016. Pazhayannur region of Thrissur district of Kerala was chosen as the project site for this purpose. Accordingly, ecogeographical survey for locating the landraces, subsequent GIS mapping and field data documentation for characterization of the spotted mango races was undertaken in this region and data processing and analytical work was carried out at the Department of Pomology and Floriculture, College of Horticulture, Vellanikkara. The materials used and the methods adopted during the project implementation are presented component wise in this chapter.

COMPONENT I – ECO GEOGRAPHICAL SURVEY OF THE REGION AND VILLAGE MAPPING OF MANGO LANDRACES

3. 1. LOCATION DESCRIPTION

Pazhayannur region of Thrissur district of Kerala is situated between 10° 42' 32" to 10° 35' 42" N latitude and 76° 25' 1.0" - 76° 24' 50"E longitude. Pazhayannur gramapanchayath (GP), has a geographical area of 59.03 square kilometers within the altitude range of 30-220 m above MSL. Total annual rainfall is 2972 mm. Soil types noticed were rockery, laterite, black soil, clay soil predominantly red lateritic.

Pazhayannur tract is located on the Eastern end of Thrissur district (Fig 3.1) with a beautiful greenery landscape. It has Palakkad district on Eastern border, Thriuvilwamala GP of Thrissur district on the Northern border. Along its North Eastern border flows the Gayathri river which joins Bharathapuzha later and ends in Arabian sea at Ponnani.

Entire Pazhayannur region along with the neighbouring GPs broadly comprises the Pazhayannur block panchayath (Fig 3.2). Pazhayannur GP comprises of four revenue villages namely Elanad, Pazhayannur, Vennur, Vadakkethara . The rural hamlets within these villages and other few locations of the region where unique land races were later spotted based on the key respondent interactions during the course of explorations are presented in the table 3.1

3.2 PRE-SURVEY CONSULTATION MEETINGS

To start with the explorations, maiden information pertaining to the land use pattern, crop diversity, crop intensity, were collected from the Kerala Land Use Board [GOK] and the first phase topographic resource maps prepared by them for the region. It was followed by further thematic meetings with KLUB expertise, local body officials of the panchayath and Agricultural Officer of the study site for working out a *modus operandi* for implementing the project.

3.3 FIELD SURVEYS- 1ST PHASE

Primary field visits were undertaken across the GP as a rapport building exercise with the local leaders and key informants. Based on these key respondent interactions and focal group discussions [FGD] followed later, the potential locations for undertaking the survey were earmarked.

Table 3.1: Villages explored for spotting the mango landraces in Pazhayannur tract
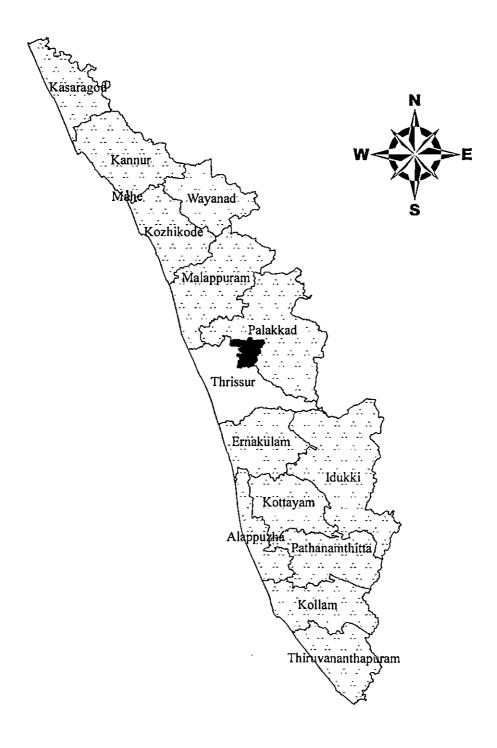
Name of the village	Rural hamlets
Elanad	Neelumpaliyal, Karimakuzhy, Thrikkanaya, Maruthampadam, Muthalamkode, Kannasserykalam, Velladi, Paruthipra, Meenakshipath, Kuttadanchira
Pazhayannur	Potta,Neelichera,Kallepadam, Plazhy,Kumbalamkode, Pazhayannur
Vennur	Vennur, Manchadi, Vendokinparambu, Kuzhikakulamb, Vattapara
Vadakkethara	Cheerakuzhy, Vadakkethara
Other locations / villages	Kuthampully (Tiruvilvamala) and Painkulam (Panjal)

3.4 FIELD IMPLEMENTATION 2ND PHASE

3.4.1 Check list preparation

A check list consisting of relevant information to be documented during field visits was prepared as per the mango descriptor (IPGRI, 2006) and adding inputs from the thematic group discussions of experts and student's advisory group.

Fig. 3.2. Outline of Pazhayannur region
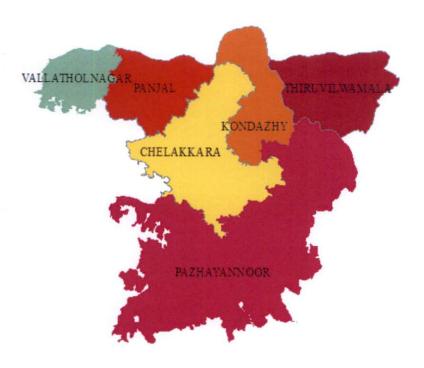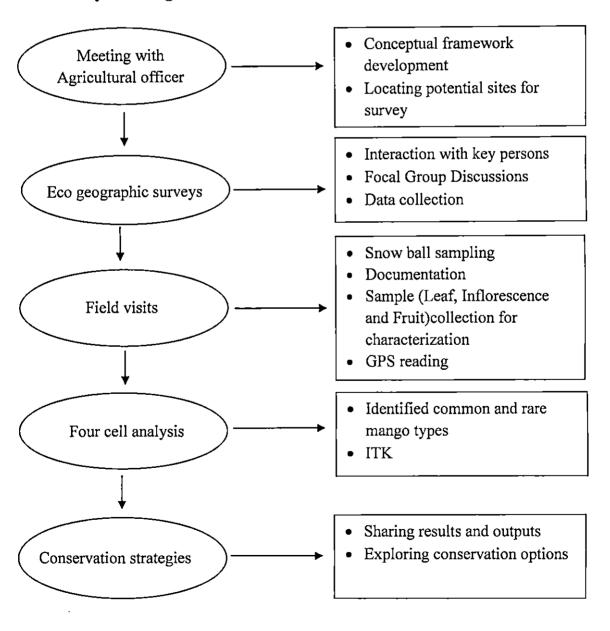
3.4.2 Selection of Homesteads

Representative homesteads with appreciable diversity of seedling mango races were located through a sociometric survey using snowball sampling method. This technique determines the sample by asking the existing study subjects to recruit future subjects from their acquaintances (Subedi *et al.*, 2005). Accordingly individual locations were visited for data collection.

Fig.3.3: Steps and methods employed for the ecogeographic survey of mango in Pazhayannur region

Meeting with Agricultural officer	• Conceptual framework development • Locating potential sites for survey
Eco geographic surveys	• Interaction with key persons • Focal Group Discussions • Data collection
Field visits	• Snow ball sampling • Documentation • Sample (Leaf, Inflorescence and Fruit)collection for characterization • GPS reading
Four cell analysis	• Identified common and rare mango types • ITK
Conservation strategies	• Sharing results and outputs • Exploring conservation options

3.5 PREPARATION OF VILLAGE MAPS AND DIGITIZATION

3.5.1 Knowledge on GIS methodology

In order to have a firsthand information on GIS and its field applications, the student attended various training programmes on Geographic Information System conducted by different agencies.

1. Training programme on Geographic information system conducted by Centre for Geoinformation technology and Kerala GIS community during 13th -14th December 2014 at Rajagiri School of engineering and technology, Kochi.

2. Training programme on Open sources software in geographic information analysis conducted by College of Forestry, Kerala Agricultural University on 16th December 2014.

3. Training programme on Remote sensing and GIS tools for natural resources management organized by College of Forestry, Kerala Agricultural University during 19th -23rd March 2016.

3.5.2 Boundary map/ Shapefile of Pazhayannur

Geo-referenced boundary map of villages availed from Indian Institute of Information Technology and Management, Kerala (IIITM-K) Thiruvananthapuram served as a base file for the purpose. It comprised of different villages of Pazhayannur such as Elanad, Pazhayannur, Vennur, Vadakkethara. Inputs from Land Resourses Information System (LRIS, 2016), Government of Kerala were also availed for supporting the above.

3.5.3 Recording of Geo co-ordinates (Geo position readings) for spotted mango landraces at different locations

Garmin e Trex 20 worldwide Handheld GPS (Global Positioning System) was used for recording the geo co-ordinates (Latitude and Longitude) in the located spots in the different villages.

3.5.4 Diversity mapping and digitization on village boundary maps using GIS software

GIS software, Arc GIS - version 10.2.2 was used for processing the geographic data (GPS readings) of the located diversity spots and for integrating it into a geo - referenced map. Such integrated maps serve for depicting the diversity and

Plate 3.1 Initial Focal Group Discussions at the villages

distribution of mango races at the village level.

3.6 PARTICIPATORY IDENTIFICATION OF KEY TRADITIONAL MANGO RACES IN THE VILLAGES

First phase focal group discussions conducted at different villages enabled to earmark few locations to start with the field survey. Individual homestead / location visits were initiated from these locations and thereafter continued by adopting the snow ball sampling procedure mentioned earlier. Data for characterization of such landraces spotted in these locations were collected through personal interaction and recorded in the formatted data sheets. Plant, flower and fruit samples were collected for further description and lab analysis. All these steps were undertaken in a participatory mode involving the resident farmers and focal leaders of the regions.

3.7 CHARACTERIZATION OF LOCAL MANGO RACES

3.7.1 Morphological characterization

The standard descriptor prescribed by the IPGRI (2006) was used as a guideline to describe the vegetative, floral, fruit and seed characters of the located landraces.

3.7.1.1 Vegetative characters

The following details were collected and recorded. (Fig 3.4)

3.7.1.1.1 Tree characters

1. Type of trees (seedling / grafted /other)
2. Age of trees
3. Tree growth habit/ form / Outline (erect/ spreading/ drooping)
4. Height of the trees (m)

3.7.1.1.2 Leaf characters

Ten mature leaves were collected and the following observations were recorded.

1. Orientation of leaves (erect/ horizontal/ drooping)
2. Leaf shape (oblong lanceolate / lanceolate / elliptic oblong)
3. Leaf tip (obtuse / acute / acuminate)
4. Leaf base (acute/obtuse/round)

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Erect   Spreading   Drooping

Tree growth habit

A. Classification of tree characters based on IBPGR descriptor (2006)

Semi-erect   Horizontal   Semi-drooping

Leaf orientation

Obtuse   Acute   Acuminate

Leaf apex shape

Acute   Obtuse   Round

Leaf base shape

B. Classification of leaf characters based on IPGRI descriptor (2006)
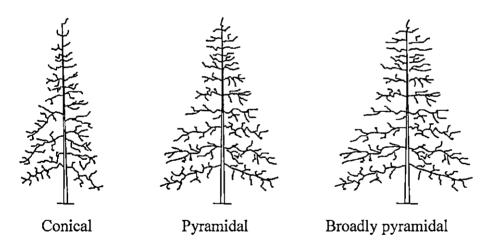
Fig 3.4 Classification of vegetative characters based on IPGRI descriptor (2006)

5. Leaf margin (entire / wavy)
6. Leaf length (cm)
7. Leaf width (cm)
8. Petiole length (cm)
9. Leaf texture (coriaceous/ chartaceous / membranous)
10. Leaf fragrance (absent/mild/strong)
11. The colour of young leaves (light green / yellowish green / light green with brown tinge / purple / reddish brown) were visually recorded.

3.7.1.1.3 Inflorescence/ Flower characters

During the time of flowering, the floral characters were studied and recorded. Inflorescences were collected and observations were made and classified into the following categories:

1. Position of inflorescence (terminal / axillary / both)
2. Shape of inflorescence (conical / pyramidal / broadly pyramidal)

| Conical | Pyramidal | Broadly pyramidal |

3. Inflorescence length (cm)
4. Inflorescence width (cm)
5. Inflorescence colour (whitish/ yellow green/ yellow/ light green/ green with red patches/ light orange/ pink/ dark pink/ purple/ light red/ red/ crimson)

3.7.2 Season of flowering (early / intermediate / late)

The trees were classified accordingly with time of flowering.
1. Early flowering if flowering started in November – December
2. Intermediate if flowering started in January – February and
3. Late if it was after March.

3.7.3 Regularity of flowering (regular / biennial / irregular)

The trees were classified as per annual bearing habit. Data recorded from custodian farmers.

1. Regular bearer: if it flowered at least once in every year,
2. Alternate bearer: if flowering occurred at least once in two years.

3.7.4 Secondary flowering / Perpetual bearing (absent/ rare / frequent)

Occurrence of secondary flowering was classified as rare if secondary flowering was absent or occurred once in a year, intermediate if it occurred twice and frequent if it occurred three or more times in a year.

3.7.5 Pollen characters

3.7.5.1 Pollen size and shape

Pollen grains were examined using phase contrast microscope (100X) and size of the grains recorded.

3.7.5.2 Pollen fertility

Pollen fertility was worked out by counting the normal well stained grains and expressed in percentage. For this purpose, acetocaramine 1 percent solution was prepared in water. Staining was done by brushing the collected pollen and observing under a phase contrast microscope.

Fertility was calculated as the percentage of normal, well stained pollen grains to the total number of pollen grains from each slide.

$$\text{Pollen fertility (\%)} = \frac{\text{No. of fertile pollen}}{\text{Total no. of pollens}} \times 100$$

3.7.5.3 In vitro pollen germination

In vitro germination of pollen collected from the different types was attempted during the investigations. For this, medium concentration of sucrose at 5-25 per cent concentration levels with 0.5 per cent agar was tried initially. Since the attempt did

not succeed the experiment was repeated at varying levels of agar *viz.* 0.25, 0.50, 0.75 per cent also.

3.7.5.6 Pollen storage

With the object of working out a suitable storage condition for pollen the dehisced male flowers collected from the field were subjected to different storage conditions. The flowers were taken in clean petri dishes and kept under different storage treatments as given below.

T_1- Keeping over calcium chloride in a desiccator at room temperature.

T_2- Keeping in refrigerator at 4^0C.

T_3- Keeping over calcium chloride in desiccator under refrigerated condition at 4^0C.

T_4. Keeping at room temperature without treatment.

3.7.6 Fruit characters

During fruiting season, twenty mature fruits were collected and used for taking the observations as listed hereunder:

3.7.6.1 Fruit morphological characters (Fig 3.5)

1. Fruit shape (oblong / elliptic / roundish)
2. Basal cavity (absent / present)
3. Beak type (absent / point / prominent / mammiform)
4. Apex (acute / obtuse)
5. Sinus type (absent / shallow / deep)
6. Shoulders (level / dorsal higher than ventral)
7. Slope of shoulders (sloping abruptly/ ending in a long curve / rising and then rounded)
8. Fruit texture
9. Fruit neck prominence (absent/ slightly prominent/ prominent/ very prominent)
10. Stalk insertion
11. Peel colour
12. Waxiness
13. Adherence of peel to pulp

3.7.6.2 Other Fruit characters

1. Fruit length (cm)
2. Fruit breadth (cm)
3. Fruit weight (g)
4. Pulp weight (g)
5. Peel thickness
6. Peel weight
7. Pulp content- (ratio of pulp to skin + stone)

3.7.6.3 Pulp characters

1. Pulp colour
2. Pulp texture (juicy/ soft/ firm)
3. Fibre in pulp (present/ absent)
4. Pulp aroma (mild/ intermediate/ strong)
5. Turpentine flavor (absent/ mild/ intermediate/ strong)

3.7.6.4 Stone characters

1. Length (cm)
2. Breadth (cm)
3. Weight (g)
4. Thickness (mm)
5. Stone content
6. Veins (level with surface / depressed / elevated)
7. Pattern of venation (parallel / forked)
8. Quantity of fibre attached to stone (absent/low/intermediate/high)
9. Length of fibre (short/ medium/ long)

Oblong   Elliptic   Round   Ovoid   Obovoid

Fruit Shape

Absent   Shallow   Medium   Deep   Very deep

Depth of fruit stalk cavity

Acute   Obtuse   Round   Slopping abruptly   Ending in a long curve   Rising and then rounded

Shape of fruit apex   **Slope of fruit ventral shoulder**

Absent   Shallow   Deep   Perceptible   Pointed   Prominent   Mammiform

Fruit sinus type   **Fruit beak type**

Absent   Slightly prominent   Prominent   Very prominent

Fruit neck prominence

Fig 3.5: Classification of fruit characters based on IPGRI descriptor (2006)

3.7.6.5 Biochemical characters

Fruit pulp was weighed and analyzed for various quality parameters.

3.7.6.5.1 Acidity

Titrable acidity was estimated as per cent anhydrous citric using the procedure standardized by Ranganna (1977).

3.7.6.5.2 Total soluble solids

Total soluble solids present in the pulp was measured with the help of digital refractometer and expressed in percentage.

3.7.6.5.3 Total sugars and reducing sugars

Total sugars, reducing sugars and non reducing sugars were estimated by the Lane and Eynon method (Ranganna, 1986).

3.7.7 Maturity

Based on maturing of fruits for harvesting, the trees were classified as early, if the fruits attained maturity by February, as intermediate, if it was by March to May and as late, if it was by June onwards.

3.7.8 Yield

Number of fruits harvested per tree per year as reported by the farmers was recorded.

3.7.9 Polyembryony

Number of seedlings sprouted from each stone was recorded.

3.8 FINAL ROUND UP MEETINGS AT THE VILLAGES AND FOUR-CELL ANALYSIS

Final round up meetings and four cell analysis involving participatory farmers were conducted at Elanad, Pazhayannur, Vennur and Vadakkethara villages as a concluding follow up of initial FGDs and individual homestead /location visits taken up earlier for recording additional information on various aspects of the study and for filling any missing gaps in data documentation pertaining to this. Four-cell analysis is

a participatory tool standardized by Bioversity International (Walter and Marja, 2007) for

1. Identifying unique, common and rare types of crop species cultivated in a community.
2. Documenting the reasons why crop species or the types are in a dynamic stage within the community.
3. Facilitating the identification of the interventions of the crop species or types within a specific community.

Such meetings with farmers were undertaken at four locations namely Vadakkethara, Elanad, Pazhayannur and Vennur on 23.05.2015, 28.05.2015, 01.06.2015 and 06.06.2015 respectively.

Step 1: Resident farmers and other key persons of different villages were invited with a request to bring all the additional and relevant information on types of mango present in their homesteads and other crops grown by them.

Step 2: Meetings were initiated with an introduction on the importance of preserving the traditional mango diversity at the homestead level and public places in the villages. Data for the analysis was recorded from the participants while the discussion progressed.

Step 3: Additional information on the existing varietal richness / diversity and related aspects in the villages was measured using questions as mentioned below to the participants.

i.   What are the mango types grown in large numbers in many homesteads?
ii. What are the mango types grown in large numbers in few homesteads?
iii. What are the mango types grown in small numbers in many homesteads?
iv. What are the mango types grown in small numbers in few homesteads?

Step 4. All the local mango races grown in the homesteads in the villages were classified into a 2×2 matrix by distributing them in four different cells.

Mango types grown in large numbers in many homesteads	Mango types grown in small numbers in many homesteads
Mango types grown in large numbers in few homesteads	Mango types grown in small numbers in few homesteads

Step 5. After assigning the types into different cells, the existing situation of these varieties were analyzed in the context of their distribution within and between cell groups.

Step 6. The participant group in each of the village was requested to discuss the results to get an insight into the threatened mango type / variety in the village. The groups were also requested to suggest the remedial measures.

3.10 DIVERSITY ESTIMATES

Richness and evenness are the key measures of biological diversity. Richness refers to the number of types or varieties regardless of their frequencies and measured using type count per homesteads. Evenness compares the frequencies of the different types or varieties, with low evenness indicating dominance by one or a few types.

Evenness was calculated by the formula (Sthapit *et al.*, 2006)

$$\text{Evenness} = 1 - \frac{\sum [(V_1)^2 + \ldots\ldots\ldots\ldots\ldots\ldots + (V_n)^2]}{N^2}$$

V_n = No. of trees per variety or type

N = Total no. of trees

3.11 INDIGENOUS TRADITIONAL KNOWLEDGE (ITK)

Documented ITK, associated with mango land races of the region is predominantly /exclusively related to preparation of different products.

3.12 PREPARATION OF DIVERSITY REGISTERS FOR IDENTIFIED MANGO RACES AT THE DIFFERENT VILLAGES AND TRADITIONAL KNOWLEDGE DOCUMENTATION

Data recorded during the individual homestead visits and later supplemented at the village meetings was used for preparation of diversity registers. Housewives readily obliged to share the ITK and facilitated hands - on - demonstration of some homely traditional mango processing practices visual documentation of the same at selected locations. The register was primarily prepared for transmitting to the local body authority of Pazhayannur for keeping as a village level record of mango diversity of the region.

3.12.1 Data sheet for diversity register of mango land races at the village level

1. Name of the village
2. Basic information of the landrace spotted (local scientific and ethnic names).
3. Existence history at a given location. (year of introduction, address of locality)
4. From where the particular race came from. (original place, source of knowledge and materials)
5. Extent and distribution of diversity. (rare, common and widely grown)
6. Local techniques / traditional knowledge (practices that describe processing of products as related to varietal specificity.
7. Bearing history, uses and marketing channels
8. Information on custodians. (Name and address)
9. Incidence of pests / diseases / phanerogamic parasites

3.13 PERFORMANCE OF SELECTED MANGO LANDRACES UNDER CONTROLLED POLLINATION AND CROSSING

In order to assess the performance of selected promising landraces as parental material for crossing with Moovandan and Neelum as female parents, crossing was

undertaken at controlled conditions at the college orchard. The procedure as standardised by Regional Fruit Research Station, Vengurla, Maharashtra was adopted and it is presented as a flow diagram below.

3.13.1 Steps followed in controlled pollination

Selection of the male and female parents

↓

Selection of newly emerging panicles expected to open out next day on the female parent

↓

Bagging of panicle with a muslin cloth bags fully stretched and fixed with two rings and rods made of alumimium wire

↓

Removal of the male flowers and the fertile stamens in bisexual flowers in early morning hours of the day of pollination

↓

Collection and bringing of the panicles in bloom from the selected male parents in the field during late evening hours of the day prior to crossing and keeping them in the lab overnight with the cut end immersed in water to prevent dehydration and wilting.

↓

Collection of male flowers from these panicles in petri dishes in the early morning hours of the next day

↓

Keeping the covered petri dishes in sunlight for anther dehiscence

↓

Brushing of freshly dehisced anther of the male parent on the stigma of the emasculated bisexual flowers and dusting the pollen

↓

Covering of artificially pollinated panicles with muslin cloth bags

↓

Continuation of the artificial pollination on the flowers in other panicles on the same day so as to obtain 15-20 bisexual flowers getting pollinated ultimately

3.14 STATISTICAL ANALYSIS

Statistical tools *viz.*, snow ball sampling technique, four cell analysis techniques, frequency distribution and summary statistics were used for characterization of spotted mango landraces. Cluster analysis for these mango landraces done by using NTSYS software and "mahanolobis D^2". Principal component analysis, scatter plots, bi variate plots prepared with using MINITAB software version 21.

Chapter IV

Results

4. RESULTS

Results generated from the present studies on "Diversity mapping and characterization of landraces of mango (*Mangifera indica.* L)" implemented during 2012-2016 at Pazhayannur region of Thrissur district of Kerala and department of Pomology and Floriculture, College of Horticulture, Vellanikkara are presented component wise in this chapter.

COMPONENT- I

4.1 GIS BASED DIVERSITY MAPPING OF MANGO LANDRACES IN PAZHAYANNUR REGION AND THEIR SPATIAL DISTRIBUTION

Geographic locations of different seedling mango landraces (LR) which were spotted in the region via snow ball sampling method and their spatial distribution are depicted through a series of GIS based maps (Fig. 4.3 to 4.6) along with the corresponding tabulated field recorded geo co-ordinate readings (Table 4.1). Pazhayannur region blank shape file/ boundary file was used as a template to pin point the geo co-ordinates of such located LR (Fig 4.1). Along with this, a geographic profile broadly indicating the area under reserve forest and other commercial plantation / mono crops of this region is also provided as a supplementary background scenario (Fig. 4.2).

A total of 100 LRs could be located in the region and they were grouped in five GIS maps (Fig 4.1 and 4.3-4.6) primarily based on their geographical position/ locations / habitat and further demarcating to the different rural hamlets of the revenue villages of the region. The details are presented in tables 4.2a to 4.2d. The details of landraces spotted at the extended locations *viz.,* Panjal and Tiruvivalamala are also presented in table 4.2 e. Custodian farmer list of these 100 mango LRs is attached as Annexure-I.
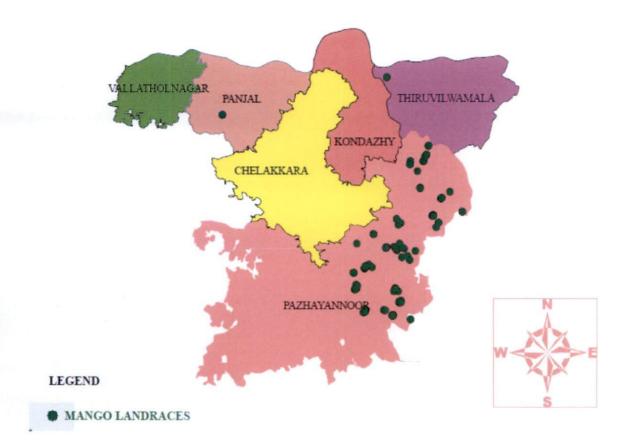
Fig. 4.1. Mapping of mango landraces of Pazhayannur by using ARC GIS (*Ver* 10.2.2) software

Fig. 4.2. Forestry and rubber area in Pazhayannur region (LRIS, 2016)

Table 4.1: Geo-co-ordinates of mango landraces located at Pazhayannur area

S.No	Accession.no	Latitude	Longitude	Name of the location	Name of the village
1	Acc 1	10° 36' 12.7"N	76° 24'21.8"E	Maruthampadam	Elanad
2	Acc 2	10° 36' 11.9" N	76° 24' 19.6"E	Maruthampadam	Elanad
3	Acc 3	10° 36' 12.0" N	76° 24' 20.7"E	Maruthampadam	Elanad
4	Acc 4	10° 36' 11.2" N	76° 24' 20.2"E	Maruthampadam	Elanad
5	Acc 5	10° 36' 11.2" N	76° 24' 20.9"E	Maruthampadam	Elanad
6	Acc 6	10° 36' 11.4" N	76° 24' 20.3"E	Maruthampadam	Elanad
7	Acc 7	10° 36' 10.9" N	76° 24' 20.7"E	Maruthampadam	Elanad
8	Acc 8	10° 36' 11.6" N	76° 24' 21.2"E	Maruthampadam	Elanad
9	Acc 9	10° 36' 22.5" N	76° 24' 02.3"E	Maruthampadam	Elanad
10	Acc 10	10° 36' 22.3" N	76° 24' 05.6"E	Maruthampadam	Elanad
11	Acc 11	10° 37' 12.0" N	76° 23' 05.0"E	Neelumpaliyal	Elanad
12	Acc 12	10° 37' 11.0" N	76° 23' 05.5"E	Neelumpaliyal	Elanad
13	Acc 13	10° 37' 14.6" N	76° 23' 04.3"E	Neelumpaliyal	Elanad
14	Acc 14	10° 37' 12.5" N	76° 23' 06.7"E	Neelumpaliyal	Elanad
15	Acc 15	10° 37' 04.3" N	76° 23' 01.3"E	Karimakuzhy	Elanad
16	Acc 16	10° 37' 04.8" N	76° 23' 02.5"E	Karimakuzhy	Elanad
17	Acc 17	10° 37' 07.1" N	76° 23' 06.1"E	Karimakuzhy	Elanad
18	Acc 18	10° 37' 05.4" N	76° 23' 03.4"E	Karimakuzhy	Elanad
19	Acc 19	10° 37' 38.5" N	76° 22'58.9"E	Thrikkanaya	Elanad
20	Acc 20	10° 37' 39.2" N	76° 22' 59.6"E	Thrikkanaya	Elanad
21	Acc 21	10° 37' 39.0" N	76° 22' 58.8"E	Thrikkanaya	Elanad
22	Acc 22	10° 37' 49.6" N	76° 23' 22.3"E	Paruthipra	Elanad
23	Acc 23	10° 37' 50.6" N	76° 23' 37.6"E	Paruthipra	Elanad
24	Acc 24	10° 37' 48.8" N	76° 23' 22.3"E	Meenakshipath	Elanad
25	Acc 25	10° 37' 47.4" N	76° 23' 21.9"E	Meenakshipath	Elanad
26	Acc 26	10° 37' 48.9" N	76° 23' 21.9"E	Meenakshipath	Elanad
27	Acc 27	10° 37' 55.8" N	76° 23' 30.9"E	Paruthipra	Elanad
28	Acc 28	10° 37' 50.1" N	76° 23' 23.6"E	Meenakshipath	Elanad
29	Acc 29	10° 37' 52.7" N	76° 23' 23.6"E	Meenakshipath	Elanad
30	Acc 30	10° 36' 23.4" N	76° 23' 23.7"E	Velladi	Elanad
31	Acc 31	10° 36' 23.2" N	76° 23' 24.1"E	Velladi	Elanad
32	Acc 32	10° 36' 17.1" N	76° 23' 20.0"E	Velladi	Elanad

Table 4.1: Geo-co-ordinates of mango landraces located at Pazhayannur area (conti.)

S.No	Accession.no	Latitude	Longitude	Name of the location	Name of the village
33	Acc 33	10° 36' 12.7" N	76° 23' 19.9"E	Velladi	Elanad
34	Acc 34	10° 36' 12.7" N	76° 23' 23.5"E	Velladi	Elanad
35	Acc 35	10° 36' 12.7" N	76° 23' 23.0"E	Velladi	Elanad
36	Acc 36	10° 36' 39.0" N	76° 24' 35.6"E	Kannasserykalam	Elanad
37	Acc 37	10° 36' 37.7" N	76° 24' 34.1"E	Kannasserykalam	Elanad
38	Acc 38	10° 36' 41.9" N	76° 24' 38.8"E	Kannasserykalam	Elanad
40	Acc 40	10° 36' 37.9" N	76° 24' 38.3"E	Kannasserykalam	Elanad
41	Acc 41	10° 37' 00.8" N	76° 24' 32.4"E	Muthalamkode	Elanad
42	Acc 42	10° 37' 07.4" N	76° 24' 25.9"E	Muthalamkode	Elanad
43	Acc 43	10° 37' 00.8" N	76° 24' 23.6"E	Muthalamkode	Elanad
44	Acc 44	10° 37' 06.3" N	76° 24' 27.4"E	Muthalamkode	Elanad
45	Acc 45	10° 38' 25.2" N	76° 24' 30.0"E	Vennur	Vennur
46	Acc 46	10° 38' 11.1" N	76° 24' 40.6"E	Manchadi	Vennur
47	Acc 47	10° 36' 03.8" N	76° 24' 58.4"E	Manchadi	Vennur
48	Acc 48	10° 38' 13.4" N	76° 24' 52.1"E	Manchadi	Vennur
49	Acc 49	10° 38' 32.8" N	76° 24' 24.1"E	Vennur	Vennur
50	Acc 50	10° 38' 05.6" N	76° 24' 56.9"E	Manchadi	Vennur
51	Acc 51	10° 38' 30.4" N	76° 24' 07.0"E	Vennur	Vennur
52	Acc 52	10° 38' 31.5" N	76° 24' 08.4"E	Vennur	Vennur
53	Acc 53	10° 38' 31.4" N	76° 24' 08.7"E	Vennur	Vennur
54	Acc 54	10° 38' 30.9" N	76° 24' 07.0"E	Vennur	Vennur
55	Acc 55	10° 38' 39.1" N	76° 23' 26.2"E	Vendokinparambu	Vennur
56	Acc 56	10° 38' 39.3" N	76° 23' 36.2"E	Vendokinparambu	Vennur
57	Acc 57	10° 38' 58.7" N	76° 23' 40.3"E	Kuzhikakulambu	Vennur
58	Acc 58	10° 38' 58.2" N	76° 23' 42.0"E	Kuzhikakulambu	Vennur
59	Acc 59	10° 38' 24.1" N	76° 25' 09.0"E	Vattapara	Vennur
60	Acc 60	10° 38' 29.0" N	76° 24' 45.5"E	Vattapara	Vennur
61	Acc 61	10° 38' 31.2" N	76° 24' 41.4"E	Vattapara	Vennur
62	Acc 62	10° 38' 28.9" N	76° 24' 27.6"E	Vennur	Vennur
63	Acc 63	10° 38' 29.5" N	76° 24' 28.0"E	Vennur	Vennur
64	Acc 64	10° 39' 35.9" N	76° 25' 44.3"E	Potta	Pazhayannur

Table 4.1: Geo-co-ordinates of mango landraces located at Pazhayannur area (conti)

S.No	Accession.no	Latitude	Longitude	Name of the location	Name of the village
65	Acc 65	10° 39' 37.9" N	76° 25' 46.8"E	Potta	Pazhayannur
66	Acc 66	10° 39' 37.5" N	76° 25' 46.4"E	Potta	Pazhayannur
71	Acc 71	10° 40' 11.4" N	76° 26' 03.1"E	Neelichira	Pazhayannur
72	Acc 72	10° 40' 13.0" N	76° 26' 04.3"E	Neelichira	Pazhayannur
73	Acc 73	10° 40' 13.2" N	76° 26' 04.7"E	Neelichira	Pazhayannur
74	Acc 74	10° 40' 25.9" N	76° 26' 22.0"E	Kallepadam	Pazhayannur
75	Acc 75	10° 39' 21.5" N	76° 24' 38.3"E	Kumbalamkode	Pazhayannur
76	Acc 76	10° 39' 17.8" N	76° 24' 32.8"E	Kumbalamkode	Pazhayannur
77	Acc 77	10° 39' 29.9" N	76° 24' 29.2"E	Kumbalamkode	Pazhayannur
78	Acc 78	10° 39' 44.3" N	76° 26' 47.6"E	Plazhy	Pazhayannur
79	Acc 79	10° 39' 45.1" N	76° 26' 47.7"E	Plazhy	Pazhayannur
80	Acc 80	10° 40' 34.1" N	76° 25' 19.6"E	Pazhayannur	Pazhayannur
81	Acc 81	10° 40' 33.9" N	76° 25' 19.5"E	Pazhayannur	Pazhayannur
82	Acc 82	10° 40' 33.2" N	76° 25' 19.5"E	Pazhayannur	Pazhayannur
83	Acc 83	10° 41' 07.5" N	76° 25' 14.1"E	Vadakkethara	Vadakkethara
84	Acc 84	10° 41' 28.5" N	76° 25' 26.4"E	Vadakkethara	Vadakkethara
85	Acc 85	10° 41' 28.3" N	76° 25' 26.2"E	Vadakkethara	Vadakkethara
86	Acc 86	10° 41' 28.8" N	76° 25' 26.4"E	Vadakkethara	Vadakkethara
87	Acc 87	10° 41' 59.7" N	76° 25' 36.9"E	Cheerakuzhy	Vadakkethara
88	Acc 88	10° 42' 00.1" N	76° 25' 37.8"E	Cheerakuzhy	Vadakkethara
89	Acc 89	10° 41' 38.0" N	76° 25' 29.5"E	Vattapara	Vadakkethara
90	Acc 90	10° 41' 40.4" N	76° 25' 32.0"E	Vattapara	Vadakkethara
91	Acc 91	10° 41' 42.0" N	76° 25' 32.7"E	Vattapara	Vadakkethara
92	Acc 92	10° 41' 28.6" N	76° 24' 59.2"E	Puthirithara	Vadakkethara
93	Acc 93	10° 41' 21.7" N	76° 24' 57.9"E	Puthirithara	Vadakkethara
94	Acc 94	10° 41' 21.8" N	76° 24' 57.6"E	Puthirithara	Vadakkethara
95	Acc 95	10° 44' 20.4" N	76° 24' 09.7"E	Kuthampully	Tiruvilvamala
96	Acc 96	10° 44' 20.4" N	76° 24' 09.8"E	Kuthampully	Tiruvilvamala
97	Acc 97	10° 44' 20.3" N	76° 24' 09.6"E	Kuthampully	Tiruvilvamala
98	Acc 98	10° 43' 03.1" N	76° 18' 25.1"E	Painkulam	Panjal
99	Acc 99	10° 43' 03.4" N	76° 18' 25.3"E	Painkulam	Panjal
100	Acc 100	10° 44' 51.6" N	76° 18' 40.4"E	Painkulam	Panjal

4.1.1 GIS based diversity mapping of mango landraces in Elanad village of Pazhayannur.

Elanad is a major revenue village in Pazhayannur GP where a sizable land area is occupied by reserve forest .It was also noted that the area under commercial plantation crops especially rubber has also expanded / getting expanded like anything in this region and such a ruthless mono cropping paving way for a loss of many landraces of different crops including mango. Nevertheless , present exploration in this region resulted in locating 44 mango LRs spread over the different hamlets of the village *viz.,* Maruthampadam, Neelumpaliyal, Karimkuzhy, Thrikkanaya, Paruthipra, Meenakshipath , Velladi , Kannasserykalam and Muthalamkode. (Fig 4.3., Table 4.2 a.). Out of this , ten LRs were located at Maruthampadam (Acc 1 to Acc 10), four LRs at Neelumpaliyal (Acc 11 to Acc 14), four LRs at Karimkuzhy (Acc 15 to Acc 18), three at Thrikkanaya (Acc 19 to Acc 21) and Paruthipra (Acc 22, Acc 23 and Acc 27), five LRs at Meenakshipath (Acc 24, Acc 25, Acc 26,Acc 28 and Acc 29), six LRs at Velladi, (Acc 30 to Acc 35), five LRs from Kannasserykalam (Acc 36 to Acc40) and four LRs from Muthalamkode. (Acc 41 to Acc 44).

4.1.2 GIS based diversity mapping of mango landraces in Vennur village of Pazhayannur

A total number of 19 mango landraces were spotted in different locations at Vennur (Fig 4.4., Table 4.2 b). Out of 19, eight accesssions located at Vennur (Acc 45, 49, 51 to 54, 62 and 63), four accessions from Manchadi (Acc 46, 47, 48 and Acc 50), two accessions each from Vendokinparambu (Acc 55 and Acc 56) and Kuzhikakulambu (Acc 57 and Acc 58) and three accessions from Vattapara (Acc 59 to Acc 61).

4.1.3 GIS based diversity mapping of mango landraces in Pazhayannur village of Pazhayannur

A total number of 19 mango landraces were located in different locations at Pazhayannur (Fig 4.5., Table 4.2 c). Out of 19, seven accessions at Potta (Acc 64 to Acc 70), three accessions from Neelichera (Acc 71 to Acc 73), one accession from

FIG. 4.3 MAPPING OF MANGO LANDRACES AT DIFFERENT HAMLETS OF ELANAD

FIG. 4.4 MAPPING OF MANGO LANDRACES AT DIFFERENT HAMLETS OF VENNUR

LEGEND

MANGO LANDRACES
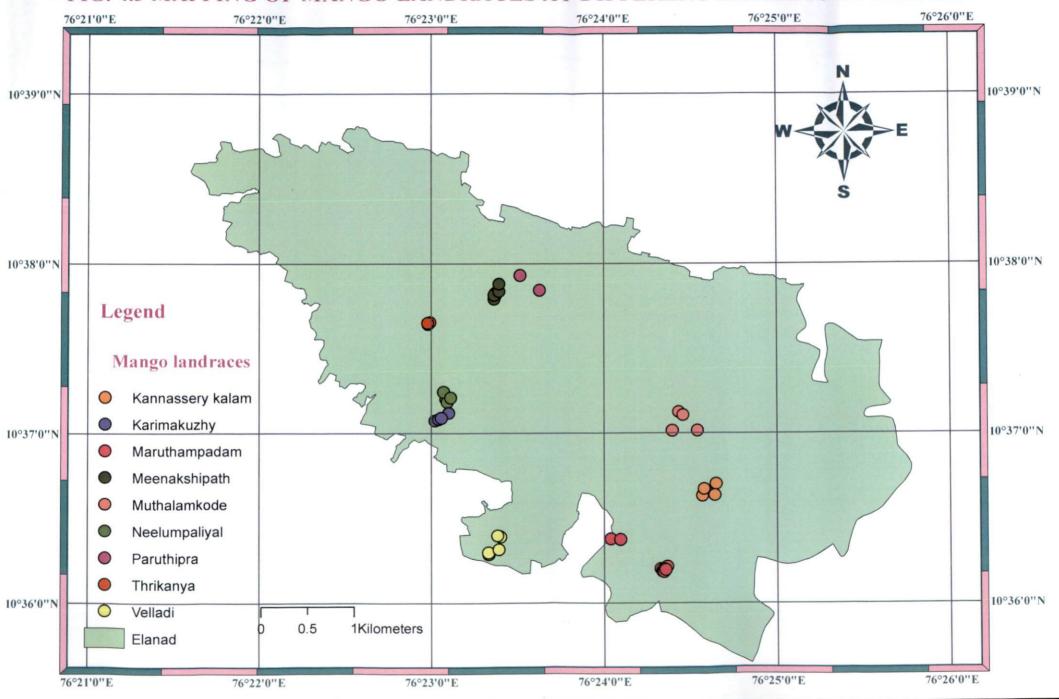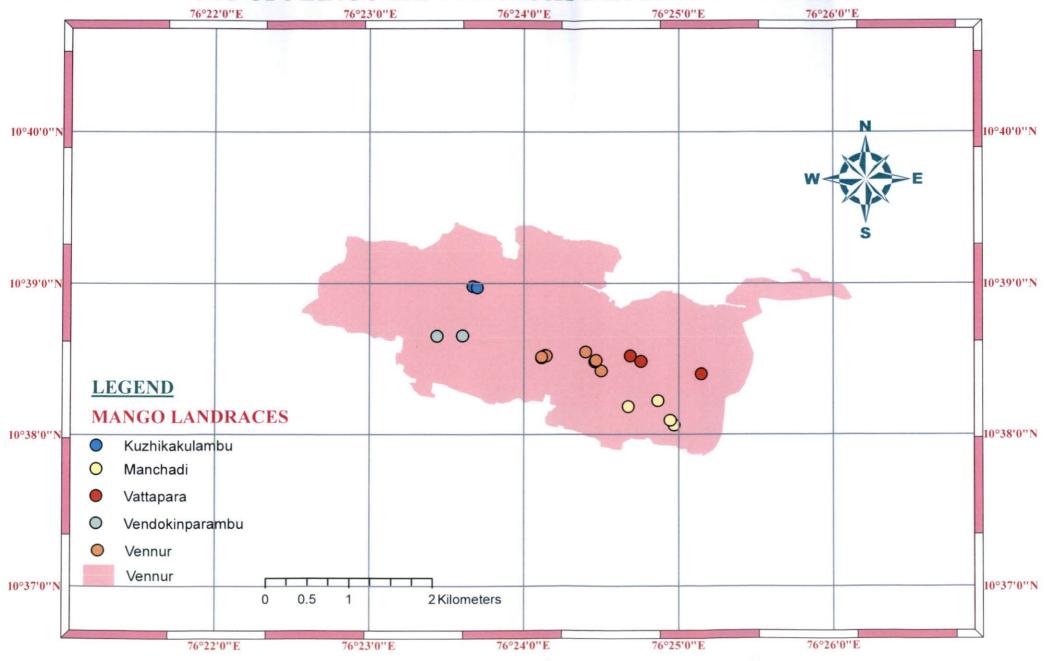
- Kuzhikakulambu
- Manchadi
- Vattapara
- Vendokinparambu
- Vennur
- Vennur

Kallepadam (Acc 74), three accessions from Kumbalamkode (Acc 75 to Acc 77), two accessions from Plazhy (Acc 78 and Acc 79) and three accessions from Pazhayannur (Acc 80 to Acc 82).

4.1.4 GIS based diversity mapping of mango landraces in Vadakethara village of Pazhayannur

Altogether 12 accessions were spotted from Vadakkethara village (Fig 4.6., Table 4.2d) and out of this, seven accessions from Vadakathara (Acc 83 to Acc 86 and Acc 89 to Acc 91), two accessions from Cheerakuzhy (Acc 87 to Acc 88) and three accessions from Puthirithara (Acc 92 to Acc 94)

4.1.5 GIS based diversity mapping of mango landraces in extended survey locations in Koothampilly (Thiruvilvamala) and Painkulam (Panjal)

One homestead in Koothampilly, Tiruwallamala and three homesteads in Painkulam in Panjal areas were also surveyed as extended locations for locating few rare LRs and accordingly collected six accessions from these locations. (Acc 95 to Acc 100).

Table 4.2 a: Distribution of mango landraces in different hamlets of Elanad

S. No	Major Village	Hamlets	Accessions	Number spotted	Frequency
1	Elanad	Maruthampadam	Acc 1 to Acc 10	10	22.73
2		Neelumpaliyal	Acc 11 to Acc 14	4	9.09
3		Karimkuzhy	Acc 15 to Acc 18	4	9.09
4		Thrikkanaya	Acc 19 to Acc 21	3	6.82
5		Paruthipra	Acc 22,23 and 27	3	6.82
6		Meenakshipath	Acc 24,25,26,28 and 29	5	11.36
7		Velladi	Acc 30 to Acc 35	6	13.64
8		Kannasserykalam	Acc 36 to Acc40	5	11.36
9		Muthalamkode	Acc 41 to Acc 44	4	9.09
			Total	44	

FIG. 4.5 MAPPING OF MANGO LANDRACES AT DIFFERENT HAMLETS OF PAZHAYANNUR

LEGEND

MANGO LANDRACES

- Kallepadam
- Kumbalamkode
- Nelichira
- Pazhayannur
- Plazhy
- Potta
- Pazhayannur
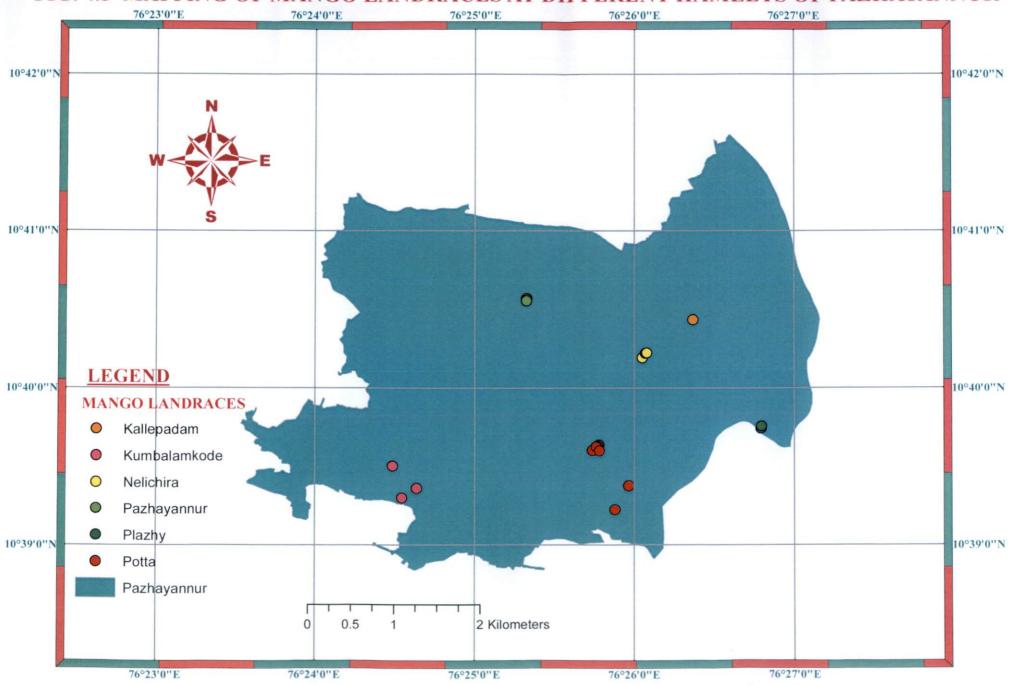
FIG. 4.6 MAPPING OF MANGO LANDRACES AT DIFFERENT HAMLETS OF VADAKKATHARA

LEGEND

Mango landraces

- Cherakuzhy
- Puthirithara
- Vadakkathara
- Vattapara
- Vadakkethera
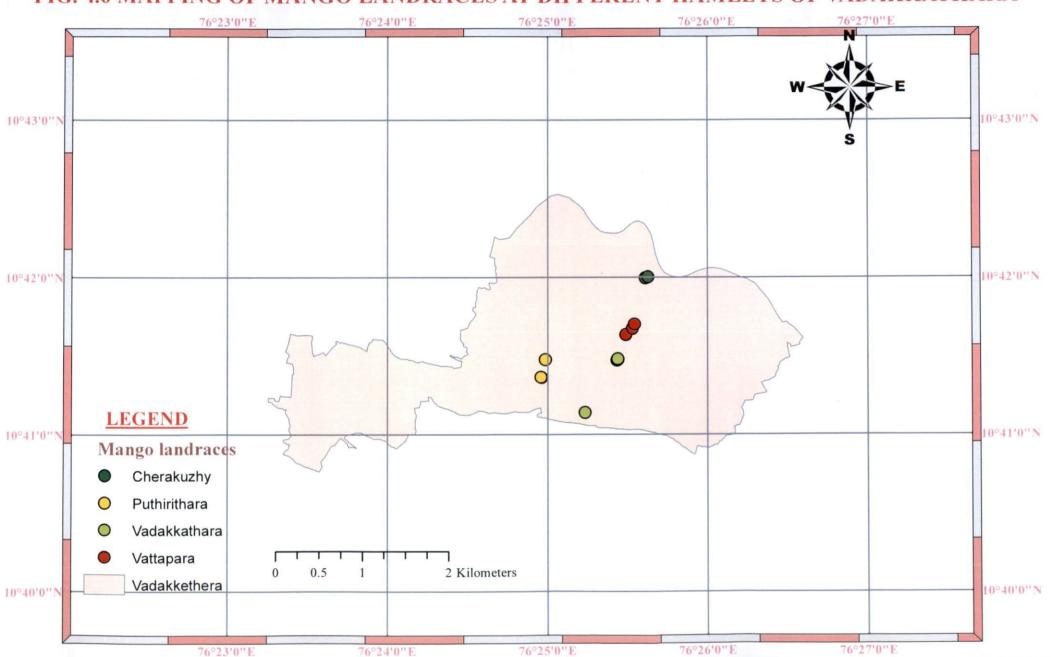
Table 4.2 b: Distribution of mango landraces in different hamlets of Vennur

S.No	Major Village	Hamlets	Accessions	Number spotted	Frequency
1	Vennur	Vennur	Acc 45,49, 51 to 54, 62 and 63	8	42.10
2		Manchadi	Acc 46,47,48 and Acc 50	4	21.05
3		Vendokinparambu	Acc 55 and Acc 56	2	10.53
4		Kuzhikakulambu	Acc 57 and Acc 58	2	10.53
5		Vattapara	Acc 59 to Acc 61	3	15.79
			Total	19	

Table 4.2 c: Distribution of mango landraces in different hamlets of Pazhayannur

S.No	Major Village	Hamlets	Accessions	Number spotted	Frequency
1	Pazhayannur	Potta	Acc 64 to Acc 70	7	36.84
2		Neelichera	Acc 71 to Acc 73	3	15.78
3		Kallepadam	Acc 74	1	52.63
4		Kumbalamkode	Acc 75 to Acc 77	3	15.78
5		Plazhy	Acc 78 and Acc 79	2	10.52
6		Pazhayannur	Acc 80 to Acc 82	3	15.78
			Total	19	

Table 4.2 d: Distribution of mango landraces in different hamlets of Vadakkethara

S.No	Major Village	Hamlets	Accessions	Number spotted	Frequency
1	Vadakathara	Vadakathara	Acc 83 to Acc 86 and Acc 89 to Acc 91	7	58.33
2		Cheerakuzhy	Acc 87 to Acc 88	2	16.67
		Puthirithara	Acc 92 to Acc 94	3	25
			Total	12	

Table 4.2 e: Distribution of mango landraces in Panjal and Tiruvilvamala

S.No	Major Village	Villages	Accessions	Number spotted	Frequency
1	Tiruvilvamala	Koothampilly	Acc 95 to Acc 97	3	50
2	Panjal	Painkulam	Acc 98 to Acc 100	3	50
			Total	6	

4.1.6 Habitat description and cropping pattern in the mango LR locations in Elanad village

Habitat description and basic features of the LRs spotted at Elanad village is furnished in the table 4.3. The spotted locations of the LRs in the village was predominantly homestead compounds and in few locations such trees were bordering paddy fields and with a characteristic luxuriant growth. In an isolated location we could also spot a LR on the boundary of forest and farmland (Acc.13).

Table 4.3. Habitat features of mango landraces spotted at Elanad village

S.No	Mango LR's	Local name	Site details	Hamlet	Details of location
1	Acc 1	Gundu manga	Homestead	Maruthampadam	Homestead back yard along with other tree species
2	Acc 2	Neela manga	Homestead	Maruthampadam	
3	Acc 3	Enna Moovandan	Homestead	Maruthampadam	
4	Acc 4	Pacha manga Marathakam	Homestead	Maruthampadam	
5	Acc 5	-	Homestead	Maruthampadam	
6	Acc 6	Kanni manga	Homestead	Maruthampadam	
7	Acc 7	Cheriyamoovandan	Homestead	Maruthampadam	
8	Acc 8	Ammini Pulichi	Homestead	Maruthampadam	
9	Acc 9	Nadan mavu	Homestead	Maruthampadam	
10	Acc 10	-	Homestead	Maruthampadam	
11	Acc 11	-	Homestead	Neelumpaliyal	Homestead front yard
12	Acc 12	-	Homestead	Neelumpaliyal	
13	Acc 13	Kattu mavu	Homestead	Neelumpaliyal	Forest boundary
14	Acc 14	Puliyan mavu	Homestead	Neelumpaliyal	Homestead front yard
15	Acc 15	Sundhari mavu	Homestead	Karimakuzhy	Homestead backyard intermingled with other tree species
16	Acc 16	-	Homestead	Karimakuzhy	
17	Acc 17	-	Homestead	Karimakuzhy	
18	Acc 18	-	Homestead	Karimakuzhy	Homestead front yard

Table 4.3. Habitat features of mango land races spotted at Elanad village (cont.)

S.No	Mango LR's	Local name	Site details	Hamlet	Details of location
19	Acc 19	Kilichundan -1	Homestead	Thrikkanaya	Homestead front yard
20	Acc 20	Kilichundan - 2	Homestead	Thrikkanaya	Homestead front yard
21	Acc 21	-	Homestead	Thrikkanaya	Homestead front yard
22	Acc 22	Karpura manga	Homestead	Paruthipra	Homestead in the middle of Paddy field
23	Acc 23	Chindhura manga	Homestead	Paruthipra	Homestead in the middle of Paddy field
24	Acc 24	Puliyan	Homestead	Meenakshipath	Multicrop component
25	Acc 25	Kalapadi	Homestead	Meenakshipath	Multicrop component
26	Acc 26	Kalapadi	Homestead	Meenakshipath	Multicrop component
27	Acc 27	Perakkamavu	Homestead	Paruthipra	Multicrop component
28	Acc 28	-	Homestead	Meenakshipath	Adjacent to Paddy field
29	Acc 29	Pulichi	Homestead	Meenakshipath	Adjacent to Paddy field
30	Acc 30	Naaran manga	Homestead	Velladi	Multicrop component
31	Acc 31	-	Homestead	Velladi	Multicrop component
32	Acc 32	Thean manga	Homestead	Velladi	Multicrop component
33	Acc 33	Gomanga	Homestead	Velladi	Multicrop component
34	Acc 34	-	Homestead	Velladi	Multicrop component
35	Acc 35	-	Homestead	Velladi	Multicrop component
36	Acc 36	-	Homestead	Kannasserykalam	Multicrop component
37	Acc 37	-	Homestead	Kannasserykalam	Multicrop component
38	Acc 38	-	Homestead	Kannasserykalam	Multicrop component
39	Acc 39	-	Homestead	Kannasserykalam	Multicrop component
40	Acc 40	-	Homestead	Kannasserykalam	Multicrop component
41	Acc 41	-	Homestead	Muthalamkode	Multicrop component
42	Acc 42	-	Homestead	Muthalamkode	Multicrop component
43	Acc 43	-	Homestead	Muthalamkode	Multicrop component
44	Acc 44	-	Homestead	Muthalamkode	Multicrop component

4.1.6.1 Crop diversity status of Elanad village

Crop diversity pattern indicated cultivation of crops like coconut, areca nut , banana, rice, cassava, vegetables and a variety of crops in the immediate peripheries (Fig 4.7). Mango is invariably one among the components in such a poly crop system. Large area in outer periphery of the homesteads is being converted for cultivation of rubber.
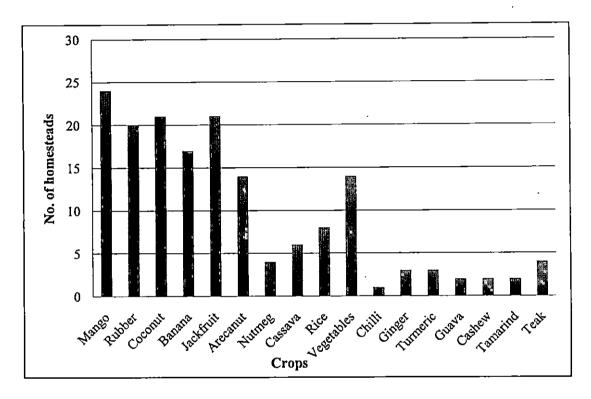
Fig. 4.7. Crop diversity status of Elanad village

4.1.7 Habitat description and cropping pattern in the mango LR locations in Vennur village.

Habitat description and basic features of the LRs spotted at Vennur village is furnished in the table 4.4. The spotted locations of the LRs in the village was predominantly homestead compounds and some such trees were bordering paddy fields. In certain locations we could spot LR adjoining rubber plantations which are engulfing a sizable land area including the conventional homesteads.

Table 4.4. Habitat features of mango land races spotted at Vennur village

S.No	Mango LR's	Local name	Site details	Hamlet	Details of location
1	Acc 45	Pachhamuvandan	Homestead	Vennur	Homestead front yard
2	Acc 46	-	Homestead	Manchadi	Multicrop component
3	Acc 47	-	Homestead	Manchadi	Homestead front yard
4	Acc 48	-	Homestead	Manchadi	Homestead front yard
5	Acc 49	-	Homestead	Vennur	Multiple crop
6	Acc 50	-	Homestead	Manchadi	Infront of homestead
7	Acc 51	-	Homestead	Vennur	Monocrop
8	Acc 52	-	Homestead	Vennur	Monocrop
9	Acc 53	-	Homestead	Vennur	Monocrop
10	Acc 54	Nadasala	Homestead	Vennur	Monocrop
11	Acc 55	-	Homestead	Vendokinparambu	With rubber plantation
12	Acc 56	-	Homestead	Vendokinparambu	Infront of homestead
13	Acc 57	Attanari	Homestead	Kuzhikakulambu	Infront of homestead
14	Acc 58	Sapota mavu	Homestead	Kuzhikakulambu	Infront of homestead
15	Acc 59	Vella moovandan	Homestead	Vattapara	Infront of homestead
16	Acc 60	-	Homestead	Vattapara	Infront of homestead
17	Acc 61	-	Homestead	Vattapara	Infront of homestead
18	Acc 62	-	Homestead	Vennur	Infront of homestead
19	Acc 63	Chindoora manga	Homestead	Vennur	Infront of homestead

4.1.7.1 Crop diversity status of Vennur village

Crop diversity pattern indicated cultivation of crops like coconut, areca nut, banana, rice, cassava, vegetables and a variety of crops in the immediate peripheries. Here also mango is invariably one among the components in such a poly crop system.
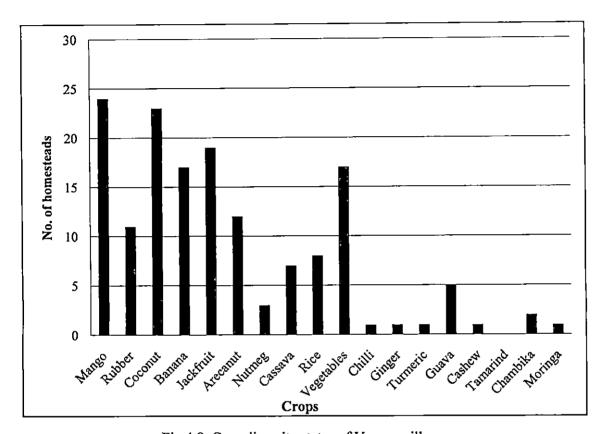
Fig 4.8. Crop diversity status of Vennur village

4.1.8 Habitat description and cropping pattern in the mango LR locations in Pazhayannur village

Habitat description and basic features of the LRs spotted at Pazhayannur village is furnished in the table 4.5. The spotted locations in the village were predominantly homestead compounds.

Table 4.5. Habitat features of mango landraces spotted at Pazhayannur village

S.No	Mango LR's	Local name	Site details	Hamlet	Details of location
1	Acc 64	-	Homestead	Potta	Road side attached to paddy field
2	Acc 65	-	Homestead	Potta	Multicrop component
3	Acc 66	-	Homestead	Potta	Multicrop component
4	Acc 67	Kannimanga	Homestead	Potta	Multicrop component
5	Acc 68	-	Homestead	Potta	Multicrop component
6	Acc 69	-	Homestead	Potta	Mono cropping
7	Acc 70	-	Homestead	Potta	Monocropping
8	Acc 71	-	Homestead	Neelichira	Infront of homestead
9	Acc 72	-	Homestead	Neelichira	Infront of homestead
10	Acc 73	Panchasara mavu	Homestead	Neelichira	Infront of homestead
11	Acc 74	-	Homestead	Kallepadam	Infront of homestead
12	Acc 75	-	Homestead	Kumbalamkode	Multiple cropping
13	Acc 76	-	Homestead	Kumbalamkode	Infront of homestead
14	Acc 77	-	Homestead	Kumbalamkode	Infront of homestead
15	Acc 78	-	Homestead	Plazhy	Multicrop component
16	Acc 79	Vellari mavu	Homestead	Plazhy	Multicrop component
17	Acc 80	-	Homestead	Pazhayannur	Monocropping
18	Acc 81	-	Homestead	Pazhayannur	Monocropping
19	Acc 82	-	Homestead	Pazhayannur	Monocropping

4.1.8.1 Crop diversity status of Pazhayannur village

Crop diversity pattern of the village indicated cultivation of crops like coconut, areca nut, banana, rice, cassava, vegetables and a miscellany of crops in the immediate peripheries (Fig 4.9). Here also mango is invariably one among the components in such a poly crop system.
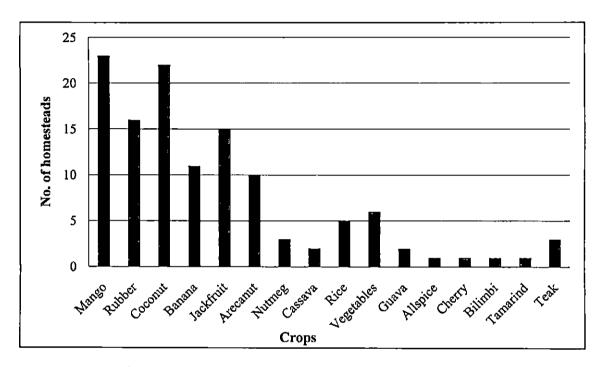
Fig 4.9. Crop diversity status of Pazhayannur village

4.1.9 Habitat description and cropping pattern in the mango LR locations in Vadakkethara village.

Habitat description and basic features of the LRs spotted at Vadakkethara village is furnished in the table 4.6. The spotted locations of the LRs in the village were predominantly homestead compounds and few public places.

Table 4.6. Habitat features of mango land races spotted at Vadakkethara village

S.No	Mango LR's	Local name	Site details	Hamlet	Details of location
1	Acc 83	Karpoora mavu	Temple palace compound	Vadakkethara	Single tree in the Pazhayannur temple compound.
2	Acc 84	-	Homestead	Vadakkethara	Multicrop component
3	Acc 85	Swarnamookkan	Homestead	Vadakkethara	Multicrop component
4	Acc 86	-	Homestead	Vadakkethara	Multicrop component
5	Acc 87	Chakiriyan	College of Applied science	Cheerakuzhy	College campus on Gayathri puzha river bank
6	Acc 88	-		Cheerakuzhy	
7	Acc 89	-	Homestead	Vattapara	Infront of homestead
8	Acc 90	-	Homestead	Vattapara	Infront of homestead
9	Acc 91	-	Homestead	Vattapara	Infront of homestead
10	Acc 92	-	Homestead	Puthirithara	Infront of homestead
11	Acc 93	-	Homestead	Puthirithara	Infront of homestead
12	Acc 94	-	Homestead	Puthirithara	Infront of homestead

4.1.9.1 Crop diversity status of Vadakkethara village

Crop diversity pattern indicated cultivation of crops like coconut, arecanut, banana, rice, cassava, vegetables and a miscellany of crops in the immediate peripheries (Fig 4.10). Here also mango is invariably one among the components in such a poly crop system. We could also spot a few age old LRs at public places like temple compound and college campus.
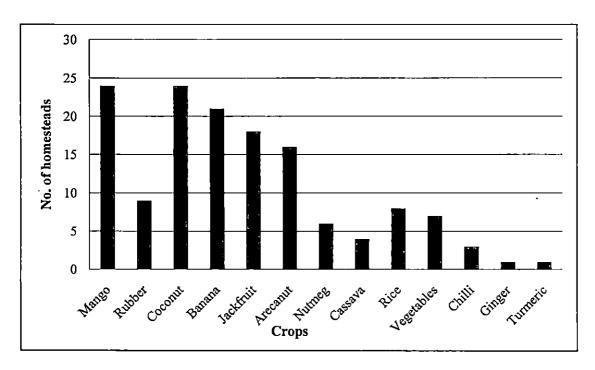
Fig 4.10. Crop diversity status of Vadakkethara village

4.1.10 Habitat description of mango LRs spotted in extended locations of survey at Panjal and Tiruvilvamala.

Habitat description and basic features of the LRs spotted at extended locations of survey at Kuthampilly in Thiruvilvamala and Painkulam village in Panjal are furnished in the table 4.7.

Table 4.7. Habitat features of mango landraces spotted at Panjal and Tiruvilvamala

S.No	Mango LR's	Local name	Site details	Hamlet	Details of location
1	Acc 95	Chandrakaran	Homestead	Kuthampilly Tiruvilvamala	Homestead back yard near paddy field
2	Acc 96	Pudhuvaya mavu	Homestead	Kuthampilly Tiruvilvamala	Homestead back yard near paddy field
3	Acc 97	-	Homestead	Kuthampilly Tiruvilvamala	Homestead back yard
4	Acc 98	Ezikode moovandan	Homestead	Painkulam	Homestead front yard on Bharathapuzha (river) bank
5	Acc 99	Chandrakkaran	Homestead	Painkulam	
6	Acc 100	Nattumavu	Homestead	Painkulam	

Neelichera

Cheerakuzhy (Gayathri river)

Potta

Painkulam (Bharathapuzha canal)

Plate 4.1. Eco geographical indicators of hamlets of Pazhayannur region

COMPONENT- II

4.2 MORPHOLOGICAL CHARACTERIZATION OF MANGO LANDRACES

Morphological characterisation of the hundred mango landraces spotted during the survey was undertaken pertaining to the different quantitative and qualitative parameters vide mango descriptor, IPGRI (2006).

4.2.1 Tree characters

Table 4.8 shows the frequency distribution of mango landraces under study for tree characters (Annexure –II) and the figures can be presented as follows.

Table 4.8 Frequency distribution of mango landraces in terms of tree age, height and growth habit characters

Morphological descriptor	Type of descriptor	Frequency (%)
Age (years)	< 20	43
	20 - 40	30
	40 - 60	17
	60 - 80	4
	80 - 100	2
	> 100	4
Height (m)	Short (≤ 6 m)	13
	Medium (6.1-9 m)	21
	Tall (9.1-12 m)	13
	Very tall (> 12 m)	53
Tree growth habit	Erect	39
	Spreading	53
	Drooping	8

4.2.1.1 Age

The trees were grouped into 6 categories according to age distribution. Age of the trees, surveyed spanned over the range of less than 20 years to more than 100 years and has facilitated the study in a better dimension. Forty three percent of the trees surveyed belong to the age group of less than 20 years, narrowing to a meagre share of 6 percent trees aged 80 years or more. There were 30 trees under the age group of 20-40 years and 17 trees of age group of 60-80 years.

4.2.1.2 Height

The trees were grouped based on height into four categories *viz.*, short (≤ 6 m), medium (6.1-9 m), tall (9.1-12 m) and very tall (>12 m). As such 53 trees were very tall in nature, 21 trees were medium height, short and tall categories had 13

Plate 4.2 Hundred year old trees located at Pazhayannur

trees each.

4.2.1.3 Tree growth habit

The growth habit of trees was studied and accordingly the LRs were grouped into 3 categories, *viz.,* erect, spreading and drooping. Fifty three accessions has shown spreading habit, thirty nine accessions were of erect habit, and eight accessions were of drooping habit.

4.2.2 Leaf characters

Table 4.9 shows the frequency distribution of the selected leaf characters as presented below vide annexure –III.

Table 4.9 Frequency distribution of mango landraces for leaf characters

Morphological descriptor	Type of descriptor	Frequency (%)
Orientation of leaf	Semi erect	9
	Horizontal	78
	Semi drooping	13
Leaf shape	Oblong	60
	Elliptic	34
	Lanceolate	5
	Ovate	1
Leaf tip	Acute	16
	Acuminate	84
Leaf base	Acute	57
	Acuminate	43
Leaf margin	Entire	74
	Wavy	26
Leaf texture	Chartaceous	46
	Coriaceous	40
	Membranous	14
Colour of young leaves	Light green	36
	Light green with brownish tinge	39
	Light brick red	11
	Reddish brown	6
	Deep coppery tan	8
Young leaf fragrance	Absent	29
	Mild	35
	Strong	36

4.2.2.1 Orientation of leaf

Based on orientation of leaf, a morphological character associated with light interception, the trees were grouped into three categories *viz.*, horizontal, semi erect and semi drooping. Out of the 100 trees seventy eight accessions were having horizontal leaf orientation, thirteen accessions were having semi drooping and nine accessions were semi erect orientation.

4.2.2.2 Shape of leaf

The leaf shape in the accessions had a predominance of oblong (60 %) followed by elliptic (34%), lanceolate (5%) and Ovate (1%).

4.2.2.3 Leaf tip

Two types of leaf tips could be observed, acute and acuminate. Among the trees, occurrence of acuminate leaf tip were largely observed accounting to its dominance in 84 trees; and remaining 16 trees had acute leaf tip.

4.2.2.4 Leaf base

Two types of leaf bases were observed *viz.*, acute (57%) and acuminate (43%). The acute leaf bases were better accounted to in the surveyed trees.

4.2.2.5 Leaf margin

Two types of leaf margins were present in the mango accessions, Viz., entire and wavy; and very large share of trees had entire margin (74%).

4.2.2.6 Leaf texture

The mango accessions showed three type of leaf texture *viz.* chartaceous, coriaceous and membranous. Among all accessions, 46 percent accessions noticed as coriaceous nature, 40 percent as chartaceous and 14 percent as membranous.

4.2.2.7 Colour of young leaves

Colour of young leaves recorded from 5-10 days old newly emerged ones. A wide colour variation of young leaves observed such as light green, light green with brownish tinge, light brick red, reddish brown, deep coppery tan in mango trees.

Light green

Light green with brownish tinge

Light brick red

Reddish brown

Deep coppery tan

Pink
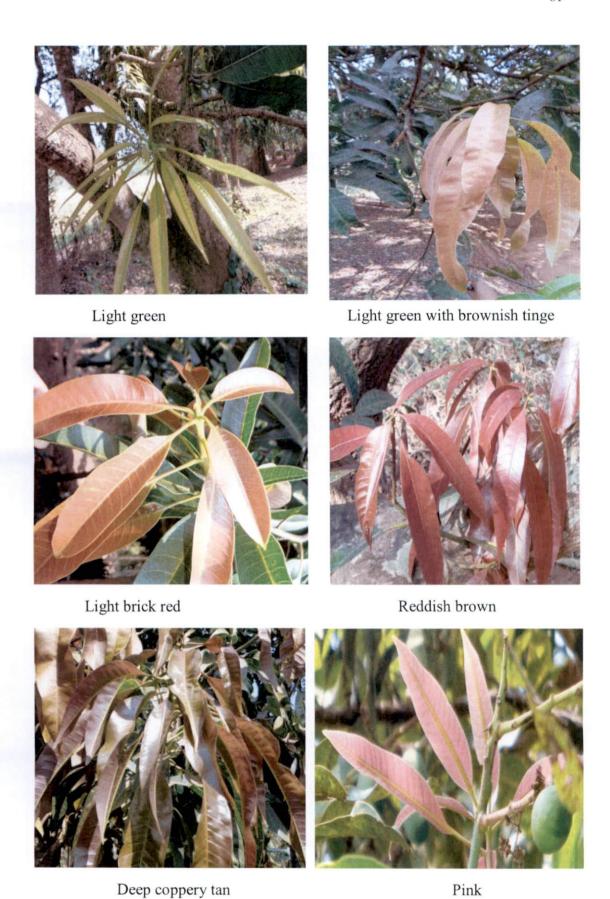
Plate 4.3 Colour of emerging leaves

Thirty six accessions had light green leaves. Light green with brownish tinge and light brick red leaves were produced by 39 and 11 percent of mango accessions. Reddish brown and deep coppery tan leaves produced by six and eight percent respectively. Light green and pink type both observed in single accession (Acc 98).

4.2.2.8 Fragrance of young leaves

The fragrance of newly emerged leaves of the 100 accessions was assessed and accordingly the accessions were grouped as absent, mild and strong. Leaf fragrance was present in seventy one accessions, of which 36 accessions had strong fragrance and thirty five accessions had mild leaf fragrance. Leaf fragrance was absent in 29 accessions surveyed.

4.2.2.9 Leaf venation

All accessions showed wide angle (> 60^0) of secondary veins to the leaf midrib and presence of curvature of secondary veins

Table 4.10 shows the range of the selected leaf characters and can be further elucidated as follows.

Table 4.10 Range of quantitative traits of mango landraces for leaf characters

Character	Range	
	Minimum value	Maximum value
Leaf length (cm)	18.95	36.5
Leaf width (cm)	3.8	8.1
Petiole length (cm)	1.51	4.65

4.2.2.10 Leaf length

Leaf length ranged from 18.95 cm in Acc. 48 to 36.5 cm in Acc 58. There was a significant variation in leaf length between the varieties. Average leaf length of all the mango types was 25.02 cm. Among all accessions, Acc58 showed a greater leaf length.

4.2.2.11 Leaf width

Leaf width ranged from 3.8 cm in Acc 30 to 8.1 cm in Acc 13. Overall leaf width was 5.15 cm. The maximum leaf width was observed in Acc13, followed by Acc 58, whereas the lowest value of width was observed in Acc 30.

4.2.2.12 Petiole length

Leaf petiole length ranged from 1.51 cm to 4.65 cm. the mean petiole length was 2.81 cm. Among all the accessions Acc 16 showed a lower petiole length, whereas the higher was recorded in Acc 58.

4.2.3 Inflorescence characters

Table 4.11 shows the frequency distribution of the selected inflorescence characters as presented below vide annexure –IV.

Table 4.11 Frequency distribution of mango landraces for inflorescence characters

Morphological descriptor	Type of descriptor	Frequency (%)
Position of inflorescence	Terminal	93
	Axillary	-
	Both	7
Shape	Conical	18
	Pyramidal	62
	Broadly pyramidal	20
Colour	Light green	55
	Green with red patch	25
	Crimson	11
	Light red	4
	Red	3
Flower density of panicle	Laxly	12
	Medium	22
	Dense	66
Season of flowering	Early	18
	Early To Mid	17
	Mid	54
	Mid To Late	9
	Late	2
Regularity of flowering	Regular bearers	78
	Alternate bearers	22

Conical   Pyramidal   Broadly pyramidal

A) Shape of inflorescence

Laxly flowered   Densely flowered   Leafy bracts

B) Density of flowers in the inflorescence   C) Presence of leafy bracts
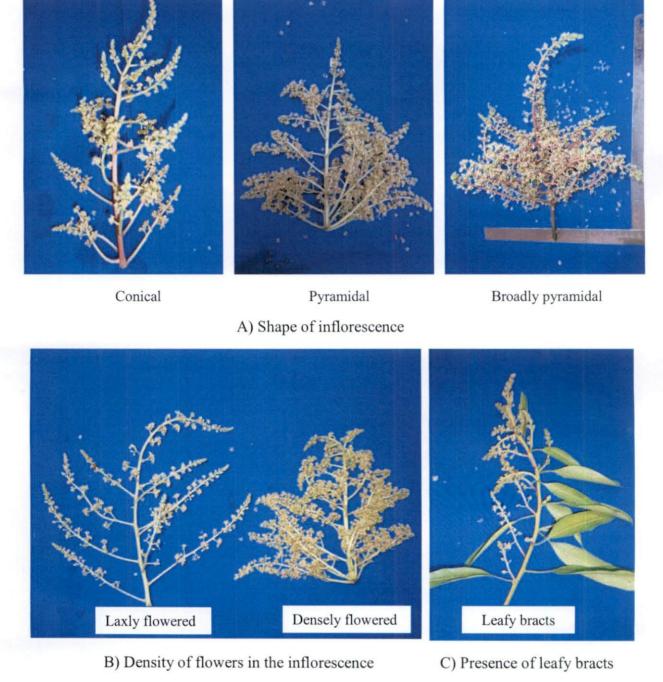
Plate 4.4 a. Inflorescence characters of mango landraces

LIGHT GREEN   GREEN WITH RED PATCHES   PINK

LIGHT RED   RED   CRIMSON

Inflorescence colour

Plate 4.4 b. Inflorescence characters of mango landraces

4.2.3.1 Position of inflorescence

Ninety three percent trees/ accessions showed terminal borne inflorescences and seven percent trees showed terminal and axillary borne inflorescences.

4.2.3.2 Shape of inflorescence

Three types of inflorescences were observed in the accessions *viz.*, conical, pyramidal and broadly pyramidal. Majority of accessions had pyramidal shape of inflorescence (62) followed by broadly pyramidal (20) and conical (18).

4.2.3.3 Colour of inflorescence

The inflorescence colour ranged from light green to crimson. Majority of the accessions had light green (55) followed by green with red patch (25), crimson (11), light red (4), red (3) and pink (2).

4.2.3.4 Density of flowers in the inflorescence

The flower density in the inflorescence was classified based on IPGRI descriptor as laxly, medium and dense. Sixty six accessions showed densely flowered inflorescence, 22 accessions showed medium and 12 accessions showed laxly flowered inflorescence.

4.2.3.5 Presence of leafy bracts

The leaf bracts were present only in 13 accessions.

4.2.3.6 Season and periodicity of flowering

The flowering in mango was observed from November to March in the different accessions. It varied according to weather conditions. However, the season of flowering were classified into three; early season (November to December), mid season (January to February) and late season (from March) and two internal periods between seasons. Eighteen accessions were early season types, fifty four accessions were mid-season types, and seventeen accessions were early-mid season types, nine accessions were mid-late season types and two were late season types.

4.2.3.7 Regularity of flowering

Majority of the mango trees were regular bearers (78). These trees produced fruits every year. Twenty two mango trees were alternate bearers, these produced

fruits in alternate years only.

4.2.3.8 Secondary flowering/off-season flowering

Secondary flowering was frequently noticed in eight mango accessions. The secondary flowering was observed in July-August in accession, 45, 59 and 77. Perpetual type of flowering was recorded in October-November in accessions, 7, 75, 76, 94 and 98.

Table 4.12 shows the range of the selected inflorescence characters which is depicted below.

Table 4.12 Range of quantitative traits of mango landraces for inflorescence

Character	Range	
	Minimum value	Maximum value
Inflorescence length (cm)	18.98	35.59
Inflorescence width (cm)	14.02	30.60

4.2.3.9 Length of inflorescence

The length of inflorescence varied from 18.98 cm in Acc. 76 to 35.59 cm in Acc. 21. The average length of inflorescence was 27.34 cm.

4.2.3.10 Width of inflorescence

The width of inflorescence varied from14.02cm in Acc. 51 to 30.60 cm in Acc. 43. The average width of inflorescence was 20.58 cm.

4.2.4 Pollen characters

4.2.4.1 Pollen shape

Three types of pollen shape were observed in the mango accessions *viz.* round, oblong and oval (Plate 4.5). Out of all, 90 accessions showed round shaped pollen, 4 accessions showed oblong shaped pollen and 6 accessions showed oval shaped pollen.

4.2.4.2 Pollen size

Pollen size varied from 22.21 to 35.43 micron in the accessions.
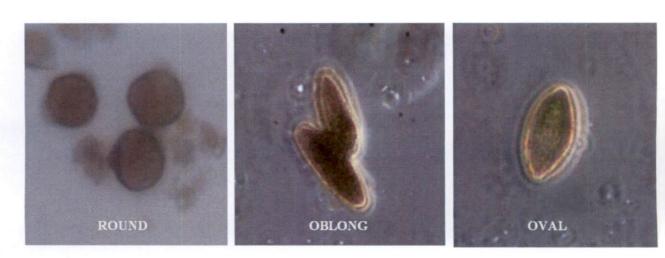
Plate 4.5 Pollen shape of mango landraces traced at Pazhayannur

4.2.5 Fruit morphological characters

Table 4.13 shows the frequency distribution of the selected fruit characters presented below vide annexure–V.

Table 4.13 Frequency distribution of mango landraces for fruit characters

Fruit characters	Type of descriptor	Frequency (%)
Shape	Round	50
	Oblong	43
	Elliptic	4
	Ovoid	1
	Obovoid	2
Basal cavity	Absent	54
	Shallow	36
	Medium	6
	Deep	2
	Very deep	2
Beak	Perceptible	77
	Pointed	9
	Prominent	10
	Mammiform	4
Apex	Acute	3
	Obtuse	14
	Round	83
Sinus	Absent	71
	Shallow	19
	Deep	10
Slope of shoulder	Sloping abruptly,	11
	Ending in along curve	20
	Rising and then rounded	69
Texture	Smooth	88
	Rough	12
Neck prominence	Absent	53
	Slightly prominent	34
	Prominent	9
	Very prominent	4
Stalk insertion	Vertical	96
	Oblique	4
Peel colour	Green	43
	Greenish yellow	28
	Yellow	19
	Yellow with red blush	9
	Brown	1
Waxiness	Waxy	30
	Nonwaxy	70
Adherence of peel to pulp	Weak	31
	Intermediate	21
	Strong	48

4.2.5.1 Shape of fruit

Five different shapes were observed, round, elliptic, obovoid, ovoid and oblong. Fifty percent of trees produced round shaped fruits, 43 percent produced oblong shaped fruits, two percent produced obovoid fruits and one percent produced ovoid shaped fruits.

4.2.5.2 Depth of fruit stalk cavity/basal cavity

With regard to fruit stalk cavity, 36 percent accessions had shallow depth, 6 percent had medium, two percent had deep, and the rest 2 percent had very deep. Rest of 54 percent of the accessions showed absence of fruit stalk cavity.

4.2.5.3 Beak of fruit

Four types of beaks, perceptible, pointed, prominent and mammiform were observed in the accessions. The perceptible type of beak trait was (77%) in the accessions showed a predominance, than pointed (43%), mammiform (4%) and prominent (10%).

4.2.5.4 Apex of fruit

Apex of the fruit was round in 83, obtuse in 14 and acute in 3 mango types.

4.2.5.5 Sinus of fruit

Sinus was present in 29 mango types. It was shallow in 19 mango types and deep in 10 mango types. It was absent in 71 mango types.

4.2.5.5 Slope of shoulders

Three types of shoulders were observed, sloping abruptly, ending in along curve and rising and then rounded, in the mango accessions. The slope of the shoulders was rising and then rounded in 69 mango types and ending in along curve in 20 mango types. It was sloping abruptly in 11 mango types.

4.2.5.6 Fruit texture

Fruit surface was smooth in 88 mango types and rough in 12 mango types.

4.2.5.7 Neck prominence

Fruit neck prominence was present in 47 mango types. It was grouped into three categories slightly prominent (34), prominent (9) and very prominent (4). It was absent in 53 mango types.

4.2.5.8 Stalk insertion

The mode of attachment of the stalk to the fruit was noted as being vertical or oblique (Plate 4.6). It was vertical in 96 accessions and oblique in 4 types (Acc 26, Acc 43, Acc 66 and Acc 71).

4.2.5.9 Peel colour
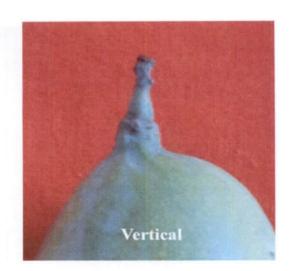
Significantly distinguishing fruit colours were observed in mango types. Brown colour peel, a rare type was noticed in Accession 58. Among 100 accessions green colour trait was predominantly observed in 43 accessions followed by greenish yellow in 28 accessions, yellow in 19 accessions and yellow with red blush trait noticed in 9 mango accessions.

4.2.5.10 Waxiness

Wax or white coating on the fruit surface was observed in 30 accessions. Rest of the 70 accessions did not show any waxy coating on fruit surface.

4.2.5.11 Peel adherence to pulp

The intensity of peel adherence to the flesh was determined manually by pulling the peel. Adherence of skin to pulp was grouped into three categories, weak, intermediate and strong (Plate 4.7). Forty eight mango accessions showed strong peel adherence to flesh, thirty one accessions had weak nature of peel adherence to pulp and the rest of the twenty accessions had intermediate nature of peel adherence to pulp.
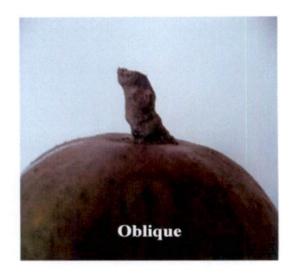
Plate 4.6. Stalk insertion

Plate 4.7. Adherence of peel to pulp
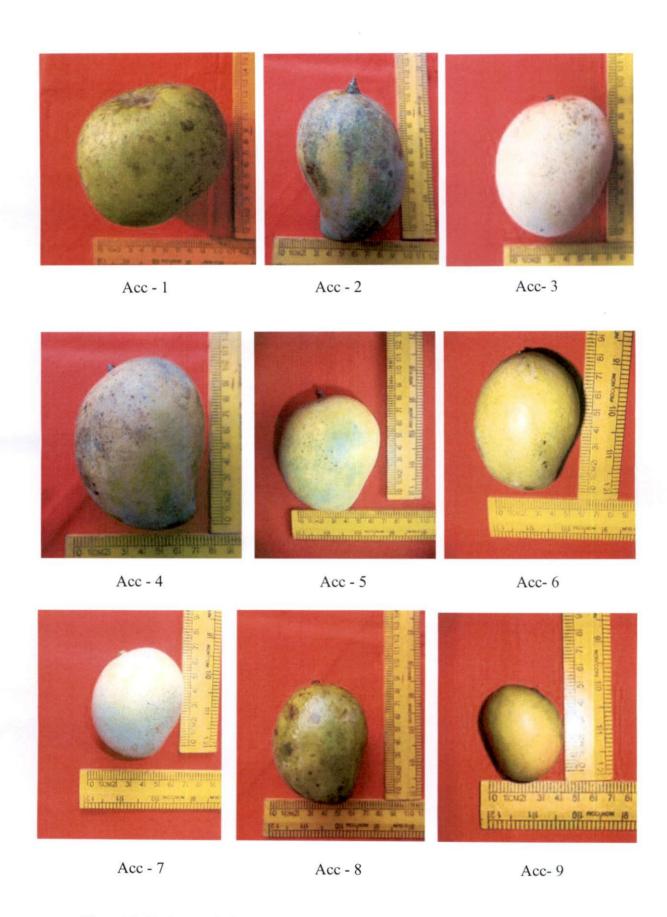
Acc - 1

Acc - 2

Acc- 3

Acc - 4

Acc - 5

Acc- 6

Acc - 7

Acc - 8

Acc- 9

Plate 4.8 Fruit morphological traits of mango landraces located at Pazhayannur

Acc - 10　　　Acc - 11　　　Acc- 12　　　Acc- 13

Acc - 14　　　Acc - 15　　　Acc- 16　　　Acc- 17

Acc - 18　　　Acc - 19　　　Acc- 20　　　Acc- 21

Acc - 22　　　Acc - 23　　　Acc- 24　　　Acc- 25

Plate 4.8 Fruit morphological traits of mango landraces located at Pazhayannur (conti.)

Acc - 26   Acc - 27   Acc- 28   Acc- 29

Acc - 30   Acc - 31   Acc- 32   Acc- 33

Acc - 34   Acc - 35   Acc- 36   Acc -37

Acc - 38   Acc - 39   Acc- 40   Acc 41

Plate 4.8 Fruit morphological traits of mango landraces located at Pazhayannur (conti.)

Acc - 42 Acc - 43 Acc- 44 Acc -45

Acc - 46 Acc - 47 Acc- 48 Acc -49

Acc - 50 Acc - 51 Acc- 52 Acc -53

Acc - 54 Acc - 55 Acc- 56 Acc -57

Plate 4.8 Fruit morphological characters of mango landraces located at Pazhayannur (conti.)

Acc - 58   Acc - 59   Acc- 60   Acc -61

Acc - 62   Acc - 63   Acc- 64   Acc -65

Acc - 66   Acc - 67   Acc- 68   Acc -69

Plate 4.8 Fruit morphological characters of mango landraces traced at Pazhayannur (conti.)

Acc - 70 Acc - 71 Acc- 72 Acc -73

Acc - 74 Acc - 75 Acc- 76 Acc -77

Acc – 78 Acc - 79 Acc- 80 Acc -81

Acc – 82 Acc - 83 Acc- 84 Acc -85

Plate 4.8 Fruit morphological traits of mango landraces located at Pazhayannur (conti.)

Acc - 86	Acc - 87	Acc- 88	Acc -89
Acc - 90	Acc - 91	Acc- 92	Acc -93
Acc - 94	Acc - 95	Acc- 96	Acc -97
Acc - 98	Acc - 99	Acc - 100	

Plate 4.8 Fruit morphological traits of mango landraces located at Pazhayannur (conti.)

4. 2. 6 Other fruit characters

Table 4.14 shows the range of the selected fruit characters presented below vide annexure - VI.

Table 4.14 Range of quantitative characters of mango landraces for fruit size

Characters	Range	
	Minimum value	Maximum value
Fruit length (cm)	4.80	18.00
Fruit width (cm)	4.30	10.45
Fruit weight (g)	44 .00	634.82
Pulp weight (g)	19.80	419.50
Peel thickness (mm)	0.55	4.05
Peel weight (g)	10.00	149.9
Pulp content (%)	31.12	74.24

4.2.6.1 Fruit length

Fruit length significantly varied from 4.8 cm to 18 cm. The highest length was observed in Acc. 19 (18 cm) followed by Acc.62 (15.90 cm), Acc. 80 (15.38 cm) and Acc.41 (12.75 cm). The lowest was observed in Acc.52 (4.8 cm) which was on par with Acc.9 (5.2 cm) and Acc.10 (5.3 cm), followed by Acc.95 (5.98 cm).

4.2.6.2 Fruit width

Fruit width ranged from 4.3 cm to 10.45 cm. The highest width was observed in Acc. 1 and Acc.56 (10.45 cm) which was on par with Acc.81 (9.96 cm) and Acc.80 (9.90 cm). The lowest was observed in Acc.9 (4.3 cm), which was on par with Acc.99 (4.64 cm).

4.2.6.3 Fruit weight

Fruit weight ranged from 44 g. to 634.82 g. The highest weight was observed in Acc.81, which was on par with Acc.80 (630 g). The lowest was observed in Acc.10 (44 g) which was on par with Acc.52 (55.70 g).

4.2.6.4 Pulp weight

Pulp weight ranged from 19.80 g to 419.50 g. The highest weight was observed in Acc.80 (419.50 g), which was on par with Acc.80 (415.38 g). The lowest was observed in Acc.10 (19.80g), which was on par with Acc.52 (21.4g), Acc. 52 (21.4g), Acc. 99 (29.3g) and Acc. 32 (32.15 g).

4.2.6.5 Peel thickness

The thickness of the skin was determined by separating the epidermis from the flesh with a knife and measurements were taken with a screw gauge. The thickness of the epidermis of the accessions varied from 0.55 mm to 4.05 mm. The highest peel thickness was observed in Acc.46 (4.05 mm) followed by Acc. 65 (3.6 mm) and Acc 61 (3.55 mm). The lowest was observed in Acc.67 (0.55 mm).

4.2.6.6 Peel weight

The weight of the peel varied from 10 g to 149.9 g. The highest weight was observed in Acc.81 (149.9 g), which was on par with Acc.80 (149.5g). The lowest was observed in Acc.10 (10 g), which was on par with Acc.90 (12.51g), Acc.10 (13.8g), Acc. 60 (14 g) and Acc.76 (14.15 g).

4.2.6.7 Pulp content

The pulp content varied from 31.12 percent in Acc. 32 to 74.24 percent in Acc. 19.

4.2.7. Fruit pulp characters

Table 4.15 shows the frequency of the selected pulp characters as presented below vide annexure –VII.

Table 4.15 Frequency distribution of mango landraces based on pulp characters

Fruit characters	Type of descriptor	Frequency (%)
Pulp colour	Greenish yellow	1
	Light yellow	6
	Yellow	48
	Yellow orange	25
	Light orange	15
	Dark orange	5
Pulp texture	Juicy	13
	Soft	18
	Firm	69
Fibre in pulp	Absent	-
	Present	100
Pulp aroma	Mild	64
	Intermediate	17
	Strong	19
Turpentine flavor	Absent	75
	Mild	10
	Intermediate	5
	Strong	10

4.2.7.1 Pulp colour

As to the pulp color, a great diversity was observed in the characterized accessions. Five types of pulp colours observed, light yellow, yellow, yellow orange, light orange, dark orange, greenish yellow. Out of all 48 percent accessions showed yellow, 25 percent accessions showed yellow orange, 15 percent accessions showed light orange, 5 percent dark orange, six percent accessions showed light yellow and one percent showed greenish yellow.

4.2.7.2 Pulp texture

Sixty nine mango types had firm pulp texture, eighteen type's possessed soft texture and thirteen types possessed juicy texture.

4.2.7.3 Fibre in pulp

All mango landraces contained fibre in the pulp.

4.2.7.4 Pulp aroma

Pulp aroma was observed in 3 categories *viz.*, mild, intermediate and strong. Mild pulp aroma observed in 64 accessions, intermediate aroma observed in 17 accessions, strong aroma observed in 19 accessions.

4.2.7.5. Turpentine flavor

Turpertine flavor reduces the edible quality of fruit and act as a repellent for consumption. It was absent in 75 percent accessions and present in 25 percent accessions. Out of 25 percent, 10 percent has strong turpentine flavor,10 percent has mild flavor. Rest 5 percent of accessions showed up intermediate flavor.

4.2.8 Fruit stone characters

Table 4.16 shows the frequency of the selected stone characters as presented below vide annexure -VIII.

Table 4.16 Range of quantitative characters of mango landraces for stone characters

Character	Range	
	Minimum value	Maximum value
Stone length (cm)	3.95	12.00
Stone width (cm)	2.50	6.05
Stone weight (g)	10.40	91.33
Stone thickness (mm)	10.10	28.90
Stone content (%)	6.35	42.78

4.2.8.1 Stone length

Stone length significantly varied from 3.95 cm to 12 cm. The highest length was observed in Acc.19 (12 cm), which was on par with Acc.80 (11.98 cm), Acc. 98 (11.57 cm) and Acc.62 (11.4 cm). The lowest was observed in Acc.66 (3.95 cm).

4.2.8.2 Stone width

Stone width ranges from 2.5 cm to 6.05 cm. The maximum width is seen in

Acc. 80 (6.05 cm), followed by Acc.19 (5.75 cm) and Acc.53 (5.55 cm) which were on par. Minimum width was observed in Acc.9 and Acc.10 (2.5 cm).

4.2.8.3 Stone weight

Stone weight ranged from 10.4 g. to 91.33 g. Among all accessions, Acc.98 (91.33 g) and Acc.10 (10.4 g) were considered superior and inferior in weight respectively. Acc 10, Acc 90, Acc 60, Acc 92, Acc 93 and Acc 9were on par and significantly lower in weight.

4.2.8.4 Stone thickness

Thickness of stone was measured by screw gauge after separation of stone from flesh. Its range varied from 10.1 mm to 28.9 mm. Acc.81, Acc 1, Acc 32, Acc 53 were on par and recorded highest thickness and accessions 38, 92, and 10 were also on par and recorded lowest thickness.

4.2.8.5 Stone content

The extremities of stone percentage of fruit were observed in Acc 92 (6.35) and Acc 32 (42.78). Rest of all were within the range. The stone content significantly varied among the mango accessions.

4.2.8.6 Veins on the stone

Veins on the stone (Plate 4.9) were observed after thorough washing of stone by tap water. Among all 48 accessions were leveled with stone surface, 22 accessions were elevated and 20 accessions were depressed.

4.2.8.7 Pattern of venation

The pattern of stone venation (Plate 4.10) was parallel in 91 accessions and forked in 5 mango accessions. Both parallel and forked patterns observed in 4 accessions.

4.2.8.8 Quantity of fibre attached to stone

According to IPGRI (2006), the fibre attached to stones (Plate 4.11) were distinguished into absent, low, intermediate and high quantity. Forty seven accessions were showed up in high quantity of stone fibre and in 6 accessions were absent. Rest of them was in low and intermediate.
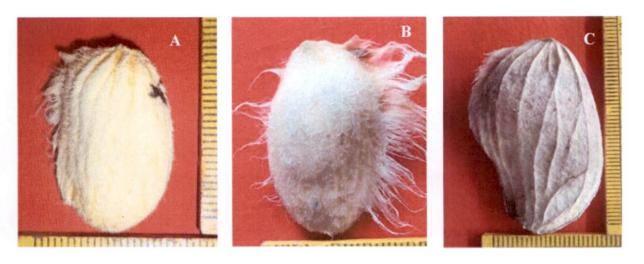
Plate 4.9 Veins on the stone A) Depressed B) Surface level C) Elevated
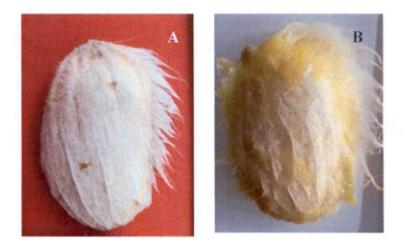
Plate 4.10 Pattern of venation A) Parallal B) Forked
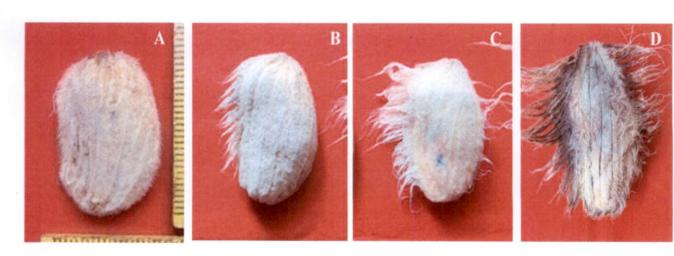
Plate 4.11 Quantity of fibre attached to stone A) Absent B) Low C) Intermediate D) High

4.2.8.9 Length of fibre

For length of fibre, stones of collected mangoes were washed thoroughly with water and the length of attached fibre to stone was grouped into three categories viz. short (<1 cm), medium (1-1.5 cm) and long (>1.5 cm). Out of 94 accessions, 58 accessions had long stone fibre followed by medium (24) and short (12).

4.2.9 Biochemical characters

Table 4.17 shows the range of the selected biochemical characters as presented below vide annexure- IX.

Table 4.17   Range of biochemical traits of mango landraces

Character		Range	
		Minimum value	Maximum value
TSS (°brix)		7.60	23.65
Acidity (%)		0.10	1.49
Reducing sugars (%)		0.88	6.22
Non reducing sugars (%)		0.74	16.03
Total sugars (%)		1.87	20.47

4.2.9.1 Total soluble solids

The total soluble solids of the ripe fruits varied from 7.6 to 23.65°brix. The maximum TSS was observed in Acc 52, Acc 15 and Acc 64. The lowest was noticed in Acc. 100 followed by Acc. 82 and Acc. 94

4.2.9.2 Acidity

Acidity varied from 0.1 to 1.49 percent. The lowest acidity was observed in Acc 31 and highest observed in Acc. 60

4.2.9.3 Reducing sugars

Reducing sugar content of fruit showed significant variation among the accessions. The content varied from 0.88 to 6.22 percent. The highest content was observed in Acc 95, followed by Acc 96 and Acc 97. The lowest observed in Acc. 82.

4.2.9.4 Non reducing sugars

Non reducing sugar content of fruit varied significantly among the accessions. The content was varied from 0.74 to 16.03 percent. The highest content was observed in Acc 15, which was on par with Acc 78. The lowest observed in Acc. 14 which was on par with Acc 83 and Acc 82.

4.2.9.5 Total sugars

Total sugar content of fruit showed significant difference among the accessions. The content varied from 1.87 to 20.47 percent. The highest content was observed in Acc 15, which was on par with Acc 78 followed by Acc 53 and Acc 64. The lowest was observed in Acc. 14 which was on par with Acc 83 and Acc 82.

4.2.10. Maturity

Based on maturing for harvest, the trees were classified as early if the fruits attained maturity by February, as intermediate if it was by March to May and as late if it was by June onwards (Annexure-X). Accordingly it was early in 11 accessions, Intermediate in 78 accessions and late in 11 accessions for table purpose. For pickling purpose the stage of maturity for harvest varied from marble stage (for Kadu/tender manga pickle), to premature stage (Chethu manga).

4.2.11 Yield

Number of fruits harvested per tree per year as reported by the farmers was recorded. It ranged from 15 to 1800 kg.

4.2.12 Polyembryony

Mango stones extracted from fully ripen fruits are planted in polythene bags and observed number of seedlings raised per stone. The maximum expression of emerged seedlings was noted. 31 accessions expressed polyembryony (Annexure-X), the emerged seedlings per stone ranges from 2 to 4.

Among 31, high level of polyembryony (4seedlings/ stone) expressed by four accessions, Acc 3, Acc 7, Acc 45 and Acc 59; medium level (3seedlings/ stone) expressed by 11 accessions, Acc 21, Acc 24, Acc 28, Acc 30, Acc 50, Acc 60, Acc 87, Acc 95, Acc 97, Acc 99 and Acc 100., and low level expressed by 16 accessions, Acc 6, Acc 9, Acc 13, Acc 14, Acc 30, Acc 43, Acc 44, Acc 46, Acc 48, Acc 53, Acc 64, Acc 68, Acc 70, Acc 83, Acc 97 and Acc 99.
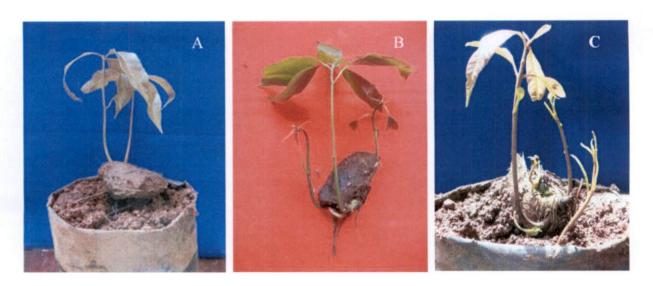
Plate 4.12 Polyembryony: expression of more seedlings from single stone

A) Two seedlings   B) Three seedlings   C) Four seedlings

4.2.11 Principal component analysis (PCA):

The Scree plot of the PCA (Figure 4.11) shows that the first three eigenvalues correspond to the whole percentage of the variance in the data set. As such the first three PC's were extracted from the complicated components (Table 4.18). The total cumulative variance of these three PC,s accounted 76.6 % of variation and all these components had eigenvalues >1.

Eigen values, the percentage of variation and cumulative variation accounted by the PC's presented in Table 4.19. The results show that the first PCA accounts 48.6 percent variation among the mango types, with the second and third PCA's accounting 21.3 and 6.7 percent of variation.

Table 4.18 Loadings of PCA for the selected fruit traits of mango landraces

Traits	PC 1	PC 2	PC 3
Fruit weight	0.349	0.110	-0.042
Pulp weight	0.333	0.122	-0.037
Peel weight	0.338	0.109	-0.074
Stone Weight	0.316	-0.002	0.009
Fruit length	0.320	0.063	-0.066
Fruit width	0.321	0.076	0.142
Stone Length	0.292	0.063	-0.053
Stone Width	0.282	-0.090	-0.081
Stone thickness	0.225	0.027	0.079
Peel thickness	0.265	0.109	-0.289
TSS	-0.138	0.460	-0.058
Acidity	-0.087	-0.145	-0.889
Reducing sugars	-0.155	0.411	-0.256
Non reducing sugars	-0.050	0.498	0.095
Total sugars	-0.092	0.526	-0.016
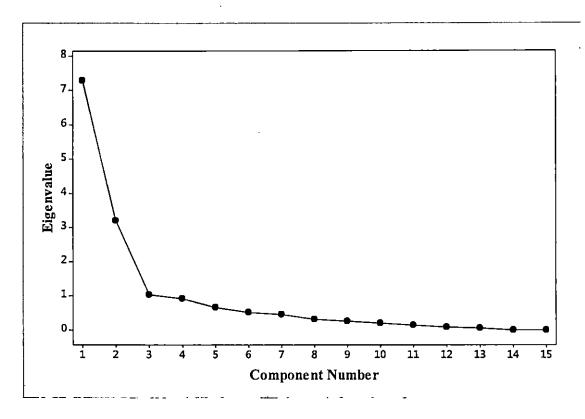
Fig 4.11 Scree plot showing eigen values in response to number of components for the estimated variables of mango

Table 4.19 Latent roots and percent of variation explained by the 15 principal components.

Principal component Axis	Eigen value	Percentage variation	cumulative variation
PC 1	7.29	48.6	48.6
PC 2	3.19	21.3	69.9
PC 3	1.01	6.7	76.6
PC 4	0.90	6.0	82.6
PC 5	0.65	4.3	87.0
PC 6	0.50	3.4	90.3
PC 7	0.45	3.1	93.4
PC 8	0.29	2.0	95.4
PC 9	0.24	1.6	97.0
PC 10	0.17	1.2	98.2
PC 11	0.14	1.0	99.1
PC 12	0.07	0.5	99.6
PC 13	0.05	0.4	100
PC 14	0.00	0.0	100
PC 15	0.00	0.0	100

The first PC was related to fruit weight and its contributing traits were peel weight and pulp weight, whereas the second PC was related to total sugars and its contributing traits were TSS, reducing and non reducing sugars. The traits, which had high loading in PC 1, were fruit weight(0.349), pulp weight (0.333), peel weight (0.338), stone weight (0.316), and fruit length (0.320), whereas, total sugars (0.526), non reducing sugars (0.498), TSS (0.460) and reducing sugars (0.411) were showing high loadings in PC II. Acidity was the lone trait having extremely high loading in PC III.
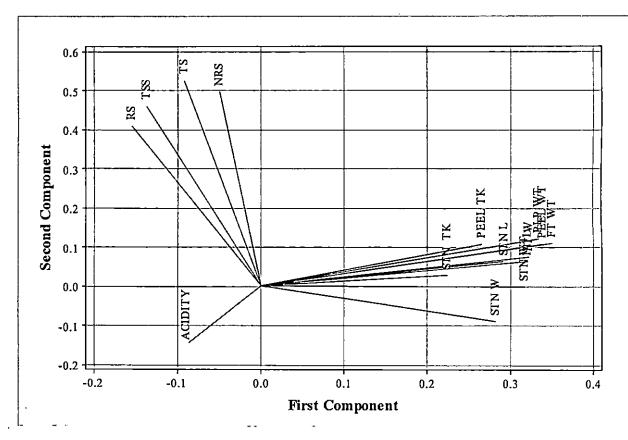
Fig. 4.12 Plot of the traits based on their respective component loadings from the first two PCs

The most prominent relations shown in Figure 4.12 are: a strong positive association among fruit weight, pulp weight, peel weight, stone length, fruit length, fruit width; as indicated by the small angles between their vectors. Another set of positive association was noticed among TSS, reducing, non reducing and total sugar content as indicated by the highly acute angles within the corresponding vector of variables. As a contrast, acidity isolated itself from both the sets as an independent phenomenon quite unpredictable in relation with the characters.
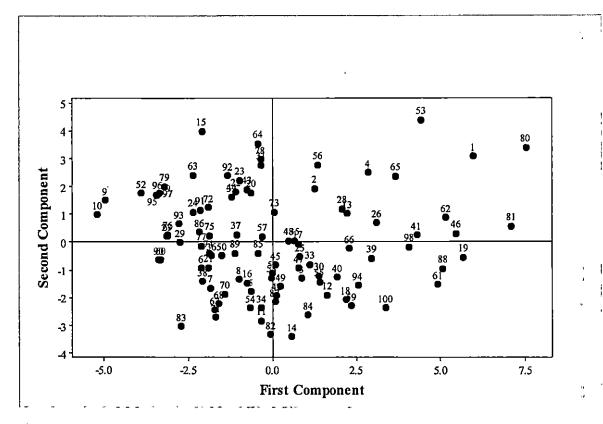
Fig. 4.13 Scatter distribution of 100 mango landraces based on principle component score.

The dispersal of the accessions in a two dimensional set up with the first and second PCs as basis was generated and visualized (Fig. 4.13). The clusters can be generated according to the proximity of accessions that a researcher must feel as being close or wide apart. Since 100 accessions are figuratively plotted and the proximity among the accessions to be judged on a magnified rostrum, the clustering of accessions based on the above depiction is not attempted, but set forth as a draft reference for further analysis as and when needed for.

The biplots of any two characteristics as thought to be most associated are also made so as to browse the whole plot area with a sweeper screen that will isolate the best accessions based on a bivariate phenomenon. The following observations, as can be read out from figures 4.14 and 4.15.

From graph 4.14, it is not easy to identify an exact relationship between acidity and TSS of the mango landraces. The screen can be placed conveniently only on the segment covering the stretch 0.1-0.5 in the X-axis, 10-22 in Y-axis in an encircled folded manner. The accessions scattered widely in the biplot justify the presence in a measure of acidity and TSS in landraces. This is justified by the nearly perpendicular vectors of TSS and acidity in Fig. 4.12.
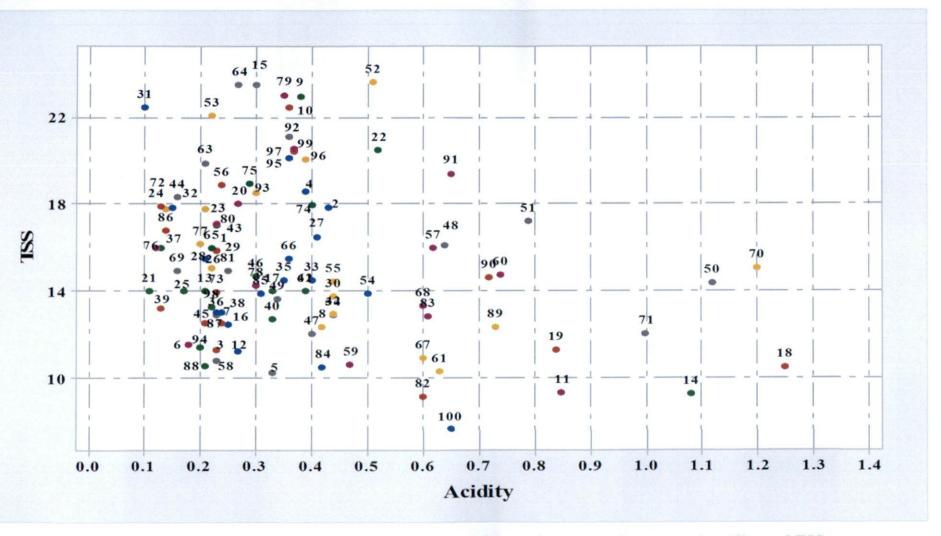
Fig. 4.14 Bi plot showing association of mango landraces for two important characters *viz* acidity and TSS

The bi variate assessment of mango landraces with respect to TSS and acidity as depicted in Fig 4.14, can be summerised as presented below.

Table 4.20. Bi variate depiction of the mango landraces based on TSS and acidity

Acidity (%)	TSS (^{0} brix)					Total
	Very low (<10)	Low (10.1-14)	Medium (14.1-18)	High (18.1-22)	Very high (>22)	
Low (<0.2)	-	6, 39 and 94 (3*)	37, 76, 86, 69, 21, 25 and 77 (7*)	24, 32, 44 and 72 (4*)	31 (1*)	15
Medium (0.21-0.3)	-	3, 7, 12, 16, 36, 38, 45, 58, 87, 88 and 98 (11*)	1, 13, 23, 26, 28, 29, 43, 46, 65, 73, 78, 80, 81 and 85 (14*)	20, 56, 63, 75, 93 (5*)	53, 64 and15 (3*)	33
High (0.3-0.4)	-	5, 40, 41, 47 and 49 (5*)	17, 33, 35, 62, 66 and 74 (6*)	4, 92, 95, 96, 97 and 99 (6*)	9, 10 and 79 (3*)	20
Very high (> 0.4)	11, 14, 82, 100 (4*)	8, 34, 59, 84, 68, 83, 67, 61, 89, 19, 71, 18, 42 (13*)	2, 27, 55, 30, 54, 48, 57, 90, 60, 51, 50, 70 (12*)	22, 91 (2*)	52 (1*)	32
Total	4	32	39	17	8	100

* Figures in the parenthesis in each column are frequencies.

As is evident from Table 4.20, the 15 mango landraces with low acidity as per IBPGR description, where distributed unevenly over the graded ranges of TSS with 7 of them belonging to medium TSS group. As acidity as per descriptor is stepped upto the medium level- the number of accessions increased to 33 with the distribution over TSS group as 11, 14, 5 and 3. In analogy of the above methods of exploration of the two important parameters the range of TSS was 5, 6, 6 and 3 at a 'high' level of acidity. Similar range was noticed for very high acidity as 4, 13, 12, 2, 2, and 1, over the TSS groups.

The relationship between fruit weight and TSS is having analogy with that TSS versus acidity quite justified by the nearly obtuse angles between corresponding vectors of the both the characters (Fig. 4.12). Though some constellations of accessions in the near vicinity of 100-200 gram fruit weight against 12-14^0 brix of TSS is seen. It is only a natural phenomenon of average weight of a fruit, of one of the most common rich species of mango landraces.

It is quite natural that one may investigate the proximity of landraces based on the vector of qualitative as also quantitative characters. Accordingly the results are presented.
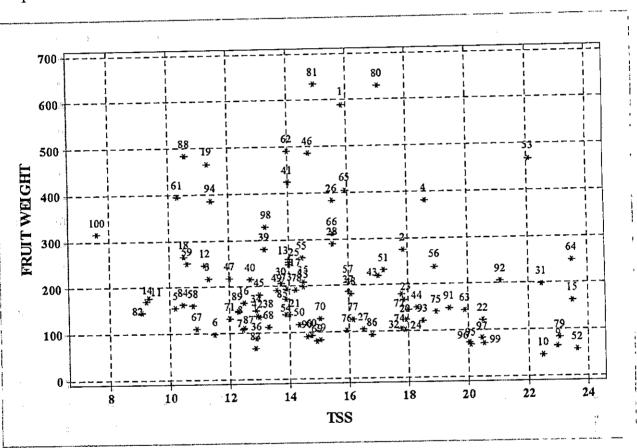
Fig. 4.15. Bi plot showing association of mango landraces for two important characters *viz* fruit weight and TSS

The bivariate assessment of mango landraces with respect to TSS and fruit size as depicted in Fig 4.15, can be summerised as presented below.

Table 4.21. Bivariate depiction of the mango landraces based on TSS and fruit size

Fruit weight (g)	TSS (^{0} brix)					Total
	Very low (<10)	Low .(10.1-14)	Medium (14.1-18)	High (18.1-22)	Very high (>22)	
Very small (<100)	-	6, 24, 36 and 83 (4*)	29, 60, 69, 86 and 90 (5*)	95, 96, 97 and 99 (4*)	9,10, 52, and 79 (4*)	17
Small (100-200)	11, 14 and 82 (3*)	5, 34, 49, 84, 58, 67, 71, 73, 89, 16, 54, 21, 8, 42, 38, 7, 87, 68, 85, and 45 (19*)	27, 70, 37, 48, 78, 33, 32, 74, 20, 72, 76, 77, 23, 48 and 50 (15*)	22, 44, 63, 75, 91 and 93 (6*)	15 and 31 (2*)	45
Medium (200-400)	100 (1*)	3, 5, 12, 18, 59, 47, 61, 40, 39, 30, 13 and 98 (12*)	2, 17, 25, 26, 28, 35, 43, 51, 55, 57 and 66 (11*)	4, 56 and 92 (3*)	64 (1*)	28
Large (>400)	(0*)	88 and 19 (2*)	65, 41, 46, 62, 1, 80 and 81 (7*)	(0*)	53 (1*)	10
	4	37	38	13	8	100

* Figures in the parenthesis in each column are frequencies.

As is evident from Table 4.21, the 17 mango landraces with very small fruit size, where distributed unevenly over the graded ranges of TSS with 5 of them belonging to medium TSS group. As fruit size is stepped upto the small -the number of accessions increased to 45 with the distribution over TSS group as 3, 19, 15, 6 and 2. In analogy of the above method of exploration of the two important parameters the range of TSS was 1, 12, 11, 3 and 1 at a medium level of fruit size. Similar range was noticed for large fruit size as 2, 7, 1 and 1 over the TSS groups.

4.2.12 Cluster analysis

One hundred landraces were grouped into non overlapping subgroups based on quantitative and quantitative characters using appropriate methods of cluster analysis - qualitative clustering done using NTSYS software based on 11 qualitative traits; quantitative clustering done based on "mahanolobis D^2 with 12 quantitative traits. The number of members of each cluster as also the individual members falling in each cluster accounting to the quantitative traits and given in tables 4.22 and 4.23.

Table 4.22 Cluster ID, size and members of qualitative cluster analysis

Cluster	Total no of accessions	Accessions In a each cluster
I	19	1, 53, 81, 9, 17, 10, 57,76, 85, 63, 21, 29, 32, 49, 88, 37, 55, 79, 54
II	11	3, 59, 75, 16, 50, 100, 72, 74, 64, 91, 86
III	3	5, 6, 80
IV	33	7, 24, 56, 73, 77, 36, 44, 22, 35, 69, 83, 38, 89, 48, 68, 11, 42, 45, 51, 52, 97, 95, 99, 96, 61, 46, 31, 40, 70, 33, 34,39, 98
V	2	14, 27
VI	1	36
VII	3	8, 84, 23
VIII	1	58
IX	1	26
X	1	66
XI	2	60, 90
XII	1	94
XIII	4	13,18, 28, 65
XIV	1	43
XV	5	92, 12, 87, 41, 82
XVI	1	19
XVII	3	15, 67, 78
XVIII	1	93
XVIX	3	2, 4, 25
XX	1	20
XXI	1	71
XXII	1	47
XXIII	1	62

Table 4.23 Cluster ID, size and members of quantitative cluster analysis

Cluster	Total no of accessions	Cluster members
Cluster1	30	Acc 5 Acc 6 Acc 7 Acc 8 Acc 11 Acc 15 Acc 16 Acc 21 Acc 27 Acc 31 Acc 35 Acc 44 Acc 48 Acc 49 Acc 58 Acc 60 Acc 63 Acc 68 Acc 70 Acc 71 Acc 72 Acc 73 Acc 75 Acc 77 Acc 78 Acc 82 Acc 85 Acc 89 Acc 91 Acc 93
Cluster 2	4	Acc 1 Acc 80 Acc 81 ACC 88
Cluster 3	12	Acc 2 Acc 12 Acc 13 Acc 18 Acc 25 Acc 28 Acc 51 Acc 55 Acc 57 Acc 64 Acc 66 Acc 100
Cluster 4	17	Acc 10 Acc 22 Acc 24 Acc 29 Acc 36 Acc 42 Acc 50 Acc 52 Acc 69 Acc 79 Acc 83 Acc 86 Acc 87 Acc 95 Acc 96 Acc 97 Acc 99
Cluster 5	6	Acc 4 Acc 26 Acc 53 Acc 61 Acc 65 Acc 94
Cluster 6	12	Acc 3 Acc 14 Acc 17 Acc 30 Acc 33 Acc 34 Acc 40 Acc 45 Acc 47 Acc 54 Acc 59 Acc 84
Cluster 7	4	Acc 19 Acc 41 Acc 46 Acc 62
Cluster 8	6	Acc 9 Acc 20 Acc 32 Acc 67 Acc 76 Acc 90
Cluster 9	3	Acc 39 Acc 56 Acc 98
Cluster 10	6	Acc 23 Acc 37 Acc 38 Acc 43 Acc 74 Acc 92

4.2.12.1 Inter cluster association of qualitative and quantitative clusters

The 100 number of accessions were distributed differently in the quantitative and qualitative clusters. The members of each qualitative cluster did not have the same quantitative characteristics *ie.*, they fell in different quantitative clusters. So as to assess the members of a qualitative cluster with the likelihood of a quantitative characteristic and trace out a mango tree with all features of the members in a qualitative cluster: seemingly alike based on a default similarity- the percent distribution of the members of a qualitative cluster over the different quantitative clusters was worked out in table 4.24. Conceptualising this table as a basis towards tracing a perceived quantitative characteristic, the weighted average based on each quantitative character was worked out with weights drawn correspondingly from table

(4.24). Thus the visualization of the perceived quantitative characteristics of each qualitative cluster was achieved and such a measurable trait has been dispensed in table 4.27.

4.2.12.2 Range statistics of cluster members for different quantitative traits

The statistics given in table 4.25 gives a measure of accountability of a quantitative character in the different clusters, the clusters being formed based on the nearest neighbourhood phenomenon.

Table 4.24 Inter cluster association of qualitative and quantitative clusters

Quantitative / Qualitative	1	2	3	4	5	6	7	8	9	10
1	21.05	15.78	10.52	15.78	5.26	10.52		15.78		5.26
2	36.36		18.18	18.18		18.18				9.09
3	66.67	33.33								
4	33.33		3.03	33.33	3.03	12.12	3.03		9.09	3.03
5	50					50				
6				100						
7	33.33					33.33				33.33
8	100									
9					100					
10		100								
11	50							50		
12					100					
13			75		25					
14										100
15	20		20	20				20		20
16							100			
17	66.67							33.33		
18	100									
19			66.67		33.33					
20								100		
21	100									
22						100				
23								100		

Table 4.25 Range statistics of cluster members for different quantitative traits

Characters	Cluster- 1	Cluster- 2	Cluster- 3	Cluster-4	Cluster- 5	Cluster-6	Cluster- 7	Cluster-8	Cluster- 9	Cluster- 10
No of accessions	N=30	N=4	N=12	N=17	N=6	N=12	N=4	N=6	N=3	N=6
Fruit weight (g)	91-206.50	483.3-634.82	207.5-315.0	44-134	380-467.5	138-250	422.5-490	62-145.5	237-327	122.5-220
Pulp weight (g)	51.3-119.50	302.75-419.5	107.1-183.7	19.8-60.0	217-292.5	63.06-148.2	293-345.75	32.15-91.85	140.7-178.8	73.05-147.5
Peel weight (g)	14-59.54	129.5-150.0	39.4-87.5	13.8-37.0	71.7-121	22.5-59.5	80-112	10-12.51	41.9-61.0	27.75-62.2
Stone weight (g)	12.87-38.16	51.08-69.54	28.0 – 60.0	10.40 – 42.0	38.7-63	31.9-52	36.75-65.1	12.77-44	54.4-91.33	13.06-28
Pulp %	39.26-70.48	62.64-67.12	48.14-69.	36.74-51.84	55.7-71.37	39.26-67.2	63.51-74.23	31.12-71.3	54.68-59.34	54.67-73.36
Stone %	10.89-23.73	9.57-10.95	11.27-19.04	23.63-35.29	10.04-16.56	14.94-25.7	7.49-13.41	14.52-42.78	22.96-27.93	6.36-18.63
Fruit length	6.50-9.60	10.65-15.38	8.3-10.55	4.8-9.49	9.25-11.2	7.5-11	11.9-18	5.2-12.5	10.0-12.74	6.50-11.37
Stone length	4.90-8.32	6.99-11.98	3.95-8.30	4.0-8.49	7.0-9.1	5.05-9.5	9.45-12	4.4-9.5	8.0-11.57	4.80-9.42
Fruit width (cm)	5.30-7.69	9.79-10.45	6.9-8.70	4.64-6.78	8.1-9.3	6.1-8.1	8.3-9.1	4.3-7.0	6.96-10.48	6.48-8.55
Stone width	3.45-5.25	4.63-6.05	3.6-5.10	2.5-4.55	4.3-5.55	3.8-5.35	4.6-5.75	2.5-4.55	3.95-5.50	3.38-4.50
Stone thickness (mm)	15.3-23.60	22.99-28.90	18.75-22.9	12-22.77	18.3-25.5	17.4-25.3	20-21.5	17-26.5	20.00-24.99	10.10-22.50
Peel thickness(mm)	0.85-2.75	3.00- 3.20	1.60-3.18	1.32-2.20	1.2-3.60	0.85-2.30	2.6-4.05	0.5-1.3	1.8-3.10	1.0 -2.9

Table 4.26 Summary statistics of the major characters of mango landraces of the quantitative clusters

Cluster (members)		Fruit weight (g)	Pulp weight(g)	Peel wt(g)	Stone weight (g)	Stone %	Pulp %	Fruit length	Stone length	Fruit width	Stone width	Peel thickness	Stone thickness
1	Mean	148.95	90.07	33.67	25.19	16.93	60.60	7.88	6.31	6.42	4.03	1.73	19.04
	SD	31.13	19.14	9.82	6.90	3.32	4.66	0.96	0.86	0.57	0.44	0.48	2.21
2	Mean	584.53	383.40	141.59	59.53	10.19	65.44	12.36	9.08	10.02	5.09	3.11	25.87
	SD	65.59	50.88	9.46	7.31	0.63	1.86	1.97	1.93	0.28	0.60	0.097	2.79
3	Mean	262.8	156.10	65.49	41.20	15.65	59.54	9.46	7.11	7.739	4.43	2.47	20.975
	SD	31.31	22.44	16.86	8.43	2.33	6.89	0.78	1.59	0.53	0.56	0.51	1.27
4	Mean	85.67	38.53	22.33	24.80	28.7	45.13	6.72	5.72	5.55	3.93	1.74	18.75
	SD	23.69	11.03	7.188	8.34	3.9	5.31	1.15	1.16	0.60	0.55	0.30	2.88
5	Mean	402.62	247.07	102.15	53.40	13.32	61.3	10.46	8.07	8.86	4.86	2.72	22.29
	SD	32.78	29.86	16.37	9.066	2.4	5.34	0.679	0.86	0.51	0.52	0.87	2.61
6	Mean	195.27	109.56	43.65	42.05	21.94	55.41	9.29	7.25	7.44	4.61	1.66	22.24
	SD	36.13	30.24	11.03	6.99	3.63	7.73	0.89	0.99	0.73	0.458	0.40	2.09
7	Mean	465.62	322.91	95.12	47.58	10.24	69.41	14.6	10.71	8.85	5.087	3.087	20.7875
	SD	30.17	25.38	16.67	12.26	2.56	4.36	2.63	1.13	0.3	0.46	0.626	1.35
8	Mean	101.38	57.5	19.54	24.33	24.17	57.094	7.57	6.127	5.545	3.593	1.02	20.40
	SD	26.91	20.94	8.46	11.71	10.41	14.09	2.51	1.849	1.02	0.751	0.29	3.36
9	Mean	280.66	157.52	53.23	69.90	24.63	56.3	11.24	9.52	8.30	4.48	2.46	22.6
	SD	41.09	18.30	9.189	17.24	2.60	2.47	1.28	1.64	1.6	0.7	0.58	2.33
10	Mean	173.94	114.91	39.92	19.11	11.579	65.46	7.89	6.37	7.35	3.8	1.72	16
	SD	37.42	30.63	11.68	5.80	4.55	6.47	1.68	1.69	0.89	0.43	0.69	4.80

Table 4.27 Perceived quantitative characteristics of qualitative clusters

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fruit weight	231.7	168.8	294.1	166.9	172.1	85.7	172.7	149.0	402.6	262.8	125.2	402.6	297.8	173.9	227.4	465.6	133.1	149.0	309.4	101.4	149.0	195.3	195.3
Pulp weight	141.7	98.5	187.8	96.0	99.8	38.5	104.8	90.1	247.1	156.1	73.8	247.1	178.8	114.9	144.5	322.9	79.2	90.1	186.4	57.5	90.1	109.6	109.6
Peel weight	55.0	39.8	69.6	38.0	38.7	22.3	39.1	33.7	102.2	65.5	26.6	102.2	74.7	39.9	51.3	95.1	29.0	33.7	77.7	19.5	33.7	43.7	.43.7
Stone weight	35.0	30.5	36.6	33.0	33.6	24.8	28.8	25.2	53.4	41.2	24.8	53.4	44.3	19.1	31.6	47.6	24.9	25.2	45.3	24.3	25.2	42.1	42.1
Stone %	18.8	19.3	14.7	21.6	19.4	28.7	16.8	16.9	13.3	15.7	20.6	13.3	15.1	11.6	16.6	10.2	19.3	16.9	14.9	24.2	16.9	21.9	21.9
Pulp %	58.0	57.1	62.2	54.8	58.0	45.1	60.5	60.6	61.3	59.5	58.8	61.3	60.0	65.5	60.0	69.4	59.4	60.6	60.1	57.1	60.6	55.4	55.4
Fruit length	8.8	8.2	9.4	8.3	8.6	6.7	8.4	7.9	10.5	9.5	7.7	10.5	9.7	7.9	9.3	14.6	7.8	7.9	9.8	7.6	7.9	9.3	14.6
Stone length	6.9	6.5	7.2	6.7	6.8	5.7	6.6	6.3	8.1	7.1	6.2	8.1	7.4	6.4	7.2	10.7	6.2	6.3	7.4	6.1	6.3	7.3	10.7
Fruit width	7.1	6.8	7.6	6.6	6.9	5.6	7.1	6.4	8.9	7.7	6.0	8.9	8.0	7.4	7.2	8.9	6.1	6.4	8.1	5.5	6.4	7.4	8.9
Stone width	4.2	4.2	4.4	4.2	4.3	3.9	4.1	4.0	4.9	4.4	3.8	4.9	4.5	3.8	4.3	5.1	3.9	4.0	4.6	3.6	4.0	4.6	5.1
Peel thickness	2.0	1.9	2.2	1.9	1.7	1.7	1.7	1.7	2.7	2.5	1.4	2.7	2.5	1.7	2.1	3.1	1.5	1.7	2.6	1.0	1.7	1.7	3.1
Stone thickness	20.8	19.6	21.3	19.8	20.6	18.8	19.1	19.0	22.3	21.0	19.7	22.3	21.3	16.0	19.1	20.8	19.5	19.0	21.4	20.4	19.0	22.2	20.8

COMPONENT-III

FINAL ROUND UP MEETINGS (FRM) AT THE VILLAGES AND FOUR-CELL ANALYSIS

4.3.1 VILLAGE LEVEL MANGO DIVERSITY STATUS

To work out the richness and diversity estimates of mango landraces at the village level so as to chalk out the viable conservation strategies of the rare and endangered LRs of the region, final round up meetings (FRM) of the villagers were taken up at Elanad, Vennur, Pazhayannur and Vadakkethara on 28.05.2015, 06.05.15, 01.06.15 and 23.05.2015 respectively.

Focus group discussions (FGD) and participatory four cell analysis (FCA) were adopted during these meetings for a concluding assessment of the on mango diversity and confirmation of the key mango landraces of the four villages.

During FCA, the participants are asked to list all the landraces of mango and place them in one of the four quadrants based on presence of landrace in their households and number of trees present.

Accordingly the existing diversity of mango landraces in these four villages was classified based on their presence as common, other distinct, vulnerable, and rare/ endangered landraces as mentioned below:

a) Common landraces: Mango landraces grown in many households and with many trees (More than 15 households with more than 4 trees)

b) Other distinct landraces: Mango landraces grown in few households and with many trees (Less than 6 households with more than 4 trees)

c) Vulnerable landraces: Mango landraces grown in many households and with few trees (More than 15 households with 1-2 trees)

d) Rare landraces: Mango landraces grown in small numbers in few homesteads (Less than 6 households with 1-2 trees)

Many trees (≥4)

	Common landraces Mango landraces grown in many households and with many trees (MHH, MT)*	Other distinct landraces Mango landraces grown in few households and with many trees (FHH, MT)*	
Many house holds **≥15**	**Vulnerable landraces** Mango landraces grown in many households and with few trees (MHH, FT)*	**Rare landraces** Mango landraces grown in small numbers in few homesteads (FHH, FT)*	**Few house holds** **≤6**

Few trees (≤1-2)

*MHH- Many hoseholds *FHH- Few households *MT- Many trees *FT- Few trees

Fig.4.16 Four cell analysis

4.3.1.1 Diversity assessment at Elanad village

Consolidated results of Elanad village are presented in Table.4.28. As per the analysis, the mango landraces such as Moovandan, Acc 13 and Pulimanga could be grouped as 'common' in the village due to their presence in large numbers in a large number of homesteads.

Other landraces which are grown in few homesteads but with many number of trees in homesteads were designated as other distinct type, and the variety Acc 2 and Acc 4 could be grouped under this category. Acc 33 (Gomanga) which is found growing in many homesteads with few numbers was grouped as vulnerable landraces.

Accordingly, the mango landraces and unnamed landraces observed in few household with few number designated as rare mango landraces. The group of rare mango landraces in Elanad village comprised of Acc 1 (Gundu), Acc 5, Acc 6 (Kannimanga), Acc 7(Cheriyamuvandan), Acc 8 (Amminipulichi), Acc 9, Acc 10, Acc 11, Acc 12, Acc 14, Acc 15 (Sundari), Acc 16, Acc 17, Acc 18, Acc 19, Acc 20, Acc 21, Acc 22, Acc 23, Acc 24, Acc 25, Acc 26, Acc 27 (Perakkamavu), Acc 28, Acc 29, Acc 30, Acc 31, Acc 32, Acc 34, Acc 35, Acc 36, Acc 37, Acc 38, Acc 39, Acc 40, Acc 41, Acc 42, Acc 43, Acc 44 (Tholikkaippan)

Table 4.28: Diversity assessment of mango landraces at Elanad village

Study site	Common landraces (MHH, MT)*	Other distinct landraces (FHH, MT)*	Vulnerable landraces (MHH, FT)*	Rare landraces (FHH, FT)*
Elanad	Muvandan Pulimanga and Acc 13	Acc 2 and Acc 4	Acc 33 (Gomanga)	Acc 1 (Gundu), Acc 5, Acc 6 (Kannimanga) Acc 7 (Cheriyamuvandan) Acc 8 (Ammini pulichi), Acc 9, Acc 10, Acc 11, Acc 12, Acc 14, Acc 15 (Sundari), Acc 16, Acc 17, Acc 18, Acc 19, Acc 20, Acc 21, Acc 22, Acc 23, Acc 24, Acc 25, Acc 26, Acc 27 (Perakkamavu) Acc 28, Acc 29, Acc 30, Acc 31, Acc 32, Acc 34, Acc 35, Acc 36, Acc 37, Acc 38, Acc 39, Acc 40, Acc 42, Acc 43 and Acc 44 (Tholikkaippan)

*MHH- Many hoseholds *FHH- Few households *MT- Many trees *FT- Few trees

4.3.1.2 Diversity assessment at Vennur village

Consolidated data for Vennur village evolved during the FRM is presented in Table 4.29. In this village the common varieties found in a large number of homesteads comprised of Moovandan, Pulimanga, Pulichi and Pachhamoovandan.

Plate 4.13. Four cell participatory analysis at Elanad

Plate 4.14. Four cell participatory analysis at Vennur

Similarly the group of rare mango landraces in the village comprised of Gomanga, Priyur, Neelum, Sindhuram, Acc 46, Acc 47, Acc 49, Acc 50, Acc 51, Acc 52, Acc 53, Acc 54, Acc 55, Acc 56, Acc 57 (Attanari), Acc 58 (Sapotamavu), Acc 59, Acc 61, Acc 62 and Acc 63.

Table 4.29: Diversity assessment of mango landraces at Vennur village

Study site	Common landraces (MHH, MT)*	Other distinct landraces (FHH, MT)*	Vulnerable landraces (MHH, FT)*	Rare landraces (FHH, FT)*
Vennur	Moovandan (Acc 59) Pulimanga (Acc 48) Pulichi (Acc 60) Pachha moovandan (Acc 45)	-	-	Gomanga, Priyur Neelum, Sindhuram Acc 46, Acc 47 Acc 49, Acc 50 Acc 51, Acc 52 Acc 53, Acc 54 Acc 55, Acc 56 Acc 57 (Attanari) Acc 58(Sapotamavu) Acc 61, Acc 62, Acc 63

*MHH- Many hoseholds *FHH- Few households *MT- Many trees *FT- Few trees

4.3.1.3 Diversity assessment at Pazhayannur village

Data recorded during the FRM at Pazhayannur village are presented in Table 4.30. Accordingly landraces, Moovandan, Pulichi (Acc 82) and Pulimanga (Acc 68) could be grouped as 'common' due to their presence in large numbers in a large number of homesteads.

Other landraces, Gomanga, Acc 69 and Neelum, could be grouped as other distinct due to its presence in few homesteads but with many numbers of trees.

Similarly the rare group of mangoes comprised of Kannimanga (Acc 67), Chindhuram, Priyur, Acc 64,Acc 65 (Gundu), Acc 66, Acc 67, Acc 70, Acc 71, Acc 72, Acc 73, Acc 74, Acc 75, Acc 76, Acc 77 (Karpuramanga), Acc 78, Acc 79, Acc 80 (Vellari) and Acc 81.

Table 4.30: Diversity assessment of mango landraces at Pazhayannur village

Study site	Common landraces MHH, MT	Other distinct landraces FHH, MT	Vulnerable landraces MHH, FT	Rare landraces FHH, FT
Pazhayannur	Muvanadan Pulichi (Acc 82) Pulimanga (Acc 68)	Neelum Acc 69	Kilichundan	Acc 67 (Kannimanga) Chindhuram, Priyur, Acc 64, Acc 65 (Gundu) Acc 66, Acc 67, Acc 70, Acc 71, Acc 72, Acc 73, Acc 74, Acc 75, Acc 76, Acc 77 (Karpuramanga) Acc 78, Acc 79, Acc 80 (Vellari) and Acc 81

Table 4.31: Diversity assessment of mango landraces at Vadakkethara village

Study site	Common landraces MHH, MT	Other distinct landraces FHH, MT	Vulnerable landraces MHH, FT	Rare landraces FHH, FT
Vadakkethara	Moovandan Pulimanga (Acc 89)	Priyur	Acc 86 (Gomanga)	Acc 83, Acc 84, Acc 85 (Swarnamuki) Acc 87, Acc 88, Acc 90, Acc 91, Acc 92 (Kilichundan var) Acc 93, Acc 94, Chindhuram Karpuramanga

Plate 4.15 Four cell participatory analysis at Pazhayannur
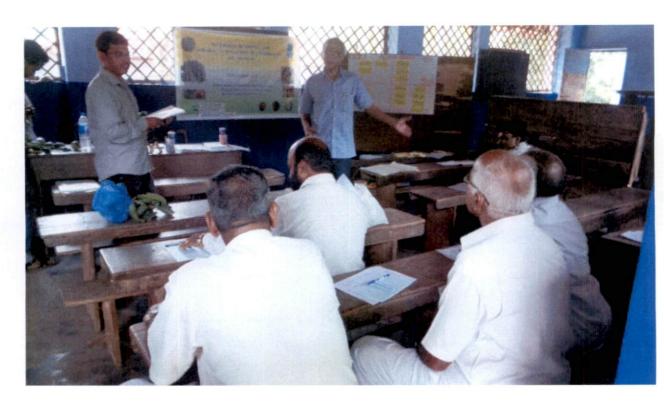
Plate 4.16. Four cell participatory analysis at Vadakkethara

4.3.1.4 Diversity assessment at Vadakkethara village

Procceedings of FRM at Vadakkethara village are presented in Table 4.31. In this village, the common varieties found in a large number of homesteads comprised of Moovandan, and Pulimanga (Acc 89). Other distinct mango landraces noticed were Priyur and Gomanga respectively. The rare group included Swarnamuki, Acc 83, Acc 84, Acc 87, Acc 88, Acc 90, Acc 91, Kilichundan (Acc 92), Acc 93, Acc 94, Chindhuram, Karpuramanga.

4.3.1.5 Overall diversity assessment of the region

Results obtained by four cell analysis from different villages is furnished in Table 4.32. Moovandan mango type predominantly occurred in Pazhayannur panchayath. Most of the landraces spotted as rare ones in this area were not having any colloquial/ popular name. The maximum number of rare mango LRs noticed in Elanad (39), followed by Vennur (19), Pazhayannur (19) and Vadakkethara (12).

Table 4.32: Overall diversity status of mango LRs of the Pazhayannur region

Status	Criteria of presence	Number of mango landraces spotted			
		Elanad	Vennur	Pazhayannur	Vadakkethara
Common LRs	MHH, MT	3	4	3	2
Other distinct LRs	FHH, MT	2	0	2	1
Vulnerable LRs	MHH, FT	1	0	1	1
Rare LRs	FHH, FT	39	19	19	12

MHH: Many households   MT: Many trees

FHH: Few households   FT: Few trees

4.3.2 ESTIMATE OF MANGO DIVERSITY

Richness and evenness are the key measures of diversity. Richness refers to number of landraces or varieties regardless of their frequencies and measured by the type count per homestead. Evenness compares the frequencies of different landraces or in other terms a variety with a low evenness value indicates dominance by one or few landraces.

4.3.2.1 Diversity estimate of mango landraces at Elanad village

Diversity estimate of mango types in Elanad village is presented in Table 4.33. Overall varietal richness of the village was 45 and at homestead level within a range of 1-24. Estimated evenness values showed higher values for landraces, viz,. Muvandan (0.9), Acc 13 (0.9) and Pulimanga (0.9) which were common in the village. Evenness values for other mango landraces were Gomanga (0.9), Acc 2 (0.8) and Acc 4 (0.8), which were grouped under other and vulnerable classes. Lower evenness recorded in rare mango group consists Acc 1 (Gundu), Acc 5, Acc 6 (Kannimanga), Acc 7 (Cheriyamuvandan), Acc 8 (Amminipulichi), Acc 9, Acc 10, Acc 11, Acc 12, Acc 14, Acc 15 (Sundari), Acc 16, Acc 17, Acc 18, Acc 19, Acc 20, Acc 21, Acc 22, Acc 23, Acc 24, Acc 25, Acc 26, Acc 27 (Perakkamavu), Acc 28, Acc 29, Acc 30, Acc 31, Acc 32, Acc 34, Acc 35, Acc 36, Acc 37, Acc 38, Acc 39, Acc 40, Acc 41, Acc 42, Acc 43, Acc 44 (Tholikkaippan).

4.3.2.2 Diversity estimate of mango landraces at Vennur village

Estimate of mango diversity in Vennur village was presented in Table 4.34. Overall varietal richness of the village was 24 and at homestead level within a range of 1-24. Estimated evenness values showed higher values (0.9) for landraces, viz,. Moovandan (Acc 59), Pulimanga (Acc 48), Pulichi (Acc 60) and Pachha moovandan (Acc 45), which were common in the village. Lower evenness recorded in rare mango group comprised of Gomanga, Priyur, Neelum, Sindhuram, Acc 46, Acc 47, Acc 49, Acc 50, Acc 51, Acc 52, Acc 53, Acc 54, Acc 55, Acc 56, Acc 57 (Attanari), Acc 58 (Sapotamavu), Acc 59, Acc 61, Acc 62 and Acc 63.

4.3.2.3 Diversity estimate of mango landraces at Pazhayannur village

Estimate of mango diversity in Pazhayannur village was presented in Table 4.35. Overall varietal richness of the village was 24 and at homestead level within a range of 1-24. Estimated evenness values showed higher values for varieties viz,.Moovandan (1.0), Pulichi (Acc 82) (0.9) and Pulimanga (Acc 68) (0.9), which were common in the village.

Evenness values for other mango landraces were Acc 69 (0.8) and Neelum (0.8), Kilichundan (0.9), which were unique and endangered landraces in the village. Lower evenness recorded in rare mango group comprised of Kannimanga(Acc 67), Chindhuram, Priyur, Acc 64,Acc 65 (Gundu), Acc 66, Acc 67, Acc 70, Acc 71, Acc 72, Acc 73, Acc 74, Acc 75, Acc 76, Acc 77 (Karpuramanga), Acc 78, Acc 79, Acc 80 (Vellari) and Acc 81.

4.3.2.4 Diversity estimate of mango landraces at Vadakkethara village

Biodiversity estimate of mango landraces in Vadakkethara village was presented in Table 4.36. Overall varietal richness of the village was 16 and the homestead level within a range of 1-24. Estimated evenness values showed higher values for landraces viz,. Muvandan (0.9), and Pulimanga (0.9), which were common in the village. Evenness values for other mango landraces were Priyur (0.7), Gomanga (Acc 86) (0.9), which were grouped under unique and endangered classes. Lower evenness recorded in rare mango group consists Swarnamuki, Acc 83, Acc 84, Acc 87, Acc 88, Acc 89, Acc 90, Kilichundan var (Acc 92), Acc 93, Acc 94, Chindhuram, Karpuramanga.

Table 4.33: Diversity estimate of mango landraces at Elanad village

Landraces	Homesteads																								Evenness
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Moovandan	4	4	5	4		4	4	5	4	4	4	15	10	10	5	6	5	4	4	4		4	7	7	0.9
Pulimanga	5	4	4			4		4	5			6		7	6	5			4		4	4	5	6	0.9
Acc 1 (Gundu)																	1								0.0
Acc 2						4	4	5				6							5		5				0.8
Acc 4						5		4				4			5				5				5		0.8
Acc 5												1													0.0
Acc 6 (Kannimanga)										1		2													0.4
Acc 7 (Cheriya moovandan)										2		2													0.5
Acc 8 (Amminipulichi)												1													0.0
Acc 9								1																	0.0
Acc 10								1																	0.0
Acc 11														1							1				0.5
Acc 12						2													1						0.4
Acc 13	6		4	4	5		6	5		4		7	4				4		4	4	4		5	4	0.9
Acc 14	1																								0.0
Acc 15 (Sundari)																	1		1						0.5
Acc 16																	1		1						0.5
Acc 17																			1						0.0
Acc 18																					1				0.0
Acc 19						2																			0.0
Acc 20						1																			0.0
Acc 21						1																			0.0
Acc 22 (Karpuram)										1		1		1											0.7
Acc 23										1															0.0
Acc 24			2																						0.0
Acc 25			2																						0.0

Table 4.33: Diversity estimate of mango landraces at Elanad village (conti.)

Landraces	Homesteads																								Evenness
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	0.0
Acc 26			2																						0.0
Acc 27 (Perakkamavu)		1			1			1																	0.7
Acc 28				1																		1			0.0
Acc 29																			1						0.0
Acc 30																			1						0.0
Acc 31																			1						0.0
Acc 32																			1			1		1	0.9
Acc 33 (Gomanga)	1		1	2	1			2			1	2	1	1	1	2		2	1			1		1	0.0
Acc 34																			1						0.0
Acc 35																			1						0.0
Acc 36															1										0.0
Acc 37															1										0.0
Acc 38															1										0.0
Acc 39															1										0.0
Acc 40															1										0.0
Acc 41																			1						0.0
Acc 42																		1							0.0
Acc 43																		1							0.0
Acc44 (Tholikkaipan)																		1							0.0
RICHNESS	5	3	6	5	3	8	3	9	2	6	2	11	3	3	11	3	5	5	13	5	5	4	4	4	
N	17	9	18	13	7	23	14	28	9	13	5	47	15	18	24	13	12	9	30	11	15	10	22	18	
EVENNESS	0.7	0.6	0.8	0.8	0.4	0.8	0.7	0.9	0.5	0.8	0.3	0.8	0.5	0.5	0.8	0.6	0.7	0.7	0.9	0.7	0.7	0.7	0.7	0.7	

Table 4.34: Diversity estimate of mango landraces at Vennur village

Landraces	Homesteads																								Evenness
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Moovandan	7		5	4	10	4	10	4	4	8	4	20	13	4	13	6	8		4	4	12	4	4	12	0.9
Gomanga	1										1		1												0.7
Priyur											1				1										0.5
Neelum	1										1	1			1										0.8
Sindhuram														1				1							0.5
Pachhamoovandan (Acc 45)	4	5			4		5		4	5		4	4	4	4				4	4	4		4	5	0.9
Acc 46																					1				0.0
Acc 47																					1				0.0
Pulimanga (Acc48)	6	4	4	5	5	4	4		5	4		5					4				5	4	4	5	0.9
Acc 49																							2		0.0
Acc 50													1				1								0.5
Acc 51																								1	0.0
Acc 52																								1	0.0
Acc 53																								1	0.0
Nadasala (Acc 54)																								1	0.0
Acc 55											1														0.0
Acc 56		1																						1	0.5
Attanari (Acc 57)		2																							0.0
Sapotamavu(Acc58)		1																							0.0
Acc 59											1														0.0
Pulichi (Acc 60)	5	4	4		5	4	4		4	4		5		4			7			4	4		5	7	0.9
Acc61																								1	0.0
Acc 62																			1						0.0
Acc63																			1					1	0.5
Richness	6	6	3	2	4	3	4	1	4	4	6	5	4	4	4	1	4	4	2	2	6	2	5	11	
N	24	17	13	9	24	12	23	4	17	21	9	35	19	13	19	6	20	7	8	8	27	8	19	36	
Evenness	0.8	0.8	0.7	0.5	0.7	0.7	0.7	0.0	0.7	0.7	0.7	0.6	0.5	0.7	0.5	0.0	0.7	0.6	0.5	0.5	0.7	0.5	0.8	0.8	

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Table 4.35: Diversity estimate of mango landraces at Pazhayannur village

Landraces	Homesteads																								Evenness
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Moovandan	4	4	10	6	6	4	4	7	4	4	4	4	4	4	6	4	5	8	4	4	4	8	10		1.0
Priyur			1				1				1			1											0.8
Neelum	6	4				6					8						5			4					0.8
Pulichi (Acc 82)	4	4	5	6	5	4	5		4		4		5			4	5	4			4		4		0.9
Kilichundan	1	2	1	1	1			1	1	2	1			1	2			1			1		2		0.9
Chindhuram			1																						0.0
Acc 64						1	1																		0.5
Gundu (Acc 65)							1		1																0.5
Acc 66							1					1													0.5
Kannimanga (Acc 67)							1																		0.0
Pulichi (Acc 68)	4	5	4	4	5	6	4		4		4		4		4	6	5	4			4				0.9
Acc 69	5		6	5				4		4												4			0.8
Acc 70								1												1					0.5
Acc 71																							1		0.0
Acc 72											1		1												0.5
Acc 73											1														0.0
Acc 74											1		1												0.5
Acc 75												1													0.0
Acc 76													1												0.0
Acc 77 Karpuramanga						2	1								1					1					0.7
Acc 78																		1							0.0
Acc 79																		1							0.0
Acc 80 Vellarimanga																			1	1					0.5
Acc 81																				1					0.0
Richness	6	5	7	5	4	5	10	4	5	6	6	3	6	3	4	3	6	4	2	7	3	3	3	2	
N	24	19	28	22	17	17	25	13	14	13	22	6	16	6	13	14	18	21	5	13	12	14	15	6	
Evenness	0.8	0.8	0.8	0.8	0.7	0.7	0.8	0.6	0.7	0.8	0.8	0.5	0.8	0.5	0.7	0.7	0.8	0.7	0.3	0.8	0.7	0.6	0.5	0.4	

Table 4.36: Diversity estimate of mango landraces at Vadakkethara village

Landraces	Homesteads																								Public places	Evenness
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
Moovandan	4	5	4	4	5	4	4	5	6	4	5	5	4	5	5		7	4	4			8	4			0.9
Priyur	5	5						6															6	4	4	0.8
Acc 83																									1	0.0
Acc 84		1																								0.0
Acc 85 (Swarnamuki)		1																								0.0
Gomanga(Acc86)	1	2		2	2	1	2		1			1			1	1	1	1			1	1	1	1	2	0.9
Acc 87																								1		0.0
Acc 88																								1		0.0
Pulimanga(Acc 89)	5	6		4	4			6	4	4		4	4			4	4		4	4		5	6	4		0.9
Pulichi (Acc 90)	1											1											1			0.7
Acc 91	1											1														0.5
Kilichundan Var.(Acc 92)	1																						1			0.5
Acc 93	1																									0.0
Acc 94	1																									0.0
Chiindhram	2																									0.0
Karpuramanga								1																		0.0
Richness	10	6	1	3	3	2	2	4	3	2	1	4	3	1	2	2	3	2	2	1	1	3	4	5	5	
N	22	20	4	10	11	5	6	18	11	8	5	11	9	5	6	5	12	5	8	4	1	14	17	11	9	
Evennesss	0.8	0.8	0.0	0.6	0.6	0.3	0.4	0.7	0.6	0.5	0.0	0.6	0.6	0.0	0.3	0.3	0.5	0.3	0.5	0.0	0.0	0.5	0.7	0.7	0.7	

4.3.3 RELATIONSHIP BETWEEN PLOT SIZE AND MANGO DIVERSITY

During the FGD and data collection process, home-gardenplots were divided into four distinct categories: A) >1acre, B) 1 - <5 acres, C) 5 - <7 acres, and D) 7≤ acres. Average varietal richness was then plotted against homegardensize for the four villages.

4.3.3.1 Relationship between Plot Size and mango diversity in Elanad

The average varietal richness value of Elanad varied from 3.6 to 11. Elanad village showed a direct positive relationship between richness and home garden plot size for size categories.

A gradual increasing trend of richness of the mango landraces was noted in the village and it was highest (11) in group D. It indicates more number of mango landraces present in large homestead areas.
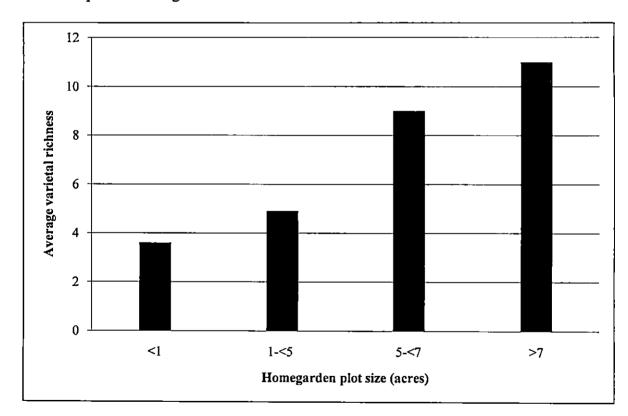
Fig 4.17 Relationship between Plot Size and mango diversity in Elanad

4.3.3.2 Relationship between Plot Size and mango diversity in Vennur

The average varietal richness value of Vennur varied from 2 to 8.5. Vennur village showed a direct positive relationship between richness and home garden plot size for size categories.

A gradual increasing trend of richness of the mango landraces was noted in the village and it was highest (8.5) in group D. It indicates more number of mango landraces present in large homestead areas.
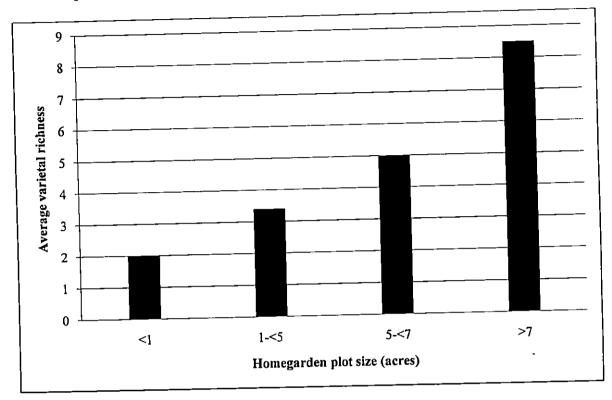
Fig 4.18 Relationship between Plot Size and mango diversity in Vennur

4.3.3.3 Relationship between Plot Size and mango diversity in Pazhayannur

The average varietal richness value of Pazhayannur varied from 3.8 to 7. Pazhayannur village showed a direct positive relationship between richness and plot size for size categories.

A gradual increasing trend of richness of the mango landraces was noted in the village and it was highest (7) in group D. It indicates more number of mango landraces present in large homestead areas.

4.3.3.4 Relationship between Plot Size and mango diversity in Vadakkatara

The average varietal richness value of Vadakkethara varied from 2 to 5. Vadakkethara village showed a direct positive relationship between richness and plot size for size categories.

A gradual increasing trend of richness of the mango landraces was noted in the village and it was highest (5) in group D. It indicates higher mango diversity in large homestead areas.
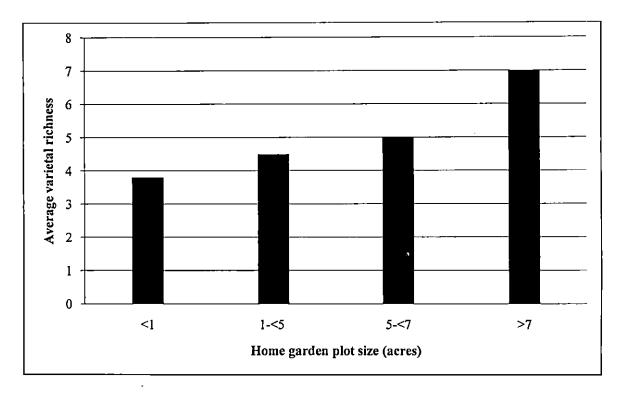
Fig 4.19 Relationship between Plot Size and mango diversity in Pazhayannur
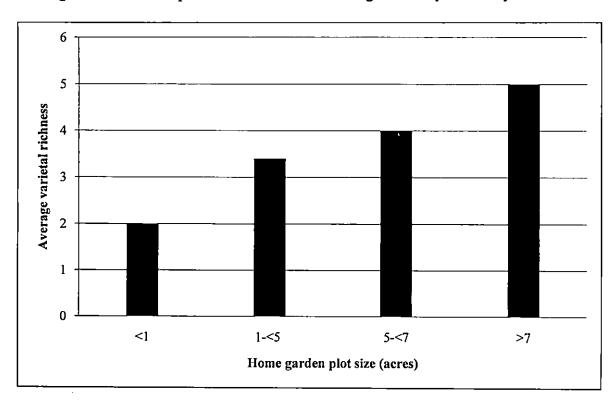
Fig 4.20 Relationship between Plot Size and mango diversity in Vadakkatara

4.3.4 INDEGENOUS TRADITIONAL KNOWLEDGE (ITK) DOCUMENTATION AND CULTURAL VALUES ASSOCIATED WITH MANGO LANDRACES IN THE REGION.

Indigenous knowledge is the knowledge of the people living together in a certain area, generated by their own and their ancestor's experience including knowledge originating from elsewhere which has been internalized by the local people.

Along with the participatory diversity analysis and individual location visits undertaken in the villages, an attempt was also made to document the traditional knowledge/ skills practiced by the villagers specifically to mango production and processing at the homesteads. It was noted that the local mango landraces occupies a prime position in this regard and associated with many- a – rural cuisine of this region. Accordingly the available information collected from the different villages is consolidated and presented below.

4.3.4.1 ITK associated with product preparation and other uses

ITK associated with mango landraces of the region is predominantly /exclusively related to preparation of different products. In all the surveyed villages mango fruits at different stages of maturity find use in many culinary items and preparation of processed products.

4.3.4.2 Kadu manga/ Kadugu manga (Tender mango pickle)

Preparation of tender mango pickle, popularly known as kadugu manga is a systematic activity taken up many village households of this region in which the lead role taken by the elderly women after getting the fruits harvested either from their own compounds or shared from neighbourhood.

The fruits are harvested with the bunches at the marble / premature stage of development. Normally turpentine flavoured types are not preferred for this preparation since flavor will interfere with the flavor of the final product. After harvesting, the fruits are separated from the bunches retaining half centimeter stalk along with, so as to allow some sap in the retained stalk. The presence of sap is

supposed to act as preservative during storage. Fruits are washed in water thereafter, and thoroughly wiped off with cloth to remove completely the adhering moisture. The fruits are placed further on a cloth spread on the floor.

Some of the aspects to be considered while choosing mango types suited for good tender mango pickle preparation are

1. Fruits should have sap rich stalks.

2. It should have sufficient peel thickness.

3. It should have excellent flavor after processing.

Hence turpentine flavoured ones are not generally preferred.

4.3.4.2.1 Addition of salt (NaCl) and primary processing
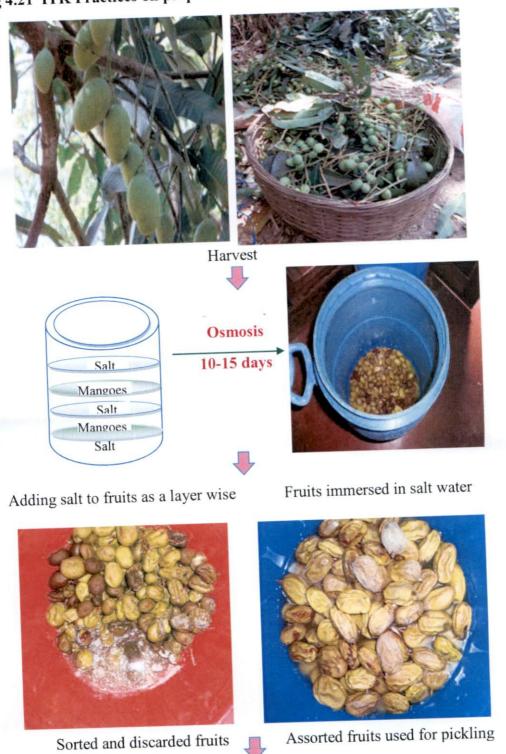
Salt is added on weight basis (W/W) @ 20 % of weight of fruits. Normally, powdered salt is used at present though crystal salt was also used in earlier days. The contents will be kept in chinese clay / plastic containers for storing the product. Salt should be added in layers. Half the quantity is spread as bottom and intercepting layers and remaining half as the top layer. Normally vessels with narrow mouth are used so as to have a minimum space exposed to the air at top, which will also reduce spoilage. After 10-15 days due to the osmotic release of water from the fruits, all the fruits get shrunken and get immersed in the salt water mixture. These fruits are taken out with a wooden ladle and entire contents are transferred to wide flat basin like vessel. The fruits are sorted thereafter to cull out the spoiled ones.

4.3.4.2.2 Final processing and storage

Assorted fruits with good shrinkage and appearance are used for final product preparation. It will be added with chilli powder, mustard powder at the right proportions. The chilli powder is prepared after removing the stalk and seeds - a practice further enhancing the storage life of the final product.

For every one kg weight of fruit 200 gm of chilli powder and 100 gm mustard powder is added. While mixing chilli powder and mustard powder, a small quantity of salt water is also added to make it into diluted slurry. The entire contents are mixed in this way with through stirring for uniform blending.

Fig 4.21 ITK Practices on preparation of Kadu manga pickle at Pazhayannur

Harvest

Osmosis

10-15 days

Adding salt to fruits as a layer wise

Fruits immersed in salt water

Sorted and discarded fruits

Assorted fruits used for pickling

Addition of chilli powder (200 g) and mustard powder (100 g) per one Kg fruit weight

Small quantity of salt water also added to make it diluted slurry

Stirring ingredients for uniform blending

Transfer to narrow mouth containers - Bharani

Covered container (Bharani) mouth with white cloth soaked in gingerly oil and fasten with wooden lid

⬇

⬇

⬇

Fresh pickle   Three years old pickle

The contents are then transferred to narrow mouth containers locally called as bharani. Both white and black coloured ones are used for this purpose. After transferring to the containers, plantain leaves coated with gingelly oil are spread on the top surface. White cloth soaked in gingelly oil is also used for this purpose. Such oil coated material will provide an insulation for the product from the outer air space. As far as possible the container should be filled up to the brim. The mouth of the container is then closed with a wooden lid. The lid will be tightly fastened with a dry cloth and there after the top will be protected with mud caps. In some places sand bags are also used for this purpose. The prepared product can be stored without spoilage and quality loss, for a minimum period of three years. The quality, flavor etc., of the produce gets excellent after the first year of storage.

4.3.4.3 Uluva manga (Fenugreek Pickle)

For the preparation of the product the fruits are harvested when the stones get hardened. Normally fibrous types preferred. As in the earlier case the fruits with half cm stalks are separated from the bunches. Then they are washed completely and drained off the excess moisture from the surface and transferred to narrow mouthed bharani and added with salt at the rate of 25 percent on weight basis. After 3 weeks when the water is full on the top ,they are sorted and transferred to basin like containers. Chilli powder @ 100 gm and fried fenugreek powder @ 75 gms /kg of fruits is then added which will form a thin slurry in due course. The contents are then transferred to narrow necked bharanies and stored. The prepared product will last at least for two years without spoilage or quality loss.

4.3.4.4 Dry Mango Pickle

Preparation of dry mango pickle is also a common feature of this region. Ripe mangoes collected from the local types are dried in the sun after de-stoning during March – April. Local juicy 'Puliyan' is extremely suited for the purpose. These dried mangoes are later used for different culinary preparations. Fully mature fruits of Muvandan are also used for this purpose. Fruits are sliced into pieces and dried under sun for two weeks. (It can be kept upto 3 years without spoilage if stored in air tight containers). Such dried slices are used for readymade pickles later during off season of mangoes.

Mature ripe Gomanga fruits are used for preparation of Chettu manga pickle. Green fruits of pulimanga are used for instant pickle preparation and ripe fruits are used for curry preparations like pulissery .

4.3.4.5 Adamanga

Adamanga' is yet another preparation in households of this region which is prepared from green mango in many homesteads. The local type 'Puliyan' is typically suited. Green mango will be cut without removal of skin and sun dried.
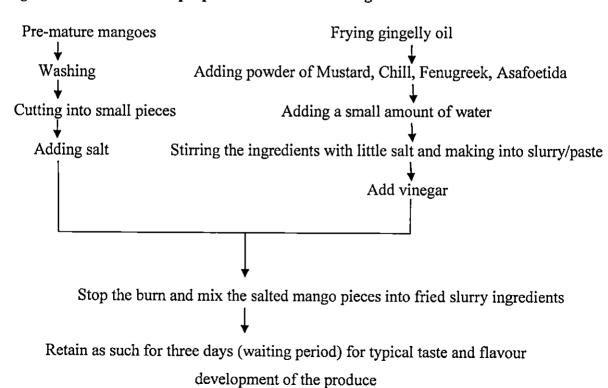
4.3.4.6 Mampazha Pulissery

Mango fruits at firm ripe stage are used throughout the region for this preparation. Chandrakaran and puliyan types are the most suited types.

4.3.4.7 Chethumanga Pickle (Instant Pickle)

Chethu manga pickle or instant mango pickle is yet another preparation of the households of the region. Mango Fruits at premature stage are used generally. Mature / ripe Gomanga fruits are also used in some villages for this purpose.

Fig 4.22a. Procedure for preparation of chethu manga

Pre-mature mangoes   Frying gingelly oil
↓   ↓

Washing   Adding powder of Mustard, Chill, Fenugreek, Asafoetida
↓   ↓

Cutting into small pieces   Adding a small amount of water
↓   ↓

Adding salt   Stirring the ingredients with little salt and making into slurry/paste
↓

Add vinegar

Stop the burn and mix the salted mango pieces into fried slurry ingredients
↓

Retain as such for three days (waiting period) for typical taste and flavour development of the produce
↓

Storage life upto 6months

Frying of oil and adding mustard, asafoetida, fenugreek, chilli and salt

Adding vinegar

Adding mango pieces to oil fried ingredients

Chettumanga/ Instant pickle

Fig 4.22 b. Preparation of instant pickle/ Chethumanga pickle

4.3.4.8 Mango stone powder

In an interesting observation we could also note mango stone powder preparations in some villages of the region. Extracted seed stones will be dried after cleaning in lukewarm water and smeared with common salt and dried in sun. In some cases the stones will be immersed in water for 3-4 days for removing the astringency before drying. The dried stones will be powdered and stored and later taken for different preparations including sweet appams.

4.3.4.9 Chakirimanga Juice

Chakiri manga fruits are used for juice preparation in some villages.

4.3.4.10 Indigenous ripening methods

In the households, harvested fruits are ripened by keeping them in bamboo baskets . Fruits will be spread on a mat of paddy straw on the bottom side of the baskets and further placed in layers with paddy straw placed in between. Fruits will attain the typical shiny colour and flavor when ripened in this way. In some hamlets paddy straw and leaves of *Cassia fistula* (kanikonna) are used for this purpose. The practice as reported by them helps in attaining attractive colour during the ripening of fruits.

4.3.4.11 ITK as related to tolerance to biotic stress

During individual site visits and village group meetings it was reported that the types with turpentine flavoured fruits (Karpoora manga)showed minimum incidence of stone weevil and fruit fly in comparison with the other types .

4.3.4.12 Collection and marketing of mango fruits in the region

Pazhayannur is the nearest mango market (Pate 4.17). Muvandan and Chandrakaran are the dominating types, which are marketed. Fruits are procured on contract basis by pre harvest contractors from different homesteads. They will take a visual estimate of yield at the flowering time and fix the price accordingly. Fruits at different stages of maturity are harvested based on demand and collected in plastic crates, and transported to market yard. They are stored in bamboo baskets along with paddy straw. Paddy straw acts as cushioning material during transport to reduce external bruises and enhance natural ripening process.

Plate 4.17 .Mango collection yard at Pazhayannur

4.3.5 DIVERSITY REGISTER FOR MANGO LANDRACES AT PAZHAYANNUR REGION

Preparation of diversity register of the mango landraces of the region was also envisaged in the programme and accordingly a comprehensive village diversity register of mango landraces was prepared in the below mentioned format, and attached as annexure-XI along with.

1. Basic information of the landrace spotted (Local, scientific and ethnic names).

2. Existence history at a given location.(year of introduction and address of locality)

3. From where the particular race came from(original place, source of knowledge and materials)

4. Extent and distribution of diversity.(rare, common and widely grown)

5. Method of use (Table/ pickling/ juice/ curry/ others)

6. Bearing history, uses and marketing channels

7. Information on custodians. (Name and address)

8. Incidence of pests / diseases / phanerogamic parasites

9. Any other useful information provided by the custodian farmer / agency.

4.3.6 HYBRIDISATION ATTEMPTS INVOLVING SELECTED LRS. OF THE REGION WITH MOOVANDAN AND NEELUM AS FEMALE PARENTS

Some of the rare unique landraces spotted during the survey were crossed with Moovandan and Neelum kept as female parents. Crossing was undertaken at controlled conditions on the trees at the college orchard.

4.3.6.1 Pollen Storage

Since survey locations are far-away places from the site of crossing , storage studies were undertaken for arriving at the optimal conditions for storing pollen (if required) with a minimum loss of viability . Results are presented in Table 4.37.

Table 4.37: Mango pollen viability at different storage conditions

S.No	Treatments	Pollen viability (%)			
		Days after storage			
		24 hours	48 hours	72 hours	96 hours
1	Keeping over calcium chloride in a dessicator	73.5[b]	14.0[d]	9.0[c]	-
2	Keeping in refrigerator at 4[0]c	77.6[a]	70.3[a]	61.5[a]	45[a]
3	Keeping over calcium chloride and refrigerator at 4[0]c	72.0[bc]	58.9[b]	40.0[b]	-
4	Keeping at room temperature	62.0[c]	42.0[c]	32.6[bc]	-

Values with similar superscript letter did not differ significantly

The studies showed that the mango pollen can be stored without much loss in viability upto 72 hours after dehiscence when it is stored in refrigerated conditions, but the viability was high (77.6 %) after 24 hours of storage but then declining to 70.3 percent and 61.5 percent after 48 hours and 72 hours respectively. Keeping over calcium chloride in dessicator retained the viability upto 73.5 percent after 24 hours of storage but thereafter suddenly reduced to 14 percent and 9 percent at 48 hours and 72 hours of storage. Keeping over Calcium chloride and under refrigerated conditions the viability of pollen retained up to 72 percent after 24 hours of storage but thereafter reduced to 58.9 and 40 percent at 48 hours and 72 hours of storage. By keeping pollen at room temperature conditions resulted at lower rate than all other treatments pollen viability was recorded 62 percent after 24 hours of storage under room condition and further declined to 42.0 and 32.6 percent after 48 and 72 hours respectively.

4.3.6.2 Controlled pollination and crossing

Procedure as standardized by Regional Fruit Research Station,Vengurla, Maharashtra for hybridization of mango varieties was adopted and was undertaken during January-February 2014 and January- February 2015.

Acc.1, Acc 15, Acc.43, Acc.56, Acc.58, Acc.67, Acc.77, Acc.78 and Acc.61 were used as a male parent for crossing and out of this, Muvandan× Acc. 1, Muvandan×Acc. 15 and Muvandan× Acc. 43, combinations yielded mature fruits finally.

In Muvandan× Acc 1, cross combination there was 40 per cent fruit set at pin head stage and after subsequent fruit drop in other stages of development only five percent of flowers reached final maturity.

In Muvandan× Acc 15, combination there was 73.33 per cent set at pin head stage, at mustard stage it was only 33 per cent and at pea nut stage (27 percent) final retention was only 3.3 per cent.

In Muvandan× Acc 43 combination2.3 per cent reached final maturity for harvest.

In Muvandan× Acc56 combination there was 22.2 per cent fruit set at pin head stage further fruit drop resulted in zero fruit retention at the mature stage.

In combination of Muvandan × Accession 58 resulted 13.3 percent per cent fruit set at pin head stage further fruit drop resulted in zero fruit retention at the mature stage.

The cross combinations, Muvandan × Accession 67, Muvandan × Accession 77Muvandan× Accession 78 and Muvandan × Accession 61 resulted 75, 12.5, 16.6 and 23.5 percent fruit set at pin head stage respectively, further fruit drop resulted in zero fruit retention at the mature stage.

Two cross combinations using Neelum as female parent were tried. In Neelum × Acc 92 combination, 54.5 per cent fruit set was noted at the pin head stage. Mustard stage accounted about 18 per cent fruit set and further fruit drop resulted in zero fruit retention at the mature stage.

In Neelum × Acc 64 combination only 30 per cent set could be noted at the pin head stage itself but further complete drop of set fruits in this stage resulted in zero retention in the final stage.

Table 4.38 Performance of selected mango landraces under control pollination and crossing

Sl No.	Combinations	No. of flowers crossed	Pin head	Mustard stage	Pea nut stage	Marble stage	Pre mature stage	Mature stage	Remarks
1	Muvandan× Accession 1	20	8	3	3	1	1	1	Cross Compatible
2	Muvandan× Accession 15	30	22	10	8	4	1	1	Cross Compatible
3	Muvandan× Accession 43	43	15	8	3	1	1	1	Cross Compatible
4	Muvandan× Accession 56	18	4	-	-	-	-	-	Cross Compatible
5	Muvandan× Accession 58	15	2	-	-	-	-	-	Cross Compatible
6	Neelum× Acccession 64	20	6	-	-	-	-	-	Cross Compatible
7	Neelum× Acccession 92	22	12	4	2	1	-	-	Cross Compatible
8	Muvandan× Accession 67	12	9	1	-	-	-	-	Cross Compatible
9	Muvandan× Accession 77	16	2	-	-	-	-	-	Cross Compatible
10	Muvandan× Accession 78	18	3	-	-	-	-	-	Cross Compatible
11	Muvandan× Accession 61	17	4	-	-	-	-	-	Cross Compatible

Plate 4.18 Female Parents (Muvandan trees)

Plate 4.19 Collection of panicles from male parents from the site and keeping
overnight in water

Plate 4.20 Collection of freshly opened flowers (contain pink anther)
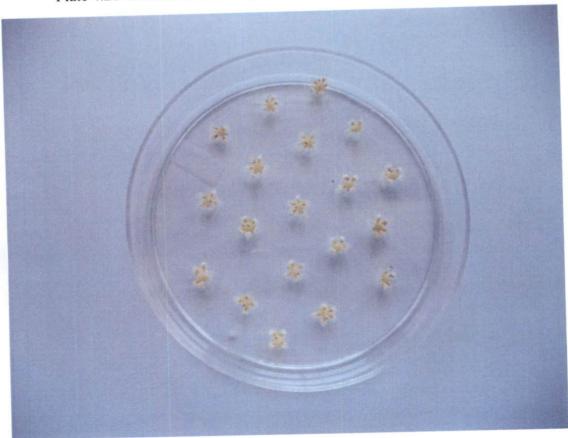
Plate 4.21 Keeping freshly opened flowers under sunlight for anther dehiscence
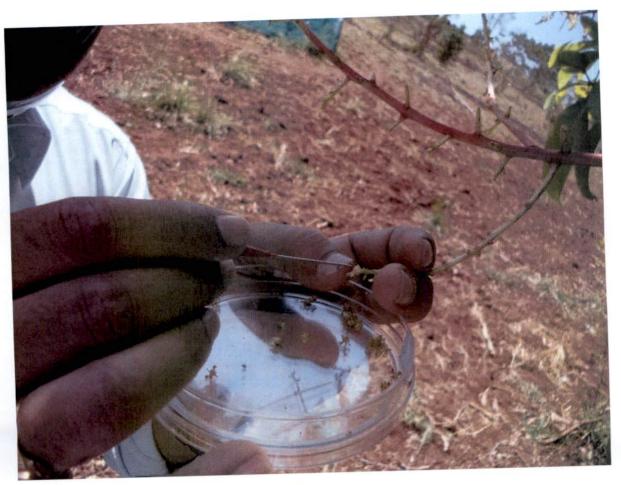
Plate 4.22 Hand pollination
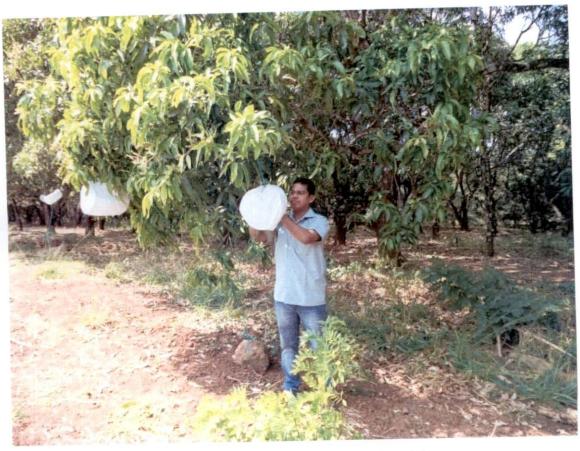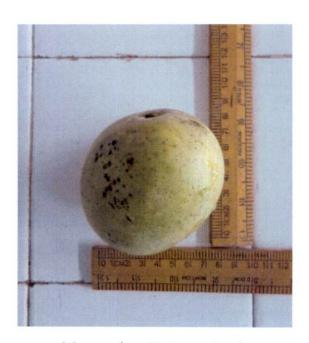
Plate 4.23 Bagging of the pollinated panicles

Moovandan

Accession 1
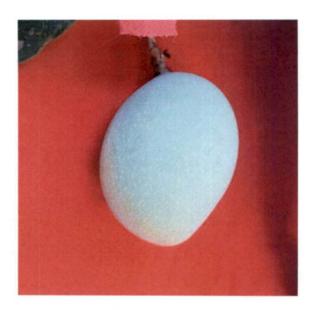
Moovandan X Accession 1

Plate 4.24 Cross between Moovandan X Acc-1

Moovandan

Accession 15

Moovandan X Accession 15

Plate 4.25 Cross between Moovandan X Acc-15

Moovandan
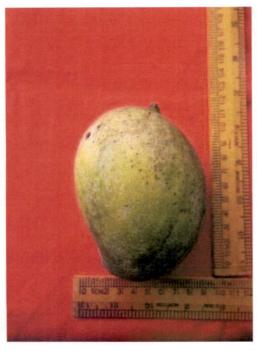
Accession 43

Moovandan X Accession 43

Plate 4.26 Cross between Moovandan X Acc-43

Neelum

Accession 92

Neelum× Acccession 92

Plate 4.27 Cross between Neelum X Acc-92

Table 4.39 Some salient traits of landraces chosen for *exsitu* conservation

S.No	Accession	Characters
1	Acc 1 (Gundu)	Large sized fruits, thick and rough peeled, ,sweet, good for table purpose
2	Acc 6 (Kannimanga)	Medium size, high fibre content in fruit
3	Acc 10	Small size, Sweet, fibre abundant
4	Acc 22	High fibre content and sweet in taste
5	Acc 24	Small sized, juicy with sweet taste
6	Acc 25	Mammiform beak , good quality
7	Acc 27	Medium sized, Flesh colour light green,
8	Acc 33 (Gomanga)	Fibrous juicy, turpentine flavoured sweet in taste
9	Acc 45(Pacha muvandan)	Regular and offseason bearer
10	Acc 57 (Attanari)	Green coloured, fibrous fruits
11	Acc 58 (Sapotamavu)	Sapota (brown) coloured mango, deep lenticels.
12	Acc 53	Large sized fruits , sweet, thick peel
13	Acc 56	Attractive yellow colour with sweet taste, firm flesh
14	Acc 67	Small sized, Pleasant flavor with sweet taste and juicy
15	Acc 84 (Swarnamuki)	Medium sized, fruits have a golden colour on ripening

Plate 4.28 Collection of scions from the field, storing and grafting on rootstocks

Collection of scion material from homesteads

Scions kept with wet cloth at cut end.

Grafting

Successful grafts ready for planting

Chapter V

Discussion

5. DISCUSSION

Conservation and maintenance of landraces (LR) as a part of the cultural heritage of a region or country is yet to be given a serious thought by crop breeders and horticulturists worldwide. LRs of a geographical region are the unique symbols which in many ways are comparable with monuments, regional dresses, and folk songs - a few telling examples of the regional or local cultural heritage (Zeven, 1998).

During the domestication phase of wild plants, man developed plants which had phenotypes surviving not only natural selection but also artificial selection. The phenotypes and genotypes of the wild plant changed as man selected for plants with certain desirable characteristics, which either were already present or else arose during cultivation. He maintained and multiplied these desirable plants. In addition to man's selection activities nature also selected phenotypes suitable to be cultivated on man-made land and gardens. These combined actions resulted, for some crops, in populations which we call landraces. The term landraces also includes garden-races. These were and still are grown, in remote areas or in small garden plots, as suggested interestingly by Hawkes (1983) that 'remote to those trying to collect landraces, but not for the growers themselves'. There has been extensive discussion on what constitutes a landrace (LR), and even it is possible to define them. Camacho Villa *et.al* (2005) defined LRs as "dynamic populations of a cultivated plant that has historical origin, distinct identity and lacks formal crop improvement, as well as often being genetically diverse, locally adapted, and associated with traditional farming systems".

Kerala has a typical humid tropical condition and the natural mango gene pool consists mainly of the seedling races of local types, predominantly grown in homesteads and as avenue trees. Homestead with rich crop diversity is the salient feature of Kerala villages. Local LRs of mango are one among the components of such a poly crop system. These are the seedling mangoes and many are poly embryonic also. But the rapid development of industrialization, urbanization, changes in land and crop use patterns, large scale deforestation, accompanied by other social and cultural pressures have resulted in large scale degradation of natural habitats and loss of native diversity.

Conduct of village level diversity analysis of local mango LRs of Kerala and preparation of germplasm catalogues and diversity registers are supposed to be the basic steps in locating useful LRs and their conservation and subsequent use as parent material for future crop improvement programmes.

Present project entitled "Diversity mapping and characterization of landraces of mango [*Mangifera indica.* L]" was taken up in this background and it comprised of diversity mapping and digitization of LRs of mango at Pazhayannur region of Thrissur dt of Kerala, their characterization, preparation of diversity registers and descriptors, documentation of associated indigenous traditional knowledge (ITK) and evolving appropriate integrated conservation and improvement strategies for the rare LRs spotted in the region during the project implementation.

5.1 Uniqueness of the study site

Study area for the present project comprised of the Pazhayannur region of Thrissur district of Kerala which is situated between 10° 42' 32" to 10° 35' 42" N latitude and 76° 25' 1.0" - 76° 24' 50"E longitude. It has a geographical area of 59.03 square kilometers within the altitude range of 30-220 m above MSL. Total annual rainfall is 2972 mm. Soil types noticed were rockery, laterite, black soil, clay soil predominantly red lateritic.

Pazhayannur tract is located on the eastern end of Thrissur district with a beautiful greenery landscape. It has Palakkad district on Eastern border, Thriuvilwamala GP of Thrissur district on the Northern border. Along its North eastern border flows the Gayathri puzha which joins Bharathapuzha later and ends in Arabian sea at Ponnani. Gayathri puzha is one of the main tributaries of the Bharathapuzha river, the second-longest river in Kerala, south India. It originates from Anaimalai hills, passes through Kollengode, Nenmara (Nemmara), Alathur, Padur and Pazhayannur before joining the Bharathapuzha at Mayannur. It is the second largest tributary of Bharathapuzha, by both length and discharge. It flows mainly through Palakkad district, except the last few kilometres. The river is non-perennial like its parent river. There is a dam built across this river at Cheerakkuzhy near Pazhayannur.

Primary assessment of mango LR diversity made by Renisha (2012) has provided much useful information on the status of traditional and other mango types grown in the homesteads of Thrissur and Palakkad districts of Kerala. Accordingly she could note a location centered predominance of certain mango types and LRs in the homesteads in Pazhayannur tract of Thrissur dt. Commercial mango mono cropping was conspicuously absent here. Muvandan and a number of its ecotypes were dominating the homesteads along with Priyur and local landraces *viz.,* Tholikaipan, Puliyan. Most of the seedling mango trees in the homesteads of both these GP's were of 50-60 years age. Uniqueness of the region as a potential repository of mango LRs more particularly of the LR Moovandan was clearly evident from these basic observations and hence offered much scope for further screening of the entire region systematically for a comprehensive diversity mapping of mango LRs at the entire region level. Based on these grounds this particular site was selected for the present investigations.

5.2 Ecogeographic surveys

Eco geographic studies refer to the process of collecting, characterizing, systemizing and analysing different kinds of data pertaining to target taxa within a defined region (Maxted *et al.,* 1995). These kinds of studies are important for the formulation and implementation of more targeted and, hence, more effective conservation strategies for plant genetic resources (PGR) (Guarino *et al.,* 2005). Taxonomic, morphological and genetic data can provide critical information about the diversity present in specific geographic areas, which, in turn, can be used for various purposes, such as the assessment of the current conservation status of PGR and to prioritize areas for *in situ* conservation. At the *ex situ* level, combining climate and other ecological information of an accession's collection site - from its passport data - with corresponding morphological or molecular characterization data has also proven useful for effective genebank management (e.g., definition of core collections, identification of collection gaps, etc.).

Geographic information systems (GIS) are useful tools for this type of analysis (Guarino *et al.,* 2002). GIS tools allow complex analyses to be done, as well as visualizing results in clear maps, which facilitate decision making by relevant

authorities and encourages the development and implementation of conservation policies (Jarvis *et al.,* 2010).

5.3 GIS based diversity mapping of mango landraces in the study site

Application of GIS tools are used as the novel methods at present as 'map makers' in different crops for diversity mapping. One of the defined objectives of the present investigations was the GIS based mapping of the mango LRs in the villages of Pazhayannur. Accordingly a pioneering attempt was made to prepare a comprehensive digitised diversity maps of the mango LR's of the region.

Geo referenced boundary map of villages availed from Indian Institute of Information Technology and Management (IIITM-K), Thiruvananthapuram, Kerala served as a base file for the purpose. It comprised of different villages of Pazhayannur such as Elanad, Pazhayannur, Vennur, Vadakkethara. Inputs from Land Resourses Information System (LRIS, 2016), Government of Kerala were also availed for supporting the above.

Garmin e Trex 20 worldwide Handheld GPS (Global Positioning System) was used for recording the geo co-ordinates (Latitude and Longitude) in the located spots in the different villages. GIS software, Arc GIS - version 10.2.2 was used for processing the geographic data (GPS readings) of the located diversity spots and for integrating it into a geo-referenced map.

A total of 100 LRs could be located during the survey of the region and they were grouped into five GIS maps based on their geographical positions. Preparation of a comprehensive digitised diversity map of mango LRs of Pazhayannur region along with individual maps for the major villages were thus the significant outcome finally emerged from the present investigations. These maps are fully digitised and prepared with scale and worked out grids. Though, use of GIS tools for different purposes has been attempted in different crops elsewhere, it is for the first time that such an attempt was made for the diversity mapping of mango LRs of Kerala . In that aspect the attempt was much rewarding in the sense that survey could produce a handful of detailed maps of the study site which can be used as base material for future diversity explorations in the region or nearby. Such digitised versions are also

much flexible and can be readily used a layer in Google Earth for identifying the exact location of the particular LR in the region.

Geo visualization research in last 15 years directed considerable effort towards enhancing dynamic and interactive maps. There are many remote places which are restricted for any physical reach for identification of plants, and in these peculiar circumstances GIS could be a tool to address all the complexity using extrapolation techniques. Using the map results one can directly approach for any particular plant / crop easily. It gives precise location of the plant in identified geographical territories (Qayum *et al.*, 2014). Since Geographic information systems (GIS) facilitates in visualizing results in clear maps ; it helps in timely decision making by relevant authorities for development and implementation of conservation policies (Jarvis *et al.*, 2010; Qayum *et al.*, 2014).

Although distribution of the mango landraces was scattered throughout the survey site, all the hamlets in the Elanad village were found unique due to the existence of a high number of LR's (44 nos), and many of these LR's recorded were found to be distinct in many of the fruit as well as other characters. The investigations clearly indicated the uniqueness of Elanad village of Pazhayannur as the highest mango LR diversity-rich area of the region. It is also clearly depicted in the diversity map prepared for this village.

5.4 Crop diversity status of the villages and relative position of mango LR's.

During the present investigations a homestead based land use practice was largely noted in all the villages surveyed with many annual and perennial species planted and maintained around the homesteads. A multispecies diversity - characterstic feature of the model home gardens as reported by Gautham *et al.* (2008) was notable in all these gardens. The crop diversity assessment of the villages provided a clear picture of the position occupied by mango among the other crops and such homesteads were the major locations where a rich assemblage of mango LRs could be located during the survey which is further elaborated below.

In Elanad (maximum diversity rich area) the locations were predominantly homestead compounds and in few places the plants were seen adjoining paddy fields and with a characteristic luxuriant growth. In Vennur village, the locations of the

LRs were predominantly homestead based and in isolated cases near to paddy fields. Some of them were near rubber plantations which are occupying a sizable land area including the conventional homesteads of this village at present. A similar situation was noted in the other villages also where mango diversity confining to the homestead peripheries either as single plant or a component of poly crop system. A notable trend observed during the survey was that a large area in the outer periphery of the many homesteads is being converted for mono cropping of rubber eventually leading to erosion of many useful plant germplasm in the process.

Home gardens are reported to be the oldest agro ecosystem (Soemarowoto, 1987; Hodel *et al.*, 1999; Nair, 2001; Trinh et al., 2003) and are an integral part of the traditional farming system of the villages. It is a land use practice around a homestead where many annual and perennial plant species are planted and maintained by the members of the household. The produce find use primarily for household consumption (Shrestha *et al.*, 2002). Home gardens are characterized by an abundance of multi-purpose species to meet the dietary requirements of its members and as sources of fruits, vegetables, fodder, fuel, medicines, spices, construction materials and income. Livestock are also raised within the home garden foraging on HH waste and providing milk, meat and eggs for HH and manure for the fields. Home gardens are dynamic in their evolution, composition and uses. They are often used as a place where farmers can experiment with, introduce and domesticate useful plants (Eyzaguirre and Linares, 2004). Their structural composition and species and varietal diversity are influenced by the socio-economic circumstances and cultural values of the users. These gardens are not only important sources of food, but are also important for on-farm management of a wide range of plant genetic resources not found in larger agro ecosystems (Agnihotri *et al.*, 2004; Sthapit *et al.*, 2004).

5.5 Characterization of mango landraces located during the survey

Diversity explorations in entire Pazhayannur region during the present investigations could spot out 100 distinct mango LRs spread over the region. In order to describe them systematically, morphological characterisation of these entire 100 mango accessions was carried out as per the standard descriptor for mango by IBPGR (2006) comprising the different tree, leaf, inflorescence, fruit and biochemical parameters. The application of morphological markers is the simplest of the formal,

standardised and repeatable methods of evaluating crop genetic diversity. Some of the most important advantages of using morphological characterisation are that published descriptor lists are readily obtainable for most major crop species, it can be carried out *in situ*, is relatively low-cost and easy to perform. Morphological characterisation is the first step that should be done before more profound biochemical or molecular studies are carried out (Hoogendijk and Williams, 2001). Morphological characterization allows for the study of plant variation using visual attributes. Fruits have been the major descriptors for identification of different varieties of fruit crops. (Toili *et al.*, 2013)

5.5.1 Tree characters

The age of the trees located were grouped into 6 categories according to age distribution. Age of the trees, surveyed spanned over the range of less than 20 years to more than 100 years and has facilitated the study in a better dimension. Forty three per cent of the trees surveyed belong to the age group of less than 20 years, narrowing to a meagre share of 6 per cent trees aged 80 years or more. There were 30 trees under the age group 20-40 years and 17 trees of age group 60-80 years. Radha and Manjula (2000) reported that, in the central part of Kerala, *ie.*, in Thrissur and Pallakkad districts, the age of the mango trees ranged from 10-80 years. Simi (2006) also reported the age of mango trees ranged from 10 to 70 years in southern Kerala.

In the present studies the spotted mango trees could be grouped into four categories based on height *viz.*, short (≤ 6 m), medium (6.1-9 m), tall (9.1-12 m) and very tall (>12 m) as per the classification followed by Radha (2001). As such 53 trees were very tall in nature, 21 trees were medium of height, short and tall categories had 13 trees each. Approximate height of the trees ranged from 10 to 35 years as reported by Radha and Manjula (2000) and 4.5 to 30m according to Simi (2006) in different regions of the state.

Tree growth habit could be made into 3 categories *viz.*, erect, spreading and drooping which is in conformity with the observations of Simi (2006).

5.5.2 Leaf characters

Leaf characters described include orientation of leaf, shape, tip, base, margin, texture, young flush colour, fragrance, venation, length, width and petiole length *etc.*

Leaf characters showed much variation among the accessions. Naik and Gangolly (1950) used leaf characters as secondary and tertiary characters for varietal identification.

The characters predominantly noticed in accessions were horizontal leaf orientation (87%), oblong leaf (60 %), acuminate leaf tip (84%), acute leaf base (57%), entire margin (74%), coriaceous nature of leaf (46%), and light green with brownish tinge (39%). Simi (2006) reported that lanceolate type of leaf shape and acuminate character of leaf tip and light green with brown tinge colour of young flush predominantly appeared in traditional mango types of southern Kerala.

Leaf length ranged from 18.95 cm to 36.5 cm and average leaf length of all the mango types was 25.02 cm. Leaf width ranged from 3.8 cm to 8.1 cm. Overall leaf width was 5.15 cm. Simi (2006) reported that leaf length ranged from 13.65 to 31.08 cm. and leaf width from 3.42 cm to 7.77 cm. National active germplasm site, CISH, lucknow maintaining 726 accessions of mango from mango growing regions of India, Florida, Brazil, Australia and Sri Lanka (Rajan *et al.*, 2013). Of these 248 accessions (North and East (150), south (26), and West (72)) were documented on 56 descriptors in the form of a catalogue (Rajan *et al.*, 2002). North Indian accessions recorded the largest mean leaf length (19.6 cm) and width (5.6 cm) while the south and westindian accessions have the smallest leaf length (18.56 cm) and leaf width (5.05 cm), respectively.

5.5.3 Inflorescence characters

The inflorescence characters predominantly noticed were the terminal position, pyramidal shape of inflorescence (62%), light green colour (55%) and densely flowered panicles (66%). Simi (2006) also reported dominance of terminal inflorescences, pyramidal shape of inflorescence and densely flowered panicles in southern Kerala. Jyothi *et al.*, (2009) reported morethan 70 percent of the mango trees had broadly pyramidal inflorescence and are densely flowered which give them a bunch like appearance. Renisha (2012) reported inflorescence rachis of Muvandan was dark red colour whereas in Neelum and Alphonso it was light red. Light green coloured inflorescence rachis was observed in Banganapalli and Vellaikolumban while in Priyur it was with light green with red tinges.

The length of inflorescence varied from 18.98 cm to 35.59 cm and width of inflorescence varied from14.02 cm to 30.60 cm. According to Timmappaiah and Suman (1987), length of panicle varied from 11.25 cm to 42.20 cm. Simi (2006) also reported 12 cm to 41 cm.

The flowering in mango was observed from November to March in the different accessions. Eighteen accessions were early season types (November to December), fifty four accessions were mid-season types (January to February). Early flowering provides the farmers with the option of marketing them to other parts of the country where the mango season starts only in June-July months. Flowering varied according to weather conditions. In north India, generally the flowering is one month late, compared to south India (Kulakarni and Rameshwar, 1981).

Majority of the mango trees in the surveyed locations were noticed as regular bearers (78). These trees produced fruits every year. Such accessions will be a potential material   for breeding programme for evolving regular bearing varieties if other characters are excellent.

Varietal influence in secondary flowering character was conspicuously noted during the survey. Secondary flowering was frequently noticed in eight mango accessions. The secondary flowering was observed in July-August in accession, 45, 59 and 77. Perpetual type of flowering (year round) was recorded in accessions, 7, 75, 76, 94 and 98. According to Naik (1963) the ability to produce more than one crop in a year is a unique feature in south india, favoured by the entire absence of frost, hail storms and severe winter conditions, as well as due to long growing season in its vast plains. Kannan (1973) also reported varietal influence in off season flowering of mango, the variety which flower throughout the year are referred as "Baramasis". These do not require long term storage of nutrients in their shoots and flowering is seen even in two months old shoots.

Three types of pollen shape were observed in the mango accessions *viz.* round, oblong and oval .Out of all, 90 accessions showed round shaped pollen, 4 accessions showed oblong shaped pollen and 6 accessions showed oval shaped pollen. Similar reports on pollen characters given by Renisha (2012).

5.5.4 Fruit morphological characters

Variability in mango types show that fruit shape was the most important and stable character for discriminating varieties from each other. Other fruit characters also have a degree of varying importance for the purpose of identification. Presence of beak, fruit size, sinus, cavity of stalk insertion are also important for studying variability in mango germplasm. (Ram and Rajan, 2003). Fruits have been exclusively used as the major descriptors for identification of different varieties of fruit crops. (Toili *et al.*, 2013).

Five different fruit shapes were observed, i.e. round, elliptic, obovoid, ovoid and oblong. Simi,(2006) observed four types of fruit shapes such as round, oblong, ellipsoid, and oblong ellipsoid. NavPrem, (2014) characterized nine sucking mango genotypes and observed fruit shapes such as ovate, oblong and ovate oblong. Round shape followed by oblong shape was predominantly noticed in mango accessions of Pazhayannur area. These observations find support from Jyothi *et al.* (2009).

Pertaining to the other fruit characters of the LRs, traits noticed predominantly were perceptible type of beak (77%), round apex (83%), absence of sinus(71%), rising and then rounded slope of the shoulders (69%), smooth surface texture (88%), absence of neck prominence (53%) and vertical stalk insertion (96%). These observations are similar to those made by Simi (2006).

A rare fruit colour, *i.e* brown peel (external skin) colour was noted in (Acc 58) hitherto not reported in mango types in Kerala. Green fruit colour was predominantly (43 %) recorded in this region. Previous reports by Jyothi *et al.* (2009) also show that peel (skin) colour of ripe fruits remained green on ripening in a large number of seedling mangoes.

Other fruit characters described include fruit length, fruit width, fruit weight, pulp weight, peel thickness, peel weight and pulp content etc. The characters among 100 accessions ranged from 4.80 cm to 18.00 cm, width 4.30 cm to 10.45 cm, weight 44.00 g to 634.82 g, pulp weight 19.80 g to 419.50 g, peel thickness 0.55mm to 4.05mm, peel weight 10.00 g to 149.9 g and pulp content 31.12 per cent to 74.24 per cent. In Kerala, Radha and Manjula, (2000) reported mango fruit weight ranged from 70 to 425 g. and Simi, (2006) reported fruit size, length and width ranged from 37.5 g

to 826 g, 4.4 cm to 18.1 cm and 3.9 to 12 cm respectively. In Punjab, Navprem *et al.*, (2012) reported fruit weight ranged from 50.3 g to 380.4 g, fruit length 4.63 cm to 12.52 cm, width 3.83 cm to 7.77 cm and fruit pulp weight 18.3 g to 267.5 g.

5.5.6 Pulp characters

Pulp characters for description included pulp colour, pulp texture, fibre in pulp, pulp aroma, and turpentine flavor etc. As regard to the pulp colour, a great diversity was observed in the characterized accessions. Five types of pulp colours observed, light yellow, yellow, yellow orange, light orange, dark orange, greenish yellow. Out of all 48 per cent accessions showed yellow, 25 per cent accessions showed yellow orange, 15 per cent accessions showed orange, five per cent dark orange, six per cent accessions showed light yellow and one per cent showed greenish yellow. Fruit pulp colour of mango ranged from yellow to orange as per (Navprem et al., 2014). Various pulp colours such as yellow, creamish yellow, light yellow, lemon yellow and orange were observed by Navprem *et al.*, (2012).and dark orange pulp in Amrapali reported by Riberio *et al.* (2013).

5.5.7 Stone characters

Stone characters described include length, stone length, stone width, stone weight, stone thickness, stone content, veins on the stone, pattern of venation, quantity of fibre attached to stone and length of fibre etc. stone characters showed a significant variation among the mango landraces. Similar reports with respect to other locations were made by Jyothi (2000) and Simi (2006).

5.5.8 Biochemical characters

Biochemical characters studied were total soluble solids, acidity, reducing sugars, non reducing sugars and total sugars etc. The total soluble solids of the ripe fruits varies from 7.6 to 23.65°brix, acidity was varied from 0.1 to 1.49 percent. reducing sugars varied from 0.88 to 6.22 percent, non reducing sugar content from 0.74 to 16.03 per cent., and total sugar content varied from 1.87 to 20.47 per cent. Total soluble solids determine the quality of juice and other canned products (Bhuyan and Kobra, 2007). Pradeepkumar *et al.* (2006) reported that TSS ranged between 12.7 and 25.2° brix among 31 north Kerala mango genotypes. Satyavati *et al.* (1972),

reported that TSS of ripe fruits of local varieties of Kerala ranged between 10 and 24° brix.

5.6 Polyembryony

The presence of more than one seedling in a germinated seed is referred to as polyembryony. Occurrence of this phenomenon in mango has been reported exclusively. In the present investigations polyembryony was noted in 31 surveyed accessions . The emerged seedlings per stone ranged from 2 to 4.   Most of the polyembryonic varieties reported to exist in India are confined to the west coast region of south India, comprising parts of Kerala and Karnataka (Radha and Manjula, 2000; Simi 2006 and Dhinesh Babu 2005)

5.7 Diversity status of traditional mango LRs in the villages of the study site - final assessment - utility of farmer participatory tools in identifying the key and rare types

To work out the richness and diversity estimates of mango landraces at the village level so as to chalk out the viable conservation strategies of the rare and endangered LRs of the region, final round up meetings (FRM) of the villagers were taken up. Focus group discussions (FGD) and participatory four cell analysis (FCA) were adopted during these meetings for a concluding assessment of the on mango diversity (Walter and Marja, 2007; Kruijssen and Mysore, 2010) and confirmation of the key mango landraces of the four villages. Four cell diversity analysis is a participatory tool standardized by Bioversity International (Walter and Marja, 2007) adopted for

1. Identifying unique, *common* and *rare* varieties of crop species cultivated in a community.
2. Documenting the reasons why crop species / types or the varieties are in a dynamic stage within the community.
3. Facilitating the identification of the interventions of the crop species or variety within a specific community.

During FCA, the participants were asked to list all the landraces of mango and place them in one of the four quadrants based on presence of landraces in their households and number of trees present.

Accordingly, the existing diversity of mango landraces in these four villages was classified based on their presence as *common*, other *distinct*, *vulnerable*, and *rare/* endangered landraces in the below mentioned format standardised by Kruijssen and Mysore (2010).

a) *Common landraces*: Mango landraces grown in many households and with many trees (More than 15 households with more than 4 trees)

b) *Other* distinct *landraces*: Mango landraces grown in few households and with many trees (Less than 6 households with more than 4 trees)

c) *Vulnerable landraces*: Mango landraces grown in many households and with few trees (More than 15 households with 1-2 trees)

d) *Rare landraces*: Mango landraces grown in small numbers in few homesteads (Less than 6 households with 1-2 trees)

As per this format Moovandan, Acc 13 and Pulimanga could be grouped as *'common'* in the Elanad village . Acc 2 and Acc 4 could be grouped under the category of *other distinct type*. Acc 33 (Gomanga) could be grouped as the *vulnerable type*. The group of *rare mangoes* in Elanad village comprised of Acc 1 (Gundu), Acc 5, Acc 6 (Kannimanga), Acc 7 (Cheriyamuvandan), Acc 8 (Amminipulichi), Acc 9, Acc 10, Acc 11, Acc 12, Acc 14, Acc 15 (Sundari), Acc 16, Acc 17, Acc 18, Acc 19, Acc 20, Acc 21, Acc 22, Acc 23, Acc 24, Acc 25, Acc 26 and Acc 27.

In Vennur, the *common* LRs found in a large number of homesteads comprised of Moovandan, Pulimanga, Pulichi and Pachhamoovandan. *Rare* mangoes comprised of Gomanga, Priyur*, Neelum*, Sindhuram*, Acc 46, Acc 47, Acc 49, Acc 50, Acc 51, Acc 52, Acc 53, Acc 54, Acc 55, Acc 56, Acc 57 (Attanari), Acc 58 (Sapotamavu), Acc 59, Acc 61, Acc 62 and Acc 63. (* pertain to this village only)

In Pazhayannur village, Moovandan, Pulichi (Acc 82) and Pulimanga (Acc 68) could be grouped as *'common'* due to their presence in large numbers in a large number of homesteads. Other types, Gomanga, Acc 69 and Neelum, could be grouped as *other* distinct due to its presence in few homesteads but with many numbers of trees. Similarly the *rare* group of mangoes comprises Kannimanga (Acc 67), Chindhuram, Priyur*, Acc 64, Acc 65 (Gundu), Acc 66, Acc 67, Acc 70, Acc 71, Acc

72, Acc 73, Acc 74, Acc 75, Acc 76, Acc 77 (Karpuramanga), Acc 78, Acc 79, Acc 80 (Vellari) and Acc 81. (* pertain to this village only)

At Vadakkathara village, the *common* varieties found in a large number of homesteads comprised of Moovandan, and Pulimanga. *Other distinct types* were Priyur* and Gomanga . The rare group included Swarnamuki, Acc 83, Acc 84, Acc 87, Acc 88, Acc 89, Acc 90, Kilichundan (Acc 92), Acc 93, Acc 94, Chindhuram, and Karpuramanga. (* pertain to this village only)

Besides, all the LRs spotted at the extended study sites at Painkulam and Kuthampully were also grouped as *rare* for the time being due to the uniqueness of these types. It comprised of Ezhikode Moovandan , Puthuvaya manga, Chandrakkaran and other accessions.

5.8 Diversity estimates

Richness and evenness are the two measures useful for gauging the biodiversity of a given site (Jarvis *et al.*, 2008; Renisha *et al.*, 2015). Richness describes the total number of genotypes (in terms of this study, species or varieties) found within a specified area. Richness was determined at the household level and was calculated by counting the total number of different farmer-named mango varieties per household unit.

Likewise, evenness details the frequency of given types within a total population. For instance, a low evenness value indicates the dominance of an agricultural system by one or few species or varieties, whereas a high value indicates a more uniform distribution of types in a given unit area (which, in this study, was the household unit).

Overall diversity estimate of mango LRs recorded during the present studies showed higher evenness values for the *common landraces*. It indicates its distribution in a large number of homesteads. Similarly lower evenness values were observed in *rare landraces*, indicating their distribution limited to few homesteads.

Diversity estimates in terms of richness and evenness values serve as a ready reckoner to identify the status of particular types /LRs in the villages. They are simple

variables to locate the dominant and rare types and facilitate in chalking out appropriate conservation strategies.

5.9 Relationship between homestead plot size and mango diversity

During the FGD and data collection process during present studies, home-garden plots were grouped into four categories *viz.*, a. >1 acre, b) 1 – <5 acres, c) 5 – <7 acres, and d) 7≤ acres. Average varietal richness was then plotted against homegarden size for the four villages. These four showed a direct positive relationship between richness and plot size for all size categories.

5.10 Constructing a mathematical basis for the survey

The observations recorded on the LRs included the qualitative and quantitative vectors (set of characters) on all the trees surveyed. It is a quite natural phenomenon to conduct various multivariate analyses, prominent among them being principal component analysis and factor analysis; leading to the individual directed cluster analysis.

5.10.1 Prominent relations observed

A strong positive association was noticeable among fruit weight, pulp weight, peel weight, stone length, fruit length, fruit width. Another set of positive association was noticed among TSS, reducing, non reducing and total sugar content and as a contrast, acidity isolated itself from both the sets as an independent phenomenon quite unpredictable in relation with the characters.

The diversity in different angles was quite noticeable with cluster analysis-qualitative, quantitative and finally the linkage established between the various characters of LRs included in cluster with their quantitative characters unevenly spread over the qualitative clusters generated.

The discussions so far has enlightened the extent of diversity of the mango resources of Pazhayannur region. The rarity of an accession may of course be counted as a phenomenon for preservation; but the outstanding common features rivetted with attractive quality characteristics may glorify the more common mango resource of the region. A concise presentation of the survey findings is accordingly furnished in Table 5.1, which is a composition of qualitative and quantitative features of

Table 5.1 Summary of survey findings

Plausible qualitative sets	Members	LS	CLR YL	INF S	FRT S	PLP CLR	PLP AMA	FRT WT	PLP W	PLP %	FRT L	FRT W	PEEL TK	STN TK
SET 1	19	EL-6 OBL-12 OVT- 1	LG 10 LGBT 7 LBR 1 DCT 1	C 6 P 11 BP 2	R19	LY 1 GLD Y 6 Y 11 LO1	M 12 INT 3 S 4	232	142	58	9	7	2	21
SET - II	11	EL-3 OBL-8	LG 6 LGBT 3 DCT 2	C 1 P 5 BP 5	OBL 2 R8 OBV 1	YO4 O 4 Y 2 LO1	M 6 INT 2 S 3	169	99	57	8	7	2	20
SET - III	33	EL- 13 OBL-19 LLT- 1	LG 15 LGBT 15 LBR 2 DCT 1	C 1 P 24 BP 8	OBL 23 EL 1 R 8 OVD 1	LY 2 YO3 GY 1 Y 19 DO 5	M 20 INT 6 S 7	167	96	55	8	7	2	20
SET- IV	5	EL- 1 OBL-3 LLT- 1	LG 1 LGBT 1 LBR 2 DCT 1	C 2 P 3	OBL 5	YO3 Y 2	M3 S 2	227	145	60	9	7	2	19
SET - V	4	OBL-4	LGBT 3 LBR 1	C 1 P 1 BP 2	R3 OBL 1	Y 3 YO1	M4	298	179	60	10	8	3	21
SET - VI	3	EL- 1 OBL-1 LLT- 1	LG 1 LGBT 2	C 1 P 2	OBL 4	LY 4	S 1 M1	133	79	59	8	6	1	19

LEAF SHAPE (LS): EL- Elliptic, OBL- Oblong, OVT- Ovate, LLT-Lanceolate;
COLOUR OF YOUNG LEAVES (CLR YL); LG-Light green, LGBT-Light green with brownish tinge, LBD-Light brick red, DCT-Deep coppery tan.
INFLORESCENCE SHAPE (INF S): C-Conical, P-Pyramidal, BP- Broadly pyramidal.
FRUIT SHAPE (FRT S): R- Round, OBL- Oblong, OBV- Obovoid, EL-Elliptic, OVD-Ovoid   PULP AROMA(PLP AMA) M-Mild, INT- Intermediate
PULP COLOUR(PLP CLR); G-Green, GY-Greenish Yellow, GLD- Golden Yellow, LY- Light Yellow, DO- Deep Orange, YO-Yellow Orange, Y-Yellow

statistically distinguishable group; the members of each set most frequently spotted in the study area. This table with the size of each set distinguishing the richness of the members as regards each characteristic can give the probabilistic outline of any combination of major characters of a mango tree in general. The more recurrent features of each and every characteristic of a mango tree can easily be read out from the table, so that the vector of major qualitative characters that may lead to the plausible major quantitative character of a mango tree can easily be sorted out.

5.11 Village based management of mango diversity- community awareness for setting conservation strategies

Four cell participatory diversity analysis conducted at the different villages of the study site to identify the key mango landraces in the villages could categorize the LRs into different groups. Based on this, a mango LR diversity management strategy pertaining to the study site as a whole (Pazhayannur) can be broadly visualized as outlined in Fig. 5.1

Any viable strategy for mango diversity management at the village level stems primarily from creating an awareness among the villagers about the importance of conserving the rare traditional/ landraces of the villages in particular and other types in general. Interface conducted with the farmers within village and FGD's served to a great extent in this direction. Accordingly the emerging strategy for the *common* and the types other than rare types is on farm / *in situ* conservation by the farmers themselves. Varietal improvement and enrichment of these types with only few trees in a large number of homesteads through PPB is also a viable proposition. Conservation of the types included in the *rare group* is more important than the former, since the potential threat of gene pool loss is looming with chances of indiscriminate cutting of the few number of trees available as rare germplasm material. Any unscrupulous cutting of these trees results in complete loss of the diversity. Proper awareness alerts to the farmers may prevent this to a great extent. But it is more secure by taking steps for an *ex situ* conservation of these types in the germplasm banks of research stations.

Fig. 5.1 Village based management of mango diversity for Pazhayannur region -A Conceptual model

Village Diversity Register of landraces - VDR

Insitu / onfarm

conservation

Ex situ conservation

in gene sanctuaries/

research stations

Many households Many trees	Few households Many trees
Common landraces	*Other distinct landraces*
Moovandan, (Acc 59)	Acc 2, 4
Pachamoovandan (Acc 45),	and 69
Acc 13, Pulimanga (Acc 48),	
Pulichi (Acc 60) , 82, 68 and 91	
Many households Few trees	**Few Households Few Trees**
Other distinct landraces	*Rare landraces*
Gomanga (Acc 33),	Swarnamuki (Acc 85)
Kilichundan,	Acc 1, 5 to 12,
Acc 86	14 to 44, 46 to 47,
	49 to 58, 61 to 67,
	70 to 90, 92 to 94, Chindhuram,
	Karpuramanga (Acc 83)

Crop improvement
through PPB

5.12 Diversity register for the mango LRs of the Pazhayannur

Preparation of mango LR diversity registers of the study site and documenting all the available information on location, custodian details, age group, flowering and fruit characters is yet another significant outcome of the present studies . Accordingly a comprehensive diversity register comprising the details of the entire 100 landraces spotted during the survey was prepared in the proper format. This document of information will be transmitted to the local body authorities and Agricultural officers of the region as a reference material primarily and to serve as a guide in chalking out strategies for *in situ* conservation of rare traditional mango types or landraces of the villages . It will also definitely serve as a valuable input for village biodiversity register preparation now actively undertaken at the gramapanchayath level throughout the Kerala state. Moreover it will also be a valuable reference material for mango researchers for future crop improvement programmes.

5.13 Indigenous Traditional Knowledge (ITK) documentation and cultural values associated with mango LRs in Pazhayannur region.

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

Indigenous Knowledge documentation (IK) is very important as it gives very useful information on growers' preferences and uses, indigenous production methods and on the role of growers in conservation and use, which could be used in developing appropriate research and development strategies on target fruit tree species.

During the present investigations, all attempts were made to document the traditional knowledge/ skills practiced by the villagers of the region specifically to mango production and processing at the homesteads. It was noted that the local mango types occupies a prime position in this regard and are associated with many a rural cuisine of this region.

ITK associated with mango land races of the region is predominantly /exclusively related to preparation of different products. In all the surveyed villages mango fruits at different stages of maturity find use in many culinary items and preparation of processed products such as kadu manga/ kadugu manga (tender mango pickle), uluva manga (fenugreek pickle), dry mango pickle, adamanga, mango stone powder, and chakirimanga juice etc. A visual documentation of the processes involved in preparation of some of the

products could also be made by profusely involving selected housewives of the different villages. One of the significant observations that could be made from these demonstrations was the pure organic ways of processing still practiced by the village house wives of the region. It is much pertinent in the sense that the organic ways of crop production and processing are coming to the fore front now a days and more and more people changing their preference to safe food items free from synthetic colours and chemical preservatives. In this line, present observations are also in consonance with Renisha, (2012) who also attempted traditional knowledge documentation with respect to the processing of mango in few villages of Thrissur and Palakkad districts of Kerala and noted a typical varietal specificity for each and every products prepared by the housewives of these regions and the simple traditional skills employed by them for making the products unique.

Chapter VI

Summary

6. SUMMARY

The project entitled "Diversity mapping and characterization of landraces of mango [*Mangifera indica. L*]" was undertaken at Pazhayannur region of Thrissur district of Kerala and Department of Pomology and Floriculture, College of Horticulture, Vellanikkara KAU during November 2012 to March, 2016. Selection of Pazhayannur region as the site of the present studies was based on the primary surveys conducted in this region earlier. The present investigations broadly envisaged the diversity mapping and digitization of mango LRs of this region, their characterization, preparation of diversity registers and descriptors, documentation of associated indigenous traditional knowledge (ITK) and evolving appropriate integrated conservation and improvement strategies for the rare LRs spotted during the project implementation. Salient results of the studies are presented below in a summarized format under the three major components below.

COMPONENT I: GIS BASED DIVERSITY MAPPING OF MANGO LANDRACES IN PAZHAYANNUR REGION AND THEIR SPATIAL DISTRIBUTION

1. Snow ball sampling method was used for locating the seedling mango landraces (LR) in homesteads and other places in the different villages of the region and their spatial distribution could be depicted through a series of GIS maps as per the geo co-ordinate readings. A total of 100 LRs could be located in different villages *viz.* Elanad, Vennur, Pazhayannur, Vadakkethara, Painkulam and Kuthampully of the study region and grouped in five GIS maps based on their geographical positions. Fully digitized maps of the entire study site could be prepared with scale and worked out grids. Garmin e Trex 20 worldwide Handheld GPS (Global Positioning System) was used for recording the geo co-ordinates (Latitude and Longitude) in the located spots in the different villages. GIS software, Arc GIS - version 10.2.2 was used for processing the geographic data (GPS readings) of the located diversity spots and for integrating it into a geo-referenced map.

2. In Elanad , 44 mango LRs could be recorded spread over the different hamlets of the village and thus adjudged as the maximum diversity rich area for mango LRs in the region and 19 nos each at Vennur and Pazhayannur revenue village

respectively. Remaining LRs were spotted in Vadakathara village (12); Painkulam (3) and Kuthampully (3)

3. A homestead based land use practice was largely noted in all these villages surveyed with many annual and perennial species planted and maintained around the homesteads and the mango diversity confining to the homestead peripheries either as single plant or a component of poly crop system.

COMPONENT-II: MORPHOLOGICAL CHARACTERIZATION OF MANGO LANDRACES SPOTTED DURING THE INVESTIGATIONS.

1. The morphological characterisation of surveyed LRs was carried out by using the standard descriptor for mango by IPGRI (2006) for different tree, leaf, inflorescence, fruit and biochemical parameters.

2. The age of the surveyed trees located were grouped into 6 categories according to age distribution. Age of the trees, surveyed spanned over the range of less than 20 years to more than 100 years and has facilitated the study in a better dimension. 43 percent of the trees surveyed belong to the age group of less than 20 years, narrowing to a meagre share of 6 percent trees aged 80 years or more. There were 30 trees under the age group 20-40 years and 17 trees of age group 60-80 years.

3. The trees could be grouped into four categories based on height *viz.*, short ($\leq$ 6 m), medium (6.1-9 m), tall (9.1-12 m) and very tall (>12 m). As such 53 trees were very tall in nature, 21 trees were medium of height, short and tall categories had 13 trees each.

4. Tree growth habit could be made into 3 categories *viz.*, erect, spreading and drooping. Fifty three accessions has shown spreading habit, thirty nine accessions were of erect habit, and eight accessions were of drooping habit.

5. The leaf characters predominantly noticed in LRs were horizontal leaf orientation (87%), oblong leaf (60 %), acuminate leaf tip (84%), acute leaf base (57%), entire margin (74%), coriaceous nature of leaf (46%), and light green with brownish tinge (39%); other leaf characters such as leaf length ranged from 18.95 cm to 36.5 cm and average leaf length of all the mango types was 25.02 cm., leaf width ranged from 3.8 cm to 8.1 cm. Overall leaf width was 5.15 cm.

6. Inflorescence characters predominantly noticed were the terminal position (100%), pyramidal shape of inflorescence (62%), light green colour (55%) and

densely flowered panicles (66%). The length of inflorescence varied from 18.98 cm to 35.59 cm and width of inflorescence varied from14.02 cm to 30.60 cm.

7. Flowering in the surveyed mango trees was observed from November to March in the different accessions. It varied according to weather conditions. However, the season of flowering could be classified into three; early season (November to December), mid season (January to February) and late season (from March) and two internal periods between seasons. Eighteen accessions were early season types, fifty four accessions were mid-season types, and seventeen accessions were early-mid season types, nine accessions were mid-late season types and two were late season types. most of the trees were regular bearers (78). Secondary flowering was frequently noticed in eight mango accessions and it was observed in July-August in accession, 45, 59 and 77. Perpetual type of flowering (year round) was recorded in accessions, 7, 75, 76, 94 and 98.

8. Three types of pollen shape were observed in the mango accessions *viz.* round, oblong and oval .Out of all, 90 accessions showed round shaped pollen, 4 accessions showed oblong shaped pollen and 6 accessions showed oval shaped pollen. Pollen size varied from 22.21 to 35.43 micron.

9. Five different shapes of fruits were observed *viz.*, round, elliptic, obovoid, ovoid and oblong. Fifty percent of trees produced round shaped fruits, 43 percent produced oblong shaped fruits, two percent produced obovoid fruits and one percent produced ovoid shaped fruits.

10. Perceptible type of fruit beak (77%), round apex (83%), absence of sinus(71%), rising and then rounded slope of the shoulders (69%), smooth surface texture (88%), absence of neck prominence (53%) and vertical stalk insertion (96%) were predominantly noted .

11. Other fruit characters *viz.*, fruit length, fruit width, fruit weight, pulp weight, peel thickness, peel weight and pulp content etc were recorded. Fruit length among LRs ranged from 4.80 cm to 18.00 cm, width - 4.30 cm to 10.45 cm, weight - 44.00 g to 634.82 g, pulp weight - 19.80 g to 419.50 g, peel thickness - 0.55mm to 4.05mm, peel weight - 10.00 g to 149.9 g and pulp content - 31.12 per cent to 74.24 per cent.

12. As regard to the pulp colour,48 per cent accessions showed yellow, 25 per cent accessions showed yellow orange, 15 per cent accessions showed orange, 5 per

cent dark orange, 6 per cent accessions showed light yellow and 1 per cent showed greenish yellow.

13. Biochemical characters studied were total soluble solids, acidity, reducing sugars, non reducing sugars and total sugars etc. The total soluble solids of the ripe fruits varies from 7.6 to 23.65°brix, acidity was varied from 0.1 to 1.49 percent. reducing sugars varied from 0.88 to 6.22 percent, non reducing sugar content from 0.74 to 16.03 per cent., and total sugar content varied from 1.87 to 20.47 per cent.

14. In the present investigations polyembryony was noted in 31 surveyed accessions . The emerged seedlings per stone ranged from 2 to 4.

15. Principal component analysis and cluster analysis were also carried out finally for fitting a mathematical basis for the survey.

COMPONENT-III: DIVERSITY ESTIMATE OF LANDRACES AT THE VILLAGE LEVEL USING FARMER PARTICIPATORY TOOLS AND STRATGIES FOR CONSERVATION.

1. Through the Four cell participatory analysis (FCA) conducted at the different villages, identification of the common and rare mango LRs of the villages could be made.

2. In Elanad village, Moovandan, Acc 13 and Pulimanga could be grouped as 'common' due to their presence in large numbers in a large number of homesteads. Other distinct group included Acc 2 and Acc 4 . Acc 33 (Gomanga) which is found growing in many homesteads with few numbers was grouped as the vulnerable type. The group of rare mangoes in Elanad village comprised of Acc 1 (Gundu), Acc 5, Acc 6 (Kannimanga), Acc 7 (Cheriyamuvandan), Acc 8 (Amminipulichi), Acc 9, Acc 10, Acc 11, Acc 12, Acc 14, Acc 15 (Sundari), Acc 16, Acc 17, Acc 18, Acc 19, Acc 20, Acc 21, Acc 22, Acc 23, Acc 24, Acc 25, Acc 26 and Acc 27.

3. In Vennur village, the common LRs found in a large number of homesteads comprised of Moovandan, Pulimanga, Pulichi and Pachha moovandan. Similarly the group of rare mangoes in the village comprised of Gomanga, Priyur, Neelum, Sindhuram, Acc 46, Acc 47, Acc 49, Acc 50, Acc 51, Acc 52, Acc 53,

Acc 54, Acc 55, Acc 56, Acc 57 (Attanari), Acc 58 (Sapotamavu), Acc 59, Acc 61, Acc 62 and Acc 63.

4. In Pazhayannur village also Moovandan, Pulichi (Acc 82) and Pulimanga (Acc 68) could be grouped as *'common'* due to their presence in large numbers in a large number of homesteads.Other types, Gomanga, Acc 69 and Neelum, could be grouped as other distinct due to its presence in few homesteads but with many numbers of trees. Similarly the *rare* group of mangoes comprises Kannimanga (Acc 67), Chindhuram, Priyur, Acc 64,Acc 65 (Gundu), Acc 66, Acc 67, Acc 70, Acc 71, Acc 72, Acc 73, Acc 74, Acc 75, Acc 76, Acc 77 (Karpuramanga), Acc 78, Acc 79, Acc 80 (Vellari) and Acc 81.

5. At Vadakkathara village, the *common* LRs found in a large number of homesteads comprised of Moovandan, and Pulimanga. The rare group included Swarnamuki, Acc 83, Acc 84, Acc 87, Acc 88, Acc 89, Acc 90, Kilichundan (Acc 92), Acc 93, Acc 94, Chindhuram, and Karpuramanga.

6. All the LRs located at Painkulam and Kuthampilly were grouped as *rare* ones with respect to the present investigations.

7. ITK associated with these mango LRs with special reference to the conventional and traditional processing of fruits were also documented

8. With the inputs collected during the individual farmer meetings and the final round up meetings, a conceptual model for *in situ* conservation of the spotted land races for the region was worked out and a comprehensive village diversity register of mango LRs of the region in the specified format was prepared as a material for future reference.

9. Initiatives were also taken up for the *ex situ* conservation of some rare mango landraces spotted during project implementation at Pazhayannur. Scion material of 15 such rare LRs spotted during the survey was collected and grafted plants were prepared for planting in the mango gene sanctuary maintained by Department of Pomology and Floriculture, College of Horticulture.

10. Crossing and hybridisation was also taken up during the project period involving selected LRs of the region as male parents with Moovandan and Neelum types maintained at the orchard of COH as female parents.

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Annexures

Annexure-I

LIST OF CUSTODIAN FARMERS ADDRESSES AT PAZHAYANNUR REGION

S.No	Mango Landraces	Farmer name	Name of the hamlet	Name of the Village
1	Acc 1	Ponnumani Urauamadakalam	Maruthampadam	Elanad
2	Acc 2	Ponnumani Urauamadakalam	Maruthampadam	Elanad
3	Acc 3	Ponnumani Urauamadakalam	Maruthampadam	Elanad
4	Acc 4	Ponnumani Urauamadakalam	Maruthampadam	Elanad
5	Acc 5	Ponnumani Urauamadakalam	Maruthampadam	Elanad
6	Acc 6	Ponnumani Urauamadakalam	Maruthampadam	Elanad
7	Acc 7	Ponnumani Urauamadakalam	Maruthampadam	Elanad
8	Acc 8	Ponnumani Urauamadakalam	Maruthampadam	Elanad
9	Acc 9	Saju P T panaphuthoffatil	Maruthampadam	Elanad
10	Acc 10	Saju P T panaphuthoffatil	Maruthampadam	Elanad
11	Acc 11	Sibbu Thadathil	Neelumpaliyal	Elanad
12	Acc 12	Ajish Thazhathuerambil	Neelumpaliyal	Elanad
13	Acc 13	Ramkumar thonur house	Neelumpaliyal	Elanad
14	Acc 14	Ramkumar thonur house	Neelumpaliyal	Elanad
15	Acc 15	Anitha Rariyamkandatha	Karimakuzhy	Elanad
16	Acc 16	Anitha Rariyamkandatha	Karimakuzhy	Elanad
17	Acc 17	Santha pallissery	Karimakuzhy	Elanad
18	Acc 18	Govindankutty	Karimakuzhy	Elanad
19	Acc 19	Padmini sreesadan	Thrikanya	Elanad
20	Acc 20	Padmini sreesadan	Thrikanya	Elanad
21	Acc 21	Remadevi kokkuri	Thrikanya	Elanad
22	Acc 22	Sreeja	Paruthipra	Elanad
23	Acc 23	Sivanarayana Pulluttukallam	Paruthipra	Elanad
24	Acc 24	M. S. Chandran Mekkonnath	Meenakshipath	Elanad
25	Acc 25	M. S. Chandran Mekkonnath	Meenakshipath	Elanad
26	Acc 26	M. S. Chandran Mekkonnath	Meenakshipath	Elanad
27	Acc 27	M. S. Krishnan Kutty Kannath	Paruthipra	Elanad
28	Acc 28	Krishnan Kutty Kunnath	Meenakshipath	Elanad
29	Acc 29	Baiju T.S. Pannikadu	Meenakshipath	Elanad
30	Acc 30	Rajan Kattiammal	Velladi	Elanad
31	Acc 31	Rajan Kattiammal	Velladi	Elanad
32	Acc 32	Rajan Kattiammal	Velladi	Elanad
33	Acc 33	Rajan Kattiammal	Velladi	Elanad

34	Acc 34	Rajan Kattiammal	Velladi	Elanad
35	Acc 35	Joy Kattiammal	Velladi	Elanad
36	Acc 36	Ravindran Kannasserykalam	Kannasserykalam	Elanad
37	Acc 37	Ravindran Kannasserykalam	Kannasserykalam	Elanad
38	Acc 38	Ravindran Kannasserykalam	Kannasserykalam	Elanad
39	Acc 39	Ravindran Kannasserykalam	Kannasserykalam	Elanad
40	Acc 40	Ravindran Kannasserykalam	Kannasserykalam	Elanad
41	Acc 41	Pramod Muthalamkodekalam	Muthalamkode	Elanad
42	Acc 42	Wilson Kunnassery	Muthalamkode	Elanad
43	Acc 43	Saju Manjali Kongothupadam	Muthalamkode	Elanad
44	Acc 44	Sabu Vattamthara	Muthalamkode	Elanad
45	Acc 45	Kuttan Kodakkatil	Vennur	Vennur
46	Acc 46	Joy Thandassery	Manchadi	Vennur
47	Acc 47	Ramachandran	Manchadi	Vennur
48	Acc 48	Shibu Pazhayakulam	Vennur	Vennur
49	Acc 49	Shibu Pazhayakulam	Vennur	Vennur
50	Acc 50	Uniikrishnan Chengathukalam	Manchadi	Vennur
51	Acc 51	Narayana Menon Konnamkundathu	Vennur	Vennur
52	Acc 52	Narayana Menon Konnamkundathu	Vennur	Vennur
53	Acc 53	Narayana Menon Konnamkundathu	Vennur	Vennur
54	Acc 54	Narayana Menon Konnamkundathu	Vennur	Vennur
55	Acc 55	Heasnar Vendokinparambu	Vendokinparambu	Vennur
56	Acc 56	Bikutty Vendokinparambu	Vendokinparambu	Vennur
57	Acc 57	Baby Thepala	Kuzhikakulambu	Vennur
58	Acc 58	Baby Thepala	Kuzhikakulambu	Vennur
59	Acc 59	Heasnar Vetanchadi	Vattapara	Vennur
60	Acc 60	Sibi Nelliknel	Vattapara	Vennur
61	Acc 61	Kunjali Vattapara	Vattapara	Vennur
62	Acc 62	Pitambran Kuruvapadam	Vennur	Vennur
63	Acc 63	Vasantha Kuruvapadam	Vennur	Vennur
64	Acc 64	Shivaraman SNDP sagagogam	Potta	Pazhayannur
65	Acc 65	Abdulla Kootupura	Potta	Pazhayannur
66	Acc 66	Abdulla Kootupura	Potta	Pazhayannur
67	Acc 67	Abdulla Kootupura	Potta	Pazhayannur
68	Acc 68	Abdulla Kootupura	Potta	Pazhayannur
69	Acc 69	Ravuni Panayanpadutha	Potta	Pazhayannur
70	Acc 70	Madhavan Panayampadam	Potta	Pazhayannur
71	Acc 71	Gopalamenon Gosssiri	Nelichira	Pazhayannur
72	Acc 72	Vijay kumar O.K Ottayil veedu	Nelichira	Pazhayannur
73	Acc 73	Vijay kumar O.K Ottayil veedu	Nelichira	Pazhayannur

			Kallepadam	Pazhayannur
74	Acc 74	Sugutha Vadhkoot	Kumbalamkode	Pazhayannur
75	Acc 75	Vasu Manamplavil	Kumbalamkode	Pazhayannur
76	Acc 76	Prakash Manamplavil	Kumbalamkode	Pazhayannur
77	Acc 77	Gopala Krishnan Thekkekulam	Plazhy	Pazhayannur
78	Acc 78	Sivaraman Vadakekolumbil	Plazhy	Pazhayannur
79	Acc 79	Sivaraman Vadakekolumbil	Pazhayannur	Pazhayannur
80	Acc 80	Prasad	Pazhayannur	Pazhayannur
81	Acc 81	Prasad	Pazhayannur	Pazhayannur
82	Acc 82	Prasad	Vadakkathara	Vadakkathara
83	Acc 83	Bhagavathi Temple palace compound	Vadakkathara	Vadakkathara
84	Acc 84	Vishnu Nambudhari	Vadakkathara	Vadakkathara
85	Acc 85	Vishnu Nambudhari	Vadakkathara	Vadakkathara
86	Acc 86	Vishnu Nambudhari	Cherakuzhy	Vadakkathara
87	Acc 87	College of Applied Science	Cherakuzhy	Vadakkathara
88	Acc 88	College of Applied Science	Vattapara	Vadakkathara
89	Acc 89	Vinodkumar	Vattapara	Vadakkathara
90	Acc 90	Vinodkumar	Vattapara	Vadakkathara
91	Acc 91	Vinodkumar	Puthirithara	Vadakkathara
92	Acc 92	Vijayan Thrithala	Puthirithara	Vadakkathara
93	Acc 93	Rukmini Korambuth	Puthirithara	Vadakkathara
94	Acc 94	Sankaran kutty	Kuthampilly	Tiruvilvamala
95	Acc 95	M. Parameswaran	Kuthampilly	Tiruvilvamala
96	Acc 96	M. Parameswaran	Kuthampilly	Tiruvilvamala
97	Acc 97	M. Parameswaran	Painkulam	Panjal
98	Acc 98	Shankar	Painkulam	Panjal
99	Acc 99	Shankar	Painkulam	Panjal
100	Acc 100	Shankar		

Annexure-II

TREE CHARACTERS

S.No	Landraces	Type of planting material	Age (years)	Tree height (m)	Tree Growth habit
1	Acc 1	Seedling	30	18	Spreading
2	Acc 2	Seedling	20	10	Spreading
3	Acc 3	Seedling	8	4	Erect
4	Acc 4	Seedling	20	8.5	Spreading
5	Acc 5	Seedling	9	4	Erect
6	Acc 6	Seedling	12	6	Spreading
7	Acc 7	Seedling	10	6.5	Erect
8	Acc 8	Seedling	40	30	Erect
9	Acc 9	Seedling	40	20	Erect
10	Acc 10	Seedling	45	25	Erect
11	Acc 11	Seedling	10	5.5	Spreading
12	Acc 12	Seedling	9	6.5	Spreading
13	Acc 13	Seedling	65	32	Spreading
14	Acc 14	Seedling	8	3.5	Spreading
15	Acc 15	Seedling	40	33	Spreading
16	Acc 16	Seedling	11	7.5	Spreading
17	Acc 17	Seedling	20	20	Erect
18	Acc 18	Seedling	35	24	Spreading
19	Acc 19	Seedling	8	7	Spreading
20	Acc 20	Seedling	8	6	Spreading
21	Acc 21	Seedling	8	5	Spreading
22	Acc 22	Seedling	50	28	Spreading
23	Acc 23	Seedling	8	8	Spreading
24	Acc 24	Seedling	10	12	Spreading
25	Acc 25	Seedling	25	15	Erect
26	Acc 26	Seedling	20	14	Erect
27	Acc 27	Seedling	10	10.5	Spreading
28	Acc 28	Seedling	35	40	Spreading
29	Acc 29	Seedling	18	12	Drooping
30	Acc 30	Seedling	35	20	Erect
31	Acc 31	Seedling	10	4	Erect
32	Acc 32	Seedling	100	40	Erect
33	Acc 33	Seedling	50	20	Erect

34	Acc 34	Seedling	80	35	Erect
35	Acc 35	Seedling	40	32	Erect
36	Acc 36	Seedling	25	15	Erect
37	Acc 37	Seedling	37	30	Erect
38	Acc 38	Seedling	16	5	Spreading
39	Acc 39	Seedling	25	20	Erect
40	Acc 40	Seedling	25	15	Erect
41	Acc 41	Seedling	30	20	Spreading
42	Acc 42	Seedling	20	12	Spreading
43	Acc 43	Seedling	30	15	Erect
44	Acc 44	Seedling	40	26	Spreading
45	Acc 45	Seedling	8	8	Spreading
46	Acc 46	Seedling	35	18	Erect
47	Acc 47	Seedling	45	20.5	Spreading
48	Acc 48	Seedling	50	30	Erect
49	Acc 49	Seedling	30	16.5	Erect
50	Acc 50	Seedling	60	20	Spreading
51	Acc 51	Seedling	50	29	**Drooping**
52	Acc 52	Seedling	8	4	Spreading
53	Acc 53	Seedling	9	5	Spreading
54	Acc 54	Seedling	**110***	25	Spreading
55	Acc 55	Seedling	20	10	Spreading
56	Acc 56	Seedling	11	8	**Drooping**
57	Acc 57	Seedling	10	8	Spreading
58	Acc 58	Seedling	10	8	Spreading
59	Acc 59	Seedling	30	20.5	Spreading
60	Acc 60	Seedling	10	9	Spreading
61	Acc 61	Seedling	10	7.5	Spreading
62	Acc 62	Seedling	10	10	Spreading
63	Acc 63	Seedling	11	10.5	Spreading
64	Acc 64	Seedling	20	10	Spreading
65	Acc 65	Seedling	25	10	Erect
66	Acc 66	Seedling	10	7	Spreading
67	Acc 67	Seedling	10	6	Spreading
68	Acc 68	Seedling	12	9	Spreading
69	Acc 69	Seedling	25	8	Erect
70	Acc 70	Seedling	50	28	Erect

71	Acc 71	Seedling	11	10	Spreading
72	Acc 72	Seedling	35	14	**Drooping**
73	Acc 73	Seedling	12	7.5	**Drooping**
74	Acc 74	Seedling	30	20	Erect
75	Acc 75	Seedling	10	10	Spreading
76	Acc 76	Seedling	18	18	**Drooping**
77	Acc 77	Seedling	25	6	**Drooping**
78	Acc 78	Seedling	50	23	Erect
79	Acc 79	Seedling	50	24	Erect
80	Acc 80	Seedling	35	18	Spreading
81	Acc 81	Seedling	30	15	Spreading
82	Acc 82	Seedling	20	15	Erect
83	Acc 83	Seedling	**105**	**48**	Erect
84	Acc 84	Seedling	15	12	Erect
85	Acc 85	Seedling	15	11	Erect
86	Acc 86	Seedling	10	8	**Drooping**
87	Acc 87	Seedling	**100**	34	Spreading
88	Acc 88	Seedling	80	32	Spreading
89	Acc 89	Seedling	15	14	Spreading
90	Acc 90	Seedling	8	8	Erect
91	Acc 91	Seedling	16	9	Spreading
92	Acc 92	Seedling	20	9	Erect
93	Acc 93	Seedling	40	23	Erect
94	Acc 94	Seedling	12	7	Erect
95	Acc 95	Seedling	65	32	Spreading
96	Acc 96	Seedling	52	34	Spreading
97	Acc 97	Seedling	60	30	Spreading
98	Acc 98	Seedling	15	15	Erect
99	Acc 99	Seedling	52	24	Spreading
100	Acc 100	Seedling	31	21	Erect

Annexure-III

LEAF CHARACTERS

S.No	Landraces	Leaf orientation	Leaf Shape	Base	Tip	Margin	Texture
1	Acc 1	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
2	Acc 2	Horizontal	Elliptic	Acute	Acuminate	Entire	Membranous
3	Acc 3	Horizontal	Oblong	Acute	Acuminate	Entire	Coriaceous
4	Acc 4	Horizontal	Oblong	Obtuse	Acuminate	Wavy	Membranous
5	Acc 5	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
6	Acc 6	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
7	Acc 7	Horizontal	Oblong	Acute	Acuminate	Entire	Coriaceous
8	Acc 8	Horizontal	Elliptic	Acute	Acute	Entire	Coriaceous
9	Acc 9	Horizontal	Oblong	Acute	Acuminate	Entire	Membranous
10	Acc 10	Horizontal	Oblong	Acute	Acuminate	Entire	Membranous
11	Acc 11	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
12	Acc 12	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
13	Acc 13	Horizontal	Oblong	Acute	Acuminate	Entire	Coriaceous
14	Acc 14	Semi erect	Oblong	Obtuse	Acuminate	Entire	Chartaceous
15	Acc 15	Semi erect	Elliptic	Acute	Acuminate	Wavy	Membranous
16	Acc 16	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
17	Acc 17	Horizontal	Elliptic	Acute	Acuminate	Wavy	Chartaceous
18	Acc 18	Horizontal	Oblong	Acute	Acute	Entire	Chartaceous
19	Acc 19	Horizontal	Oblong	Obtuse	Acute	Entire	Membranous
20	Acc 20	Semi drooping	Elliptic	Acute	Acuminate	Wavy	Chartaceous
21	Acc 21	Horizontal	Oblong	Acute	Acuminate	Wavy	Membranous
22	Acc 22	Horizontal	Oblong	Acute	Acuminate	Wavy	Membranous
23	Acc 23	Semi drooping	Oblong	Obtuse	Acute	Entire	Coriaceous
24	Acc 24	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
25	Acc 25	Horizontal	Lanceolate	Obtuse	Acuminate	Entire	Chartaceous
26	Acc 26	Horizontal	Elliptic	Acute	Acuminate	Entire	Chartaceous
27	Acc 27	Semi-Drooping	Oblong	Obtuse	Acuminate	Entire	Coriaceous
28	Acc 28	Horizontal	Oblong	Acute	Acuminate	wavy	Chartaceous
29	Acc 29	Semi erect	Elliptic	Acute	Acute	Entire	Coriaceous
30	Acc 30	Semi erect	Elliptic	Acute	Acuminate	Entire	Chartaceous
31	Acc 31	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
32	Acc 32	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
33	Acc 33	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous

34	Acc 34	Horizontal	Lanceolate	Acute	Acuminate	Wavy	Membranous
35	Acc 35	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
36	Acc 36	Horizontal	Oblong	Obtuse	Acute	Entire	Coriaceous
37	Acc 37	Semi drooping	Oblong	Obtuse	Acuminate	Entire	Chartaceous
38	Acc 38	Horizontal	Oblong	Obtuse	Acuminate	Entire	Chartaceous
39	Acc 39	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
40	Acc 40	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
41	Acc 41	Horizontal	Lanceolate	Acute	Acute	Entire	Chartaceous
42	Acc 42	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
43	Acc 43	Horizontal	Elliptic	Obtuse	Acuminate	Entire	Coriaceous
44	Acc 44	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
45	Acc 45	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
46	Acc 46	Horizontal	Elliptic	Obtuse	Acuminate	Entire	Chartaceous
47	Acc 47	Horizontal	Lanceolate	Acute	Acute	Entire	Chartaceous
48	Acc 48	Semi drooping	Oblong	Acute	Acute	Entire	Membranous
49	Acc 49	Semi drooping	Oblong	Acute	Acuminate	Entire	Chartaceous
50	Acc 50	Horizontal	Oblong	Obtuse	Acuminate	Wavy	Membranous
51	Acc 51	Horizontal	Elliptic	Obtuse	Acute	Entire	Chartaceous
52	Acc 52	Horizontal	Elliptic	Acute	Acuminate	Wavy	Chartaceous
53·	Acc 53	Horizontal	Elliptic	Acute	Acuminate	Entire	Chartaceous
54	Acc 54	Horizontal	Ovate	Obtuse	Acuminate	Wavy	Chartaceous
55	Acc 55	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
56	Acc 56	Horizontal	Oblong	Obtuse	Acuminate	Wavy	Coriaceous
57	Acc 57	Semi drooping	Elliptic	Obtuse	Acuminate	Entire	Coriaceous
58	Acc 58	Horizontal	Elliptic	Obtuse	Acuminate	Wavy	Membranous
59	Acc 59	Semi erect	Oblong	Acute	Acuminate	Entire	Coriaceous
60	Acc 60	Semi drooping	Oblong	Obtuse	Acute	Entire	Coriaceous
61	Acc 61	Horizontal	Oblong	Acute	Acuminate	Entire	Coriaceous
62	Acc 62	Horizontal	Oblong	Obtuse	Acute	Entire	Chartaceous
63	Acc 63	Horizontal	Elliptic	Acute	Acuminate	Wavy	Chartaceous
64	Acc 64	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
65	Acc 65	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
66	Acc 66	Horizontal	Elliptic	Obtuse	Acuminate	Entire	Membranous
67	Acc 67	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
68	Acc 68	Horizontal	Elliptic	Obtuse	Acuminate	Wavy	Coriaceous
69	Acc 69	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
70	Acc 70	Horizontal	Elliptic	Acute	Acute	Entire	Coriaceous

71	Acc 71	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
72	Acc 72	Horizontal	Oblong	Obtuse	Acuminate	Wavy	Coriaceous
73	Acc 73	Semi erect	Elliptic	Acute	Acuminate	Wavy	Coriaceous
74	Acc 74	Horizontal	Elliptic	Obtuse	Acuminate	Wavy	Chartaceous
75	Acc 75	Semi erect	Oblong	Obtuse	Acuminate	Wavy	Coriaceous
76	Acc 76	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
77	Acc 77	Horizontal	Elliptic	Acute	Acuminate	Wavy	Coriaceous
78	Acc 78	Horizontal	Lanceolate	Acute	Acuminate	Wavy	Coriaceous
79	Acc 79	Semi erect	Oblong	Acute	Acuminate	Entire	Coriaceous
80	Acc 80	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
81	Acc 81	Semi drooping	Oblong	Obtuse	Acuminate	Entire	Coriaceous
82	Acc 82	Semi drooping	Oblong	Acute	Acute	Entire	Membranous
83	Acc 83	Horizontal	Elliptic	Acute	Acuminate	Entire	Chartaceous
84	Acc 84	Horizontal	Oblong	Obtuse	Acuminate	Entire	Coriaceous
85	Acc 85	Horizontal	Oblong	Obtuse	Acuminate	Wavy	Chartaceous
86	Acc 86	Semi drooping	Elliptic	Acute	Acuminate	Entire	Chartaceous
87	Acc 87	Horizontal	Oblong	Acute	Acuminate	Entire	Chartaceous
88	Acc 88	Semi erect	Elliptic	Acute	Acuminate	Entire	Chartaceous
89	Acc 89	Semi drooping	Oblong	Obtuse	Acute	Wavy	Coriaceous
90	Acc 90	Semi drooping	Oblong	Obtuse	Acute	Entire	Coriaceous
91	Acc 91	Horizontal	Oblong	Acute	Acuminate	Entire	Coriaceous
92	Acc 92	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
93	Acc 93	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
94	Acc 94	Horizontal	Oblong	Obtuse	Acuminate	Entire	Chartaceous
95	Acc 95	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
96	Acc 96	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
97	Acc 97	Horizontal	Elliptic	Acute	Acuminate	Entire	Coriaceous
98	Acc 98	Horizontal	Elliptic	Acute	Acuminate	Wavy	Chartaceous
99	Acc 99	Horizontal	Oblong	Obtuse	Acuminate	Entire	Chartaceous
100	Acc 100	Horizontal	Elliptic	Acute	Acuminate	Entire	Chartaceous

Annexure-III

LEAF CHARACTERS (conti.)

S.No	Landraces	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Colour of young leaves (Visual)	Fragrance
1	Acc 1	21.96	4.93	3.33	Light green	Absent
2	Acc 2	28.55	5.23	2.89	Light brick red	Mild
3	Acc 3	28.73	5.59	3.74	Light green	Mild
4	Acc 4	29.26	5.21	3.11	Light brick red	Mild
5	Acc 5	22.26	4.34	3.60	Light green	Mild
6	Acc 6	24.94	4.44	2.51	Light green	Strong
7	Acc 7	28.61	4.77	2.93	Light green	Mild
8	Acc 8	23.82	5.11	3.88	Light green with brownish tinge	Strong
9	Acc 9	20.08	4.33	2.15	Light green with brownish tinge	Strong
10	Acc 10	22.48	5.22	1.97	Light green with brownish tinge	Strong
11	Acc 11	27.70	5.40	2.65	Light green	Absent
12	Acc 12	30.05	5.49	3.66	Light brick red	Mild
13	Acc 13	36.39	**8.10**	4.00	Light green with brownish tinge	Strong
14	Acc 14	30.20	7.03	3.22	Deep coppery tan	Strong
15	Acc 15	25.08	4.00	3.05	Reddish brown	Absent
16	Acc 16	19.78	4.50	1.51	Light green	Absent
17	Acc 17	28.53	6.01	2.28	Light green	Mild
18	Acc 18	25.57	5.31	2.20	Light brick red	Mild
19	Acc 19	26.59	6.41	3.49	Light brick red	Mild
20	Acc 20	27.00	6.00	3.49	Light brick red	Strong
21	Acc 21	24.32	5.83	2.23	Reddish brown	Strong
22	Acc 22	22.20	5.26	2.46	Light brick red	Strong
23	Acc 23	20.72	4.94	2.25	Light green	Absent
24	Acc 24	22.70	4.39	2.59	Light green with brownish tinge	Absent
25	Acc 25	27.88	5.66	2.56	Reddish brown	Mild
26	Acc 26	24.04	4.53	3.63	Deep coppery tan	Strong
27	Acc 27	25.02	4.58	3.38	Light green with brownish tinge	Mild
28	Acc 28	30.09	6.02	4.06	Light green with brownish tinge	Strong
29	Acc 29	24.28	5.00	4.10	Light green with brownish tinge	Strong
30	Acc 30	21.15	**3.80**	3.11	Light green	Mild
31	Acc 31	22.01	4.60	2.05	Light green	Absent

32	Acc 32	24.27	4.38	2.54	Light green	Absent
33	Acc 33	24.17	5.67	3.79	Light green	Mild
34	Acc 34	23.26	4.82	3.81	Light green	Strong
35	Acc 35	25.97	5.21	3.51	Light green	Strong
36	Acc 36	22.43	5.46	2.68	Light green with brownish tinge	Absent
37	Acc 37	22.07	5.21	2.06	Light green with brownish tinge	Mild
38	Acc 38	19.11	3.86	2.53	Light green	Mild
39	Acc 39	22.75	4.66	3.49	Light green	Mild
40	Acc 40	24.07	4.33	2.72	Light green	Mild
41	Acc 41	23.11	5.05	2.03	Reddish brown	Strong
42	Acc 42	22.54	4.65	2.07	Light green with brownish tinge	Absent
43	Acc 43	24.11	5.50	2.42	Reddish brown	Mild
44	Acc 44	19.86	4.50	2.78	Light green	Strong
45	Acc 45	22.16	5.09	3.02	Light green	Mild
46	Acc 46	22.51	4.30	1.99	Light green	Strong
47	Acc 47	24.84	5.55	3.06	Light green	Mild
48	Acc 48	18.95	4.53	1.60	Light green with brownish tinge	Strong
49	Acc 49	24.59	4.85	2.54	Light green	Absent
50	Acc 50	23.23	4.55	2.42	Light green	Strong
51	Acc 51	22.22	4.55	2.22	Light green	Strong
52	Acc 52	33.76	6.05	4.04	Light green with brownish tinge	Strong
53	Acc 53	23.60	4.78	3.61	Light green	Strong
54	Acc 54	29.89	6.05	3.50	Light brick red	Mild
55	Acc 55	20.50	4.05	2.99	Light green	Absent
56	Acc 56	23.93	4.96	2.55	Light green with brownish tinge	Mild
57	Acc 57	22.49	5.05	3.21	Light green with brownish tinge	Mild
58	Acc 58	36.50	**7.70**	4.65	Light green with brownish tinge	Absent
59	Acc 59	28.88	5.44	3.43	Light green with brownish tinge	Mild
60	Acc 60	23.39	4.38	2.68	Light green with brownish tinge	Strong
61	Acc 61	21.85	4.94	2.15	Light green with brownish tinge	Mild
62	Acc 62	20.66	5.05	2.15	Reddish brown	Absent
63	Acc 63	27.16	5.12	3.00	Light green with brownish tinge	Absent
64	Acc 64	27.61	5.47	2.44	Light green	Absent
65	Acc 65	22.65	5.11	3.55	Light green with brownish tinge	Mild
66	Acc 66	24.60	4.75	3.85	Light green with brownish tinge	Mild
67	Acc 67	21.50	4.77	2.06	Light green with brownish tinge	Absent
68	Acc 68	30.50	7.45	2.48	Light green with brownish tinge	Absent

69	Acc 69	24.51	5.48	3.69	Light green	Mild
70	Acc 70	23.42	5.26	4.21	Light green with brownish tinge	Strong
71	Acc 71	28.27	5.70	3.15	Light green	Strong
72	Acc 72	22.15	5.03	2.15	Light green with brownish tinge	Absent
73	Acc 73	26.39	5.04	2.82	Light green with brownish tinge	Strong
74	Acc 74	23.00	5.40	2.00	Light green with brownish tinge	Strong
75	Acc 75	26.82	5.03	2.60	Light green	Strong
76	Acc 76	26.71	5.42	2.50	Light green	Strong
77	Acc 77	24.26	5.01	2.42	Light brick red	Absent
78	Acc 78	23.10	5.39	2.52	Light green with brownish tinge	Absent
79	Acc 79	27.89	4.44	2.49	Light green with brownish tinge	Absent
80	Acc 80	24.60	5.36	2.80	Light green with brownish tinge	Absent
81	Acc 81	32.33	5.45	3.45	Light green	Mild
82	Acc 82	23.38	5.65	2.60	Light brick red	Absent
83	Acc 83	21.77	5.38	2.39	Deep coppery tan	Strong
84	Acc 84	22.38	4.26	2.28	Deep coppery tan	Strong
85	Acc 85	21.27	4.48	2.15	Light green	Mild
86	Acc 86	25.56	5.60	3.95	Light green	Mild
87	Acc 87	25.13	5.19	3.02	Deep coppery tan	Strong
88	Acc 88	23.43	5.18	2.50	Deep coppery tan	Strong
89	Acc 89	25.66	5.25	2.11	Light green with brownish tinge	Mild
90	Acc 90	25.89	5.48	2.26	Light green with brownish tinge	Mild
91	Acc 91	28.26	5.82	2.51	Deep coppery tan	Strong
92	Acc 92	30.39	6.07	3.18	Light green with brownish tinge	Mild
93	Acc 93	29.88	4.54	4.10	Light brick red	Absent
94	Acc 94	21.83	4.69	2.50	Light green with brownish tinge	Absent
95	Acc 95	26.18	4.82	2.50	Light green with brownish tinge	Absent
96	Acc 96	26.16	4.65	2.55	Light green with brownish tinge	Absent
97	Acc 97	24.49	5.02	2.40	Light green with brownish tinge	Absent
98	Acc 98	24.33	5.11	2.44	Light green and pink	Mild
99	Acc 99	26.63	5.09	2.41	Light green with brownish tinge	Strong
100	Acc 100	28.43	5.29	4.16	Deep coppery tan	Strong
	Average	25.02	5.15	2.81		
	CD (5%)	0.83	0.23	0.22		
	C.V	1.67	2.36	3.71		

Annexure-IV

INFLORESCENCE CHARACTERS

S.No	Landraces	Position	Shape	Colour of inflorescence	Density	Length (cm)	Width (cm)	Pollen shape	Pollen size (µm)
1	Acc 1	Terminal	C	LG	Laxly	33.44	25.61	Round	22.22
2	Acc 2	Terminal	P	LR	Laxly	28.88	19.85	Round	22.95
3	Acc 3	Terminal	BP	Crimson	Medium	30.44	22.23	Round	23.39
4	Acc 4	Terminal	P	LR	Laxly	27.94	18.93	Round	23.78
5	Acc 5	Terminal	P	LG	Laxly	30.89	22.88	Oval	23.99
6	Acc 6	Terminal	C	LG	Densely	32.83	26.27	Round	24.00
7	Acc 7	Terminal	BP	Crimson	Medium	28.97	22.21	Round	24.38
8	Acc 8	Terminal	P	LG	Densely	29.05	22.20	Round	24.38
9	Acc 9	Terminal	P	LG	Densely	24.76	19.98	Round	24.42
10	Acc 10	Terminal	P	LG	Densely	29.77	21.76	Round	24.54
11	Acc 11	Terminal	P	LG	Medium	24.70	21.95	Round	24.55
12	Acc 12	Terminal	C	GRP	Densely	25.65	15.00	Round	24.6
13	Acc 13	Terminal	BP	GRP	Densely	26.94	20.10	Round	24.65
14	Acc 14	Terminal	P	GRP	Densely	28.29	18.40	Round	24.71
15	Acc 15	Terminal	P	LG	Laxly	28.11	18.93	Round	24.78
16	Acc 16	Terminal	BP	Crimson	Medium	29.51	21.50	Round	24.83
17	Acc 17	Terminal	P	LG	Laxly	25.51	16.94	Round	24.86
18	Acc 18	Terminal	P	GRP	Medium	27.78	16.96	Round	25.17
19	Acc 19	Terminal	P	GRP	Densely	22.50	17.44	Round	25.25
20	Acc 20	Terminal	P	GRP	Densely	24.51	19.62	Round	25.44
21	Acc 21	Terminal	C	GRP	Laxly	35.59	23.61	Round	25.45
22	Acc 22	Terminal	C	LG	Densely	33.54	23.75	Oblong	25.54
23	Acc 23	Terminal	P	GRP	Medium	28.50	19.51	Round	25.55
24	Acc 24	Terminal	P	Pink	Laxly	26.50	22.83	Round	26.04
25	Acc 25	Terminal	P	Pink	Laxly	23.51	20.56	Round	26.04
26	Acc 26	Both	P	LR	Densely	27.50	23.61	Round	26.06
27	Acc 27	Both	BP	LG	Densely	33.50	26.22	Round	26.25
28	Acc 28	Terminal	BP	GRP	Densely	28.11	19.72	Round	26.44
29	Acc 29	Terminal	P	GRP	Densely	23.38	20.75	Round	26.44
30	Acc 30	Terminal	P	GRP	Densely	30.00	18.41	Round	26.49
31	Acc 31	Terminal	P	GRP	Medium	31.03	20.50	Round	26.59
32	Acc 32	Terminal	C	LG	Laxly	31.59	24.94	Round	26.61

33	Acc 33	Both	P	LG	Medium	33.11	22.09	Round	26.66
34	Acc 34	Terminal	BP	LG	Densely	29.77	23.18	Round	26.70
35	Acc 35	Terminal	BP	LG	Medium	25.51	24.00	Round	26.75
36	Acc 36	Terminal	BP	LG	Densely	26.51	19.62	Round	26.94
37	Acc 37	Terminal	P	LG	Densely	27.66	24.00	Round	27.00
38	Acc 38	Terminal	P	GRP	Densely	31.97	20.35	Round	27.03
39	Acc 39	Terminal	P	GRP	Densely	24.81	21.39	Round	27.19
40	Acc 40	Terminal	P	LG	Densely	28.15	22.32	Round	27.21
41	Acc 41	Terminal	P	LG	Densely	25.53	24.11	Round	27.32
42	Acc 42	Terminal	P	GRP	Densely	30.77	23.32	Round	27.33
43	Acc 43	Terminal	P	LG	Laxly	33.72	30.60	Round	27.33
44	Acc 44	Terminal	P	LG	Densely	27.65	24.53	Round	27.42
45	Acc 45	Terminal	P	Crimson	Medium	25.02	21.37	Round	27.42
46	Acc 46	Terminal	P	Crimson	Medium	27.21	23.83	Round	27.46
47	Acc 47	Terminal	BP	LG	Laxly	28.77	18.28	Round	27.49
48	Acc 48	Terminal	BP	LG	Medium	27.54	21.51	Round	27.50
49	Acc 49	Terminal	P	GRP	Medium	26.49	17.85	Round	27.61
50	Acc 50	Both	C	GRP	Densely	24.17	14.73	Round	27.62
51	Acc 51	Terminal	P	LG	Densely	23.28	14.02	Round	27.70
52	Acc 52	Terminal	P	LG	Densely	26.50	16.78	Round	27.83
53	Acc 53	Terminal	C	Crimson	Medium	31.55	22.33	Round	27.99
54	Acc 54	Terminal	BP	Red	Medium	28.44	20.22	Oblong	28.00
55	Acc 55	Terminal	BP	Red	Densely	23.29	20.22	Round	28.05
56	Acc 56	Terminal	P	Red	Densely	25.70	20.34	Round	28.16
57	Acc 57	Terminal	C	LG	Densely	24.43	16.43	Round	28.30
58	Acc 58	Terminal	C	GRP	Densely	25.47	18.11	Round	28.30
59	Acc 59	Terminal	BP	Crimson	Medium	30.50	21.45	Round	28.33
60	Acc 60	Terminal	P	LG	Densely	27.61	16.06	Round	28.33
61	Acc 61	Terminal	BP	LG	Medium	28.53	19.09	Round	28.43
62	Acc 62	Terminal	P	GRP	Densely	27.50	23.89	Round	28.50
63	Acc 63	Both	P	GRP	Densely	24.77	18.17	Round	28.50
64	Acc 64	Terminal	P	GRP	Densely	25.67	21.73	Round	28.53
65	Acc 65	Terminal	C	Crimson	Medium	32.55	24.34	Round	28.55
66	Acc 66	Terminal	BP	LG	Densely	28.11	25.90	Round	28.61
67	Acc 67	Terminal	P	LG	Densely	25.10	19.16	Round	28.75
68	Acc 68	Terminal	P	LG	Densely	29.59	26.17	Round	28.82
69	Acc 69	Terminal	P	LG	Densely	25.19	18.47	Round	29.02

No	Acc	Position		Color	Density			Shape	
70	Acc 70	Terminal	P	LG	Densely	29.76	27.10	Round	29.17
71	Acc 71	Terminal	C	LG	Densely	24.22	18.11	Round	29.32
72	Acc 72	Terminal	P	LG	Densely	24.72	22.16	Round	29.38
73	Acc 73	Terminal	P	LG	Densely	23.89	18.99	Round	29.75
74	Acc 74	Terminal	BP	LG	Densely	27.72	24.16	Round	29.76
75	Acc 75	Terminal	P	GRP	Densely	27.28	17.79	Round	29.88
76	Acc 76	Terminal	P	LG	Densely	18.98	17.88	Round	30.00
77	Acc 77	Terminal	P	LG	Densely	20.83	16.95	Oblong	30.50
78	Acc 78	Both	C	LG	Densely	22.16	19.04	Round	30.72
79	Acc 79	Terminal	P	LG	Densely	19.49	18.38	Round	30.83
80	Acc 80	Terminal	C	Crimson	Medium	30.32	21.00	Round	31.00
81	Acc 81	Terminal	C	Crimson	Densely	22.11	17.55	Round	31.00
82	Acc 82	Terminal	P	LG	Densely	25.27	14.78	Round	31.06
83	Acc 83	Terminal	BP	LR	Densely	26.51	20.44	Oval	31.12
84	Acc 84	Both	P	LG	Densely	22.25	17.94	Round	31.26
85	Acc 85	Terminal	P	LG	Densely	24.72	19.45	Round	31.33
86	Acc 86	Terminal	P	LG	Densely	24.83	20.95	Round	31.50
87	Acc 87	Terminal	C	LG	Densely	29.825	22.88	Round	31.88
88	Acc 88	Terminal	P	LG	Densely	25.37	19.27	Round	31.98
89	Acc 89	Terminal	P	LG	Densely	27.58	15.36	Round	32.14
90	Acc 90	Terminal	P	LG	Densely	28.44	17.05	Round	32.22
91	Acc 91	Terminal	P	GRP	Densely	23.99	17.94	Round	32.80
92	Acc 92	Terminal	P	GRP	Medium	29.56	28.61	Round	33.30
93	Acc 93	Terminal	C	GRP	Medium	26.39	14.53	Round	33.50
94	Acc 94	Terminal	C	LG	Densely	25.42	17.55	Oblong	33.50
95	Acc 95	Terminal	P	LG	Densely	28.52	20.56	Oval	33.70
96	Acc 96	Terminal	P	LG	Densely	26.48	19.25	Oval	33.70
97	Acc 97	Terminal	P	LG	Densely	29.98	17.78	Oval	34.00
98	Acc 98	Terminal	BP	Crimson	Medium	32.56	21.06	Round	34.20
99	Acc 99	Terminal	P	LG	Densely	24.08	18.80	Oval	34.75
100	Acc100	Terminal	BP	LG	Densely	29.61	21.33	Round	35.43

P-Pyramidal

BP- Broadly pyramidal

C- Conical

LG- Light green

GRP- Green with red patches

LR-Light red

CD (0.05)   1.48   1.65

Average   27.34   20.58

Annexure-IV

INFLORESCENCE AND FLOWERING CHARACTERS

S.No	Landraces	Season of flowering	Regularity of flowering	Secondary Flowering
1	Acc 1	Mid	Regular	Absent
2	Acc 2	Mid to late	Regular	Absent
3	Acc 3	Mid	Regular	Absent
4	Acc 4	Mid to late	Regular	Absent
5	Acc 5	Mid	Regular	Absent
6	Acc 6	Early	Regular	Absent
7	Acc 7	Early	Regular	**Frequent**
8	Acc 8	Early	Regular	Absent
9	Acc 9	Early to Mid	Regular	Absent
10	Acc 10	Early to Mid	Regular	Absent
11	Acc 11	Early to Mid	Regular	Absent
12	Acc 12	Late	Regular	Absent
13	Acc 13	Mid	Regular	Absent
14	Acc 14	Mid	Regular	Absent
15	Acc 15	Mid	Regular	Absent
16	Acc 16	Mid	Regular	Absent
17	Acc 17	Mid	Alternate	Absent
18	Acc 18	Early	Regular	Absent
19	Acc 19	Mid to Late	Regular	Absent
20	Acc 20	Mid to Late	Regular	Absent
21	Acc 21	Mid	Regular	Absent
22	Acc 22	Mid	Regular	Absent
23	Acc 23	Mid	Regular	Absent
24	Acc 24	Early	Regular	Absent
25	Acc 25	Mid to late	Regular	Absent
26	Acc 26	Mid to late	Regular	Absent
27	Acc 27	Early to Mid	Alternate	Absent
28	Acc 28	Mid	Regular	Absent
29	Acc 29	Mid	Regular	Absent
30	Acc 30	Mid	Regular	Absent
31	Acc 31	Mid	Regular	Absent
32	Acc 32	Mid	Regular	Absent
33	Acc 33	Mid	Regular	Absent

34	Acc 34	Mid	Regular	Absent
35	Acc 35	Mid	Alternate	Absent
36	Acc 36	Mid	Regular	Absent
37	Acc 37	Mid	Regular	Absent
38	Acc 38	Mid	Alternate	Absent
39	Acc 39	Mid	Alternate	Absent
40	Acc 40	Mid	Alternate	Absent
41	Acc 41	Mid	Alternate	Absent
42	Acc 42	Mid	Alternate	Absent
43	Acc 43	Mid	Alternate	Absent
44	Acc 44	Early	Regular	Absent
45	Acc 45	Early to mid	Regular	**Frequent**
46	Acc 46	Mid	Alternate	Absent
47	Acc 47	Mid to late	Regular	Absent
48	Acc 48	Mid	Regular	Absent
49	Acc 49	Mid	Regular	Absent
50	Acc 50	Mid	Regular	Absent
51	Acc 51	Mid	Regular	Absent
52	Acc 52	Early to mid	Regular	Absent
53	Acc 53	Mid	Regular	Absent
54	Acc 54	Mid	Alternate	Absent
55	Acc 55	Early to mid	Regular	Absent
56	Acc 56	Early to mid	Regular	Absent
57	Acc 57	Mid	Regular	Absent
58	Acc 58	Mid	Alternate	Absent
59	Acc 59	Early	Regular	**Frequent**
60	Acc 60	Mid	Regular	Absent
61	Acc 61	Mid	Alternate	Absent
62	Acc 62	Mid	Regular	Absent
63	Acc 63	Mid	Alternate	Absent
64	Acc 64	Early	Regular	Absent
65	Acc 65	Mid	Regular	Absent
66	Acc 66	Mid	Regular	Absent
67	Acc 67	Early to mid	Regular	Absent
68	Acc 68	Mid	Regular	Absent
69	Acc 69	Mid	Regular	Absent
70	Acc 70	Mid	Alternate	Absent

71	Acc 71	Early to mid	Alternate	Absent
72	Acc 72	Mid	Regular	Absent
73	Acc 73	Mid	Alternate	Absent
74	Acc 74	Early	Regular	Absent
75	Acc 75	Early	Regular	Frequent
76	Acc 76	Early	Regular	Frequent
77	Acc 77	Mid	Regular	Frequent
78	Acc 78	Mid	Regular	Absent
79	Acc 79	Mid	Alternate	Absent
80	Acc 80	Mid	Alternate	Absent
81	Acc 81	Late	Regular	Absent
82	Acc 82	Early	Regular	Absent
83	Acc 83	Mid	Regular	Absent
84	Acc 84	Early to Mid	Regular	Absent
85	Acc 85	Mid	Regular	Absent
86	Acc 86	Early	Regular	Absent
87	Acc 87	Early	Alternate	Absent
88	Acc 88	Early	Alternate	Absent
89	Acc 89	Early	Regular	Absent
90	Acc 90	Early	Regular	Absent
91	Acc 91	Early to Mid	Regular	Absent
92	Acc 92	Mid to late	Regular	Absent
93	Acc 93	Mid to late	Regular	Absent
94	Acc 94	Early	Perpetual	Frequent
95	Acc 95	Early to Mid	Regular	Absent
96	Acc 96	Early to Mid	Regular	Absent
97	Acc 97	Early to Mid	Regular	Absent
98	Acc 98	Early to Mid	Perpetual	Frequent
99	Acc 99	Early to Mid	Regular	Absent
100	Acc 100	Mid	Alternate	Absent

Annexure-V

FRUIT MORPHOLOGICAL CHARACTERS

S.No	Landraces	Shape	Basal cavity	Apex	Beak	Sinus	Slope of shoulders	Fruit texture
1	Acc 1	Round	Very Deep	Round	Perceptible	Absent	RR	Rough
2	Acc 2	Oblong	Absent	Obtuse	Prominent	Deep	RR	Smooth
3	Acc 3	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
4	Acc 4	Oblong	Shallow	Obtuse	Prominent	Deep	RR	Smooth
5	Acc 5	Roundish	Shallow	Obtuse	Perceptible	Absent	RR	Smooth
6	Acc 6	Oblong	Shallow	Obtuse	Perceptible	Absent	RR	Smooth
7	Acc 7	Roundish	Absent	Round	Perceptible	Absent	RR	Smooth
8	Acc 8	Elliptic	Absent	Obtuse	Perceptible	Absent	ELC	Smooth
9	Acc 9	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
10	Acc 10	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
11	Acc 11	Elliptic	Absent	Round	Perceptible	Absent	RR	Smooth
12	Acc 12	Oblong	Absent	Round	Prominent	Shallow	SA	Smooth
13	Acc 13	Oblong	Shallow	Obtuse	Perceptible	Shallow	RR	Rough
14	Acc 14	Roundish	Absent	Round	Prominent	Deep	RR	Smooth
15	Acc 15	Oblong	Absent	Round	Pointed	Shallow	RR	Smooth
16	Acc 16	Roundish	Shallow	Round	Perceptible	Shallow	RR	Smooth
17	Acc 17	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
18	Acc 18	Round	Shallow	Round	Prominent	Shallow	RR	Rough
19	Acc 19	Oblong	Absent	Obtuse	Prominent	Shallow	SA	Smooth
20	Acc 20	Oblong	Absent	Obtuse	Pointed	Deep	ELC	Smooth
21	Acc 21	Round	Absent	Round	Perceptible	Absent	RR	Smooth
22	Acc 22	Ovoid	Absent	Round	Perceptible	Absent	ELC	Smooth
23	Acc 23	Oblong	Absent	Obtuse	Perceptible	Absent	ELC	Smooth
24	Acc 24	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
25	Acc 25	Oblong	Shallow	Obtuse	Mammiform	Deep	RR	Smooth
26	Acc 26	Round	Shallow	Round	Pointed	Absent	RR	Smooth
27	Acc 27	Roundish	Absent	Obtuse	Prominent	Deep	RR	Smooth
28	Acc 28	Roundish	Shallow	Obtuse	Perceptible	Shallow	RR	Rough
29	Acc 29	Roundish	Absent	Round	Perceptible	Absent	RR	Smooth
30	Acc 30	Roundish	Absent	Round	Mammiform	Deep	RR	Smooth
31	Acc 31	Oblong	Absent	Round	Perceptible	Absent	ELC	Rough
32	Acc 32	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth

33	Acc 33	Oblong	Absent	Round	Perceptible	Absent	ELC	Smooth
34	Acc 34	Oblong	Absent	Round	Perceptible	Absent	ELC	Smooth
35	Acc 35	Oblong	Shallow	Round	Perceptible	Absent	ELC	Smooth
36	Acc 36	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
37	Acc 37	Roundish	Medium	Round	Perceptible	Absent	RR	Smooth
38	Acc 38	Roundish	Absent	Round	Perceptible	Absent	ELC	Smooth
39	Acc 39	Oblong	Absent	Round	Perceptible	Absent	ELC	Smooth
40	Acc 40	Oblong	Absent	Round	Perceptible	Absent	ELC	Smooth
41	Acc 41	Oblong	Absent	Round	Perceptible	Shallow	SA	Smooth
42	Acc 42	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
43	Acc 43	Roundish	Medium	Round	Perceptible	Absent	RR	Rough
44	Acc 44	Oblong	Shallow	Round	Perceptible	Absent	RR	Smooth
45	Acc 45	Roundish	Absent	Round	Perceptible	Absent	RR	Smooth
46	Acc 46	Oblong	Medium	Round	Pointed	Absent	RR	Smooth
47	Acc 47	Oblong	Absent	Acute	Prominent	Deep	SA	Rough
48	Acc 48	Oblong	Absent	Round	Perceptible	Absent	SA	Smooth
49	Acc 49	Round	Shallow	Round	Perceptible	Absent	RR	Smooth
50	Acc 50	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
51	Acc 51	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
52	Acc 52	Roundish	Absent	Round	Perceptible	Shallow	RR	Smooth
53	Acc 53	Roundish	Very Deep	Round	Perceptible	Absent	RR	Rough
54	Acc 54	Roundish	Medium	Round	Perceptible	Absent	RR	Smooth
55	Acc 55	Roundish	Medium	Round	Perceptible	Absent	RR	Smooth
56	Acc 56	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
57	Acc 57	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
58	Acc 58	Oblong	Absent	Acute	Perceptible	Absent	ELC	Rough
59	Acc 59	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
60	Acc 60	Roundish	Absent	Round	Pointed	Absent	SA	Smooth
61	Acc 61	Oblong	Shallow	Round	Perceptible	Absent	RR	Smooth
62	Acc 62	Oblong	Absent	Acute	Mammiform	Deep	SA	Rough
63	Acc 63	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
64	Acc 64	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
65	Acc 65	Roundish	Absent	Round	Perceptible	Shallow	RR	Rough
66	Acc 66	Roundish	Shallow	Round	Perceptible	Shallow	RR	Smooth
67	Acc 67	Oblong	Shallow	Round	Perceptible	Shallow	RR	Smooth
68	Acc 68	Oblong	Absent	Round	Perceptible	Absent	SA	Smooth
69	Acc 69	Roundish	Absent	Round	Perceptible	Absent	ELC	Smooth

70	Acc 70	Elliptic	Absent	Round	Perceptible	Absent	ELC	Smooth
71	Acc 71	Oblong	Absent	Round	Prominent	Deep	RR	Smooth
72	Acc 72	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
73	Acc 73	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
74	Acc 74	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
75	Acc 75	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
76	Acc 76	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
77	Acc 77	Roundish	Absent	Round	Perceptible	Absent	RR	Smooth
78	Acc 78	Oblong	Absent	Round	Pointed	Shallow	ELC	Smooth
79	Acc 79	Roundish	Shallow	Round	Perceptible	Absent	RR	Smooth
80	Acc 80	Obovoid	Shallow	Obtuse	Perceptible	Absent	RR	Smooth
81	Acc 81	Round	Deep	Round	Perceptible	Absent	RR	Rough
82	Acc 82	Oblong	Absent	Round	Pointed	Shallow	SA	Smooth
83	Acc 83	Round	Absent	Round	Perceptible	Absent	ELC	Smooth
84	Acc 84	Elliptic	Absent	Obtuse	Perceptible	Absent	ELC	Smooth
85	Acc 85	Round	Shallow	Round	Perceptible	Absent	RR	Smooth
86	Acc 86	Round	Shallow	Round	Perceptible	Absent	RR	Smooth
87	Acc 87	Oblong	Absent	Round	Prominent	Shallow	SA	Smooth
88	Acc 88	Round	Deep	Round	Perceptible	Absent	RR	Smooth
89	Acc 89	Round	Absent	Round	Perceptible	Absent	ELC	Smooth
90	Acc 90	Round	Absent	Round	Pointed	Shallow	SA	Smooth
91	Acc 91	Obovoid	Shallow	Round	Perceptible	Absent	RR	Smooth
92	Acc 92	Oblong	Absent	Round	Mammiform	Shallow	RR	Smooth
93	Acc 93	Oblong	Absent	Round	Perceptible	Shallow	ELC	Smooth
94	Acc 94	Round	Medium	Round	pointed	Shallow	RR	Smooth
95	Acc 95	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
96	Acc 96	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
97	Acc 97	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
98	Acc 98	Oblong	Absent	Round	Perceptible	Absent	ELC	Smooth
99	Acc 99	Oblong	Absent	Round	Perceptible	Absent	RR	Smooth
100	Acc 100	Oblong	Shallow	Round	Perceptible	Absent	RR	Smooth

RR- Raising and then rounded

SA- Sloping abrupty

ELC- Ending in a long curve

Annexure-V

FRUIT MORPHOLOGICAL CHARACTERS (conti.)

S. No	Land races	Neck prominence	Stalk insertion	Peel colour	Waxiness	Adherence of peel to pulp
1	Acc 1	Absent	Vertical	Green	Non waxy	Strong
2	Acc 2	Prominent	Vertical	Greenish yellow	Waxy	Intermediate
3	Acc 3	Slightly prominent	Vertical	Yellow	Waxy	Weak
4	Acc 4	Slightly prominent	Vertical	Yellow	Waxy	Intermediate
5	Acc 5	Slightly prominent	Vertical	Yellow	Non waxy	Strong
6	Acc 6	Absent	Vertical	Yellow	Non waxy	Weak
7	Acc 7	Slightly prominent	Vertical	Green	Waxy	Weak
8	Acc 8	Absent	Vertical	Green	Non waxy	Weak
9	Acc 9	Slightly prominent	Vertical	Greenish yellow	Non waxy	Weak
10	Acc 10	Absent	Vertical	Greenish yellow	Non waxy	Weak
11	Acc 11	Absent	Vertical	Green	Waxy	Intermediate
12	Acc 12	Prominent	Vertical	Yellow with orange blush	Non waxy	Strong
13	Acc 13	Absent	Vertical	Yellow	Non waxy	Strong
14	Acc 14	Prominent	Vertical	Green	Non waxy	Weak
15	Acc 15	Slightly prominent	Vertical	Yellow with red blush	Non waxy	Intermediate
16	Acc 16	Slightly prominent	Vertical	Greenish yellow	Waxy	Strong
17	Acc 17	Slightly prominent	Vertical	Greenish yellow	Non waxy	Strong
18	Acc 18	Absent	Vertical	Green	Non waxy	Intermediate
19	Acc 19	Prominent	Vertical	Yellow with red blush	Waxy	Strong
20	Acc 20	Very prominent	Vertical	Yellow with red blush	Waxy	Strong
21	Acc 21	Absent	Vertical	Yellow with red blush	Non waxy	Weak
22	Acc 22	Slightly prominent	Vertical	Green	Non waxy	Weak
23	Acc 23	Absent	Vertical	Yellow with red blush	Non waxy	Intermediate
24	Acc 24	Slightly prominent	Vertical	Greenish yellow	Non waxy	Weak
25	Acc 25	Absent	Vertical	Green	Waxy	Strong
26	Acc 26	Very prominent	Oblique	Green	Waxy	Strong
27	Acc 27	Absent	Vertical	Green	Non waxy	Strong
28	Acc 28	Absent	Vertical	Yellow	Non waxy	Strong
29	Acc 29	Absent	Vertical	Greenish yellow	Non waxy	Strong
30	Acc 30	Slightly prominent	Vertical	Greenish yellow	Non waxy	Strong
31	Acc 31	Absent	Vertical	Greenish yellow	Non waxy	Strong
32	Acc 32	Absent	Vertical	Green	Non waxy	Intermediate

33	Acc 33	Absent	Vertical	Greenish yellow	Non waxy	Intermediate
34	Acc 34	Absent	Vertical	Yellow	Waxy	Strong
35	Acc 35	Slightly prominent	Vertical	Green	Non waxy	Weak
36	Acc 36	Slightly prominent	Vertical	Greenish yellow	Waxy	Weak
37	Acc 37	Absent	Vertical	Yellow	Non waxy	Strong
38	Acc 38	Very prominent	Vertical	Green	Non waxy	Intermediate
39	Acc 39	Slightly prominent	Vertical	Yellow with red blush	Non waxy	Weak
40	Acc 40	Absent	Vertical	Greenish yellow	Non waxy	Weak
41	Acc 41	Prominent	Vertical	Greenish yellow	Non waxy	Strong
42	Acc 42	Absent	Vertical	Greenish yellow	Non waxy	Strong
43	Acc 43	Absent	Oblique	Yellow with red blush	Non waxy	Strong
44	Acc 44	Slightly prominent	Vertical	Green	Waxy	Strong
45	Acc 45	Absent	Vertical	Green	Non waxy	Weak
46	Acc 46	Absent	Vertical	Green	Non waxy	Strong
47	Acc 47	Prominent	Vertical	Green	Non waxy	Strong
48	Acc 48	Slightly prominent	Vertical	Green	Non waxy	Weak
49	Acc 49	Absent	Vertical	Green	Non waxy	Weak
50	Acc 50	Absent	Vertical	Greenish yellow	Waxy	Weak
51	Acc 51	Absent	Vertical	Green	Non waxy	Strong
52	Acc 52	Absent	Vertical	Green	Non waxy	Strong
53	Acc 53	Absent	Vertical	Greenish yellow	Non waxy	Strong
54	Acc 54	Absent	Vertical	Green	Non waxy	Intermediate
55	Acc 55	Absent	Vertical	Yellow	Non waxy	Intermediate
56	Acc 56	Slightly prominent	Vertical	Yellow	Non waxy	Strong
57	Acc 57	Absent	Vertical	Green	Non waxy	Intermediate
58	Acc 58	Absent	Vertical	Brown	Waxy	Weak
59	Acc 59	Slightly prominent	Vertical	Greenish yellow	Waxy	Weak
60	Acc 60	Absent	Vertical	Greenish yellow	Waxy	Weak
61	Acc 61	Absent	Vertical	Green	Non waxy	Strong
62	Acc 62	Very prominent	Vertical	Yellow	Waxy	Strong
63	Acc 63	Absent	Vertical	Yellow with red blush	Non waxy	Strong
64	Acc 64	Absent	Vertical	Green	Waxy	Weak
65	Acc 65	Absent	Vertical	Yellow	Non waxy	Strong
66	Acc 66	Slightly prominent	Oblique	Green	Non waxy	Intermediate
67	Acc 67	Slightly prominent	Vertical	Greenish yellow	Non waxy	Weak
68	Acc 68	Slightly prominent	Vertical	Green	Non waxy	Strong
69	Acc 69	Slightly prominent	Vertical	Green	Non waxy	Intermediate

70	Acc 70	Absent	Vertical	Greenish yellow	Non waxy	Strong
71	Acc 71	Slightly prominent	Oblique	Yellow with red blush	Waxy	Strong
72	Acc 72	Absent	Vertical	Green	Waxy	Strong
73	Acc 73	Slightly prominent	Vertical	Green	Non waxy	Intermediate
74	Acc 74	Absent	Vertical	Greenish yellow	Waxy	Intermediate
75	Acc 75	Slightly prominent	Vertical	Green	Waxy	Intermediate
76	Acc 76	Absent	Vertical	Green	Non waxy	Strong
77	Acc 77	Slightly prominent	Vertical	Yellow	Non waxy	Weak
78	Acc 78	Slightly prominent	Vertical	Greenish yellow	Non waxy	Strong
79	Acc 79	Absent	Vertical	Yellow	Non waxy	Weak
80	Acc 80	Slightly prominent	Vertical	Yellow	Non waxy	Strong
81	Acc 81	Absent	Vertical	Green	Non waxy	Strong
82	Acc 82	Prominent	Vertical	Greenish yellow	Non waxy	Weak
83	Acc 83	Slightly prominent	Vertical	Greenish yellow	Non waxy	Weak
84	Acc 84	Absent	Vertical	Green	Waxy	Strong
85	Acc 85	Slightly prominent	Vertical	Green	Non waxy	Strong
86	Acc 86	Absent	Vertical	Yellow	Waxy	Weak
87	Acc 87	Prominent	Vertical	Greenish yellow	Non waxy	Strong
88	Acc 88	Absent	Vertical	Greenish yellow	Non waxy	Strong
89	Acc 89	Slightly prominent	Vertical	Green	Waxy	Weak
90	Acc 90	Absent	Vertical	Green	Waxy	Weak
91	Acc 91	Absent	Vertical	Green	Waxy	Intermediate
92	Acc 92	Prominent	Vertical	Yellow	Non waxy	Intermediate
93	Acc 93	Slightly prominent	Vertical	Yellow	Waxy	Strong
94	Acc 94	Slightly prominent	Vertical	Green	Waxy	Intermediate
95	Acc 95	Absent	Vertical	Green	Non waxy	Strong
96	Acc 96	Absent	Vertical	Green	Non waxy	Strong
97	Acc 97	Absent	Vertical	Green	Non waxy	Strong
98	Acc 98	Slightly prominent	Vertical	Greenish yellow	Non waxy	Intermediate
99	Acc 99	Absent	Vertical	Green	Non waxy	Strong
100	Acc100	Absent	Vertical	Greenish yellow	Waxy	Weak

Annexure-VI

OTHER FRUIT CHARACTERS

S.No	Land races	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Pulp weight (g)	Peel thickness (mm)	Peel weight (g)	Pulp content (%)
1	Acc 1	11.10	10.45	590.00	396.00	3.20	137.50	67.12
2	Acc 2	10.00	07.80	275.00	150.00	2.60	85.00	54.55
3	Acc 3	08.75	08.05	215.50	145.00	1.40	32.00	67.20
4	Acc 4	10.80	08.10	380.00	217.00	2.75	100.00	57.13
5	Acc 5	08.35	06.60	155.00	93.90	1.90	40.50	60.53
6	Acc 6	07.00	05.80	96.20	51.30	1.80	23.65	53.26
7	Acc 7	06.80	06.20	106.00	64.70	1.50	24.30	61.05
8	Acc 8	08.80	06.60	148.00	83.00	1.50	35.00	56.17
9	Acc 9	05.20	04.30	62.00	38.80	1.00	10.00	62.65
10	Acc 10	05.30	04.90	44.00	19.80	1.60	13.80	45.00
11	Acc 11	07.50	06.40	175.00	105.00	2.00	45.00	59.98
12	Acc 12	10.00	07.50	245.00	150.00	2.60	56.00	61.21
13	Acc 13	09.90	08.30	257.15	152.15	3.18	62.30	59.15
14	Acc 14	08.50	07.50	169.50	80.80	1.38	46.35	47.67
15	Acc 15	09.00	06.50	161.50	107.15	1.35	35.35	66.35
16	Acc 16	08.00	06.80	163.50	107.10	1.00	29.90	65.54
17	Acc 17	09.50	08.00	246.50	148.20	0.85	59.00	60.12
18	Acc 18	08.50	07.80	265.00	127.50	3.05	87.50	48.14
19	Acc 19	18.00	08.30	465.00	345.00	2.65	80.00	74.24
20	Acc 20	12.50	07.00	145.50	91.85	1.10	31.85	63.20
21	Acc 21	07.30	05.90	136.20	87.20	1.55	29.00	64.03
22	Acc 22	07.90	05.65	120.10	44.45	2.20	33.65	36.74
23	Acc 23	07.10	08.55	177.00	113.65	1.40	35.35	64.21
24	Acc 24	06.55	06.00	100.00	45.80	1.38	24.80	45.81
25	Acc 25	09.10	06.95	250.00	146.50	2.00	61.00	58.62
26	Acc 26	10.50	08.50	382.50	235.00	2.18	100.00	61.42
27	Acc 27	06.55	05.30	104.00	66.25	1.80	24.25	63.71
28	Acc 28	10.55	08.00	289.60	183.70	2.60	68.00	63.43
29	Acc 29	05.90	05.05	81.50	37.95	1.40	20.00	46.56
30	Acc 30	09.50	08.10	205.00	118.00	1.75	37.25	57.54
31	Acc 31	09.00	07.00	197.00	114.50	2.50	49.00	58.12

32	Acc 32	07.00	06.25	103.00	32.15	1.30	26.85	31.12
33	Acc 33	09.50	07.85	196.50	110.55	1.95	39.30	56.14
34	Acc 34	08.95	06.10	147.50	70.20	1.75	39.40	47.60
35	Acc 35	08.50	07.00	206.5	119.50	2.40	49.00	57.78
36	Acc 36	07.22	06.41	86.00	33.28	1.35	28.98	38.57
37	Acc 37	07.00	07.5.	185.10	135.80	1.00	33.65	73.37
38	Acc 38	07.50	06.8.	133.50	73.05	1.05	35.60	54.68
39	Acc 39	11.00	07.50	278.00	153.00	2.50	61.00	55.06
40	Acc 40	10.45	08.00	215.00	113.00	2.10	50.00	52.58
41	Acc 41	12.75	09.00	422.50	293.00	3.05	81.00	69.35
42	Acc 42	08.25	06.05	134.00	60.00	2.05	37.00	44.82
43	Acc 43	07.90	08.30	220.00	138.95	2.05	62.20	63.09
44	Acc 44	08.95	06.80	148.30	83.10	1.35	31.50	55.95
45	Acc 45	08.95	06.45	181.50	99.00	1.60	38.90	54.54
46	Acc 46	11.90	09.10	485.00	307.90	4.05	112.00	63.51
47	Acc 47	11.00	06.50	217.50	141.38	2.09	43.63	64.99
48	Acc 48	09.50	06.81	180.00	91.80	2.75	53.00	50.89
49	Acc 49	08.10	07.55	189.00	117.40	1.68	38.00	62.12
50	Acc 50	07.10	5.85	115.00	59.50	2.07	22.50	51.70
51	Acc 51	08.80	08.00	230.10	158.66	1.95	39.40	68.95
52	Acc 52	04.80	06.10	55.70	21.40	1.60	14.75	38.43
53	Acc 53	10.55	09.30	467.50	292.50	3.10	121.00	62.57
54	Acc 54	07.50	07.10	138.00	83.60	1.30	22.50	60.58
55	Acc 55	08.30	08.70	260.75	179.25	1.61	44.50	68.75
56	Acc 56	10.00	10.45	237.00	140.70	1.80	41.90	59.34
57	Acc 57	08.60	06.90	207.50	107.10	2.20	63.25	51.61
58	Acc 58	09.60	06.30	158.80	91.05	2.70	38.90	57.34
59	Acc 59	09.50	08.00	250.00	142.00	2.30	56.00	56.80
60	Acc 60	06.50	05.40	91.00	64.13	1.35	14.00	70.48
61	Acc 61	11.20	09.20	395.00	220.00	3.55	112.50	55.71
62	Acc 62	15.90	09.00	490.00	345.75	2.60	107.50	70.56
63	Acc 63	07.00	06.00	143.00	91.95	1.85	26.50	64.31
64	Acc 64	09.30	07.25	248.50	171.50	2.00	49.00	69.01
65	Acc 65	10.50	09.05	405.00	242.55	3.60	107.70	59.87
66	Acc 66	10.25	08.10	310.00	176.85	3.10	85.00	57.07
67	Acc 67	07.35	04.80	108.00	52.85	0.55	21.90	48.93
68	Acc 68	08.00	06.00	110.50	65.00	0.95	25.50	58.82

69	Acc 69	06.00	05.80	80.50	39.95	1.85	20.95	49.63
70	Acc 70	07.95	06.25	127.00	71.80	1.75	26.15	56.53
71	Acc 71	06.50	06.00	130.00	82.48	1.50	25.22	63.44
72	Acc 72	08.35	06.80	167.00	115.95	0.85	24.75	69.43
73	Acc 73	08.50	07.00	193.00	118.50	2.30	42.50	61.43
74	Acc 74	06.50	6.50	122.50	80.50	2.90	27.75	65.72
75	Acc 75	07.00	5.95	139.00	86.00	1.30	21.50	61.87
76	Acc 76	06.60	5.50	101.50	66.35	0.85	14.15	65.37
77	Acc 77	06.50	6.00	125.00	80.28	1.50	23.22	64.27
78	Acc 78	09.48	6.50	190.00	110.15	2.05	48.95	57.98
79	Acc 79	06.05	5.75	82.50	42.45	1.85	20.25	51.45
80	Acc 80	15.38	9.90	630.00	419.50	3.06	149.50	66.59
81	Acc 81	12.33	9.96	634.82	415.38	3.01	149.90	65.43
82	Acc 82	08.10	6.50	145.00	81.56	1.59	33.33	56.24
83	Acc 83	06.06	5.06	65.13	33.07	1.32	16.28	50.74
84	Acc 84	09.40	7.69	160.76	63.07	1.48	59.54	39.26
85	Acc 85	06.99	7.58	170.00	109.43	1.99	38.61	64.37
86	Acc 86	07.95	6.78	91.50	37.14	1.41	31.44	40.57
87	Acc 87	09.49	5.50	109.50	42.73	1.97	28.16	38.96
88	Acc 88	10.65	9.80	483.32	302.75	3.20	129.49	62.64
89	Acc 89	08.04	7.12	144.73	79.43	1.99	39.76	54.80
90	Acc 90	06.39	5.42	88.28	63.00	1.33	12.51	71.31
91	Acc 91	07.55	6.61	147.36	87.72	1.47	41.19	59.45
92	Acc 92	11.37	6.48	205.56	147.51	1.92	45.00	71.74
93	Acc 93	07.22	5.63	121.00	75.00	1.70	32.85	61.97
94	Acc 94	09.25	9.05	385.77	275.37	1.20	71.70	71.37
95	Acc 95	05.98	5.05	67.50	30.53	2.07	16.33	45.20
96	Acc 96	06.56	5.05	73.00	35.78	2.00	15.55	49.06
97	Acc 97	06.48	4.78	81.00	42.00	1.85	16.57	51.84
98	Acc 98	12.74	6.96	327.00	178.88	3.10	56.80	54.69
99	Acc 99	06.81	4.64	69.48	29.30	1.77	18.68	42.20
100	Acc100	10.32	7.58	315.00	170.00	2.84	85.00	53.99
CD (5%)		0.63	0.46	16.83	12.5			

Annexure-VII

FRUIT PULP CHARACTERS

S.No	Land races	Pulp colour	Pulp texture	Pulp aroma	Turpentine flavour
1	Acc 1	Yellow	Firm	Intermediate*	Absent
2	Acc 2	Yellow orange	Firm	Intermediate	Absent
3	Acc 3	Yellow	Firm	Strong	Absent
4	Acc 4	Yellow orange	Firm	Intermediate	Absent
5	Acc 5	Yellow	Firm	Mild	Absent
6	Acc 6	Yellow	Soft	Intermediate	Absent
7	Acc 7	Yellow	Firm	Intermediate	Absent
8	Acc 8	Yellow orange	Soft	Intermediate*	Absent
9	Acc 9	Yellow	Juicy	Intermediate	Absent
10	Acc 10	Yellow	Juicy	Intermediate	Absent
11	Acc 11	Yellow orange	Soft	Mild	Mild
12	Acc 12	Yellow orange	Firm	Mild	Absent
13	Acc 13	Yellow orange	Firm	Mild	Absent
14	Acc 14	Dark orange	Firm	Strong	Strong
15	Acc 15	Yellow orange	Firm	Mild	Intermediate
16	Acc 16	Yellow orange	Firm	Strong	Absent
17	Acc 17	Orange	Firm	Mild	Absent
18	Acc 18	Yellow	Firm	Mild	Absent
19	Acc 19	Yellow	Firm	Mild	Absent
20	Acc 20	Yellow	Firm	Mild	Absent
21	Acc 21	Yellow orange	Firm	Mild	Absent
22	Acc 22	Yellow	Firm	Strong	Absent
23	Acc 23	Yellow orange	Firm	Mild	Intermediate
24	Acc 24	Yellow	Firm	Strong	Strong
25	Acc 25	Yellow	Firm	Mild	Absent
26	Acc 26	Yellow	Firm	Mild	Absent
27	Acc 27	Yellow orange	Firm	Mild	Absent
28	Acc 28	Yellow	Firm	Mild	Absent
29	Acc 29	Yellow	Soft	Mild	Strong
30	Acc 30	Orange	Firm	Intermediate	Absent
31	Acc 31	Yellow	Firm	Intermediate	Absent
32	Acc 32	Yellow	Juicy	Mild	Absent
33	Acc 33	Yellow	Juicy	Strong	Strong

34	Acc 34	Yellow	Firm	Strong	Strong
35	Acc 35	Yellow	Soft	Mild	Absent
36	Acc 36	Yellow	Soft	Strong	Mild
37	Acc 37	Yellow	Firm	Strong	Absent
38	Acc 38	Yellow	Firm	Mild	Absent
39	Acc 39	Yellow	Firm	Mild	Absent
40	Acc 40	Yellow	Firm	Mild	Absent
41	Acc 41	Yellow orange	Firm	Mild	Absent
42	Acc 42	Yellow	Firm	Mild	Absent
43	Acc 43	Orange	Firm	Mild	Absent
44	Acc 44	Orange	Firm	Mild	Absent
45	Acc 45	Yellow	Firm	Mild	Mild
46	Acc 46	Light yellow	Firm	Mild	Mild
47	Acc 47	Yellow	Firm	Mild	Absent
48	Acc 48	Yellow	Soft	Mild	Absent
49	Acc 49	Orange	Soft	Mild	Absent
50	Acc 50	Yellow	Soft	Mild	Absent
51	Acc 51	Yellow	Firm	Strong	Absent
52	Acc 52	Dark orange	Juicy	Intermediate	Absent
53	Acc 53	Yellow	Firm	Mild	Absent
54	Acc 54	Yellow	Soft	Strong	Absent
55	Acc 55	Yellow orange	Firm	Mild	Absent
56	Acc 56	Yellow	Firm	Mild	Absent
57	Acc 57	Orange	Firm	Mild	Absent
58	Acc 58	Yellow	Soft	Mild	Absent
59	Acc 59	Orange	Firm	Mild	Absent
60	Acc 60	Yellow orange	Soft	Mild	Absent
61	Acc 61	Orange	Firm	Mild	Absent
62	Acc 62	Orange	Firm	Mild	Absent
63	Acc 63	Orange	Firm	Mild	Mild
64	Acc 64	Orange	Firm	Intermediate	Absent
65	Acc 65	Yellow	Firm	Mild	Absent
66	Acc 66	Yellow	Firm	Mild	Strong
67	Acc 67	Yellow orange	Juicy	Strong	Absent
68	Acc 68	Yellow	Soft	Mild	Mild
69	Acc 69	Orange	Soft	Mild	Strong
70	Acc 70	Greenish yellow	Firm	Mild	Intermediate

71	Acc 71	Yellow	Firm	Mild	Absent
72	Acc 72	Orange	Firm	Intermediate	Strong
73	Acc 73	Yellow	Firm	Mild	Strong
74	Acc 74	Light orange	Soft	Strong and pleasant	Absent
75	Acc 75	Yellow orange	Firm	Mild	Absent
76	Acc 76	Yellow	Firm	Strong and pleasant	Absent
77	Acc 77	Yellow	Juicy	Mild	Absent
78	Acc 78	Light orange	Firm	Mild	Mild
79	Acc 79	Light yellow	Juicy	Mild	Intermediate
80	Acc 80	Yellow orange	Firm	Strong	Absent
81	Acc 81	Yellow	Firm	Mild	Absent
82	Acc 82	Yellow	Firm	Mild	Mild
83	Acc 83	Light yellow	Soft	Mild	Strong
84	Acc 84	Yellow	Firm	Mild	Mild
85	Acc 85	Yellow orange	Firm	Mild	Absent
86	Acc 86	Yellow orange	Juicy	Mild	Absent
87	Acc 87	Yellow	Firm	Strong	Absent
88	Acc 88	Light orange	Firm	Strong and good	Absent
89	Acc 89	Yellow orange	Soft	Mild	Intermediate
90	Acc 90	Yellow orange	Soft	Mild	Absent
91	Acc 91	Orange	Firm	Mild	Absent
92	Acc 92	Yellow orange	Firm	Strong	Mild
93	Acc 93	Yellow	Firm	Mild	Absent
94	Acc 94	Yellow orange	Firm	Intermediate	Absent
95	Acc 95	Dark orange	Juicy	Intermediate	Absent
96	Acc 96	Dark orange	Juicy	Intermediate	Absent
97	Acc 97	Dark orange	Juicy	Intermediate	Absent
98	Acc 98	Yellow orange	Firm	Mild	Absent
99	Acc 99	Dark orange	Juicy	Strong	Absent
100	Acc100	Yellow orange	Firm	Mild	Absent

Annexure-VIII

FRUIT STONE CHARACTERS (conti.)

S.No	Landraces	Veins on the stone	Pattern of venation	Quantity of fibre attach to stone	Length of fibre
1	Acc 1	Elevated	Parallel	High	Long
2	Acc 2	Level with surface	Forked	Intermediate	Medium
3	Acc 3	Level with surface	Parallel	High	Long
4	Acc 4	Level with surface	Forked	Intermediate	Medium
5	Acc 5	Level with surface	Parallel	High	Long
6	Acc 6	Depressed	Parallel	High	Long
7	Acc 7	Level with surface	Parallel	High	Long
8	Acc 8	Level with surface	Parallel	High	Long
9	Acc 9	Level with surface	Parallel	High	Long
10	Acc 10	Depressed	Parallel	High	Long
11	Acc 11	Elevated	Both	Low	Medium
12	Acc 12	Level with surface	Parallel	Intermediate	Long
13	Acc 13	Level with surface	Parallel	High	Medium
14	Acc 14	Level with surface	Parallel	High	Long
15	Acc 15	Elevated	Parallel	Absent	-
16	Acc 16	Level with surface	Parallel	Low	Short
17	Acc 17	Level with surface	Parallel	Low	Medium
18	Acc 18	Depressed	Forked	Low	Medium
19	Acc 19	Level with surface	Parallel	Absent	-
20	Acc 20	Level with surface	Parallel	Absent	-
21	Acc 21	Level with surface	Parallel	High	Long
22	Acc 22	Depressed	Parallel	High	Long
23	Acc 23	Elevated	Parallel	Absent	-
24	Acc 24	Level with surface	Parallel	Intermediate	Long
25	Acc 25	Level with surface	Parallel	Intermediate	Long
26	Acc 26	Level with surface	Parallel	Intermediate	Long
27	Acc 27	Level with surface	Parallel	Low	Short
28	Acc 28	Level with surface	Parallel	Long	Medium
29	Acc 29	Level with surface	Parallel	Intermediate	Medium

30	Acc 30	Level with surface	Parallel	High	Long
31	Acc 31	Level with surface	Parallel	Intermediate	Short
32	Acc 32	Level with surface	Parallel	High	Long
33	Acc 33	Level with surface	Parallel	High	Long
34	Acc 34	Level with surface	Parallel	Intermediate	Long
35	Acc 35	Level with surface	Parallel	High	Long
36	Acc 36	Level with surface	Parallel	High	Long
37	Acc 37	Elevated	Parallel	Low	Long
38	Acc 38	Level with surface	Parallel	Intermediate	Long
39	Acc 39	Level with surface	Parallel	High	Long
40	Acc 40	Depressed	Parallel	High	Long
41	Acc 41	Elevated	Parallel	Intermediate	Long
42	Acc 42	Level with surface	Parallel	Absent	-
43	Acc 43	Elevated	Parallel	Low	Short
44	Acc 44	Level with surface	Parallel	Intermediate	Medium
45	Acc 45	Level with surface	Parallel	High	Long
46	Acc 46	Elevated	Parallel	Intermediate	Long
47	Acc 47	Level with surface	Parallel	Absent	-
48	Acc 48	Depressed	Parallel	High	Medium
49	Acc 49	Level with surface	Parallel	Low	Short
50	Acc 50	Level with surface	Parallel	High	Medium
51	Acc 51	Depressed	Parallel	High	Long
52	Acc 52	Depressed	Parallel	High	Long
53	Acc 53	Elevated	Parallel	High	Long
54	Acc 54	Depressed	Parallel	Low	Medium
55	Acc 55	Level with surface	Parallel	Low	Medium
56	Acc 56	Level with surface	Parallel	Low	Medium
57	Acc 57	Elevated	Parallel	Intermediate	Long
58	Acc 58	Level with surface	Parallel	High	Long
59	Acc 59	Level with surface	Parallel	High	Long
60	Acc 60	Level with surface	Parallel	High	Medium
61	Acc 61	Level with surface	Both	High	Long
62	Acc 62	Elevated	Parallel	Low	Short
63	Acc 63	Depressed	Parallel	Low	Short
64	Acc 64	Elevated	Parallel	Low	Short
65	Acc 65	Elevated	Parallel	Intermediate	Long
66	Acc 66	Elevated	Parallel	Intermediate	Long

67	Acc 67	Level with surface	Parallel	High	Long
68	Acc 68	Depressed	Parallel	Low	Medium
69	Acc 69	Elevated	Parallel	Low	Long
70	Acc 70	Depressed	Parallel	Intermediate	Medium
71	Acc 71	Level with surface	Parallel	Low	Short
72	Acc 72	Elevated	Parallel	Intermediate	Long
73	Acc 73	Level with surface	Parallel	Intermediate	Long
74	Acc 74	Level with surface	Parallel	High	Long
75	Acc 75	Level with surface	Both	High	Long
76	Acc 76	Depressed	Parallel	High	Long
77	Acc 77	Level with surface	Parallel	Intermediate	Long
78	Acc 78	Level with surface	Parallel	Low	Short
79	Acc 79	Level with surface	Parallel	High	Long
80	Acc 80	Level with surface	Parallel	Intermediate	Long
81	Acc 81	Elevated	Parallel	High	Long
82	Acc 82	Level with surface	Parallel	High	Long
83	Acc 83	Depressed	Parallel	Low	Short
84	Acc 84	Level with surface	Forked	High	Long
85	Acc 85	Depressed	Parallel	Intermediate	Medium
86	Acc 86	Depressed	Parallel	High	Long
87	Acc 87	Level with surface	Parallel	Intermediate	Medium
88	Acc 88	Elevated	Both	Intermediate	Medium
89	Acc 89	Elevated	Parallel	High	Medium
90	Acc 90	Level with surface	Parallel	High	Medium
91	Acc 91	Elevated	Parallel	Low	Medium
92	Acc 92	Elevated	Parallel	Low	Medium
93	Acc 93	Level with surface	Parallel	Low	Short
94	Acc 94	Level with surface	Forked	High	Long
95	Acc 95	Depressed	Parallel	High	Long
96	Acc 96	Depressed	Parallel	High	Long
97	Acc 97	Depressed	Parallel	High	Long
98	Acc 98	Elevated	Parallel	High	Long
99	Acc 99	Depressed	Parallel	High	Long
100	Acc100	Level with surface	Parallel	High	Long

Annexure-IX

BIOCHEMICAL CHARACTERS

S.No	Landraces	TSS (^{0}Brix)	Acidity (%)	Reducing sugars (%)	Nonreducing sugars (%)	Total sugars (%)
1	Acc 1	15.85	0.23	4.65	9.43	14.08
2	Acc 2	17.85	0.43	3.16	10.44	13.60
3	Acc 3	11.30	0.23	2.45	3.70	6.15
4	Acc 4	18.60	0.39	3.20	11.10	14.30
5	Acc 5	10.20	0.33	2.05	3.55	5.60
6	Acc 6	11.50	0.18	3.77	4.43	8.20
7	Acc 7	12.45	0.25	2.23	4.00	6.23
8	Acc 8	12.30	0.40	3.13	5.07	8.20
9	Acc 9	23.00	0.38	5.30	7.65	12.95
10	Acc 10	22.50	0.36	5.39	5.79	11.18
11	Acc 11	9.30	0.85	1.20	2.00	3.20
12	Acc 12	11.20	0.27	1.34	1.56	2.90
13	Acc 13	14.00	0.21	2.22	10.08	12.30
14	Acc 14	9.25	1.08	1.13	0.74	1.87
15	Acc 15	23.50	0.30	4.44	16.03	20.47
16	Acc 16	12.50	0.24	2.40	3.90	6.30
17	Acc 17	14.00	0.33	3.54	5.65	9.19
18	Acc 18	10.50	1.25	1.65	2.45	4.10
19	Acc 19	11.30	0.84	2.16	3.76	5.92
20	Acc 20	18.00	0.27	3.15	11.34	14.49
21	Acc 21	14.00	0.11	3.83	2.78	6.61
22	Acc 22	20.50	0.52	3.50	11.49	14.99
23	Acc 23	17.80	0.21	5.27	10.39	15.66
24	Acc 24	17.90	0.13	5.31	7.30	12.61
25	Acc 25	14.00	0.17	3.35	2.98	6.33
26	Acc 26	15.50	0.21	2.60	6.50	9.10
27	Acc 27	16.50	0.41	5.07	5.09	10.16
28	Acc 28	15.50	0.21	2.22	10.08	12.30
29	Acc 29	15.05	0.22	4.18	6.65	10.83
30	Acc 30	13.75	0.44	2.15	3.67	5.82
31	Acc 31	22.45	0.1	5.55	8.83	14.38
32	Acc 32	17.80	0.14	3.49	12.13	15.62

33	Acc 33	14.50	0.40	1.93	5.07	7.00
34	Acc 34	12.90	0.44	1.29	1.39	2.68
35	Acc 35	14.50	0.35	2.05	7.85	9.90
36	Acc 36	12.90	0.23	3.58	6.38	9.96
37	Acc 37	16.00	0.12	3.04	7.42	10.46
38	Acc 38	13.00	0.24	1.76	5.18	6.94
39	Acc 39	13.20	0.13	1.83	5.28	7.11
40	Acc 40	12.70	0.33	3.31	1.87	5.18
41	Acc 41	14.00	0.39	4.72	1.59	6.31
42	Acc 42	12.95	0.44	1.65	2.62	4.27
43	Acc 43	17.00	0.23	5.16	8.56	13.72
44	Acc 44	18.30	0.16	4.45	9.36	13.82
45	Acc 45	13.00	0.23	3.39	3.99	7.38
46	Acc 46	14.70	0.30	2.23	3.54	5.77
47	Acc 47	12.00	0.40	3.23	2.87	6.10
48	Acc 48	16.10	0.64	4.89	3.50	8.39
49	Acc 49	13.60	0.34	1.40	3.21	4.61
50	Acc 50	14.35	1.12	5.56	3.72	9.28
51	Acc 51	17.20	0.79	2.42	2.00	4.42
52	Acc 52	23.65	0.51	5.40	8.05	13.45
53	Acc 53	22.10	0.22	4.65	13.39	18.04
54	Acc 54	13.90	0.50	0.98	2.39	3.37
55	Acc 55	14.45	0.44	1.32	3.28	4.60
56	Acc 56	18.90	0.24	3.75	12.58	16.33
57	Acc 57	16.00	0.62	4.94	3.59	8.53
58	Acc 58	10.80	0.23	2.31	3.70	6.01
59	Acc 59	10.60	0.47	0.94	1.96	2.90
60	Acc 60	14.75	0.74	4.71	5.56	10.27
61	Acc 61	10.30	0.63	1.38	2.12	3.50
62	Acc 62	14.00	0.39	4.72	2.88	7.60
63	Acc 63	19.90	0.21	5.37	10.63	16.00
64	Acc 64	23.50	0.27	4.44	13.03	17.47
65	Acc 65	15.95	0.22	4.15	9.38	13.53
66	Acc 66	15.50	0.36	1.54	5.80	7.34
67	Acc 67	10.90	0.60	2.56	2.11	4.67
68	Acc 68	13.30	0.60	1.56	2.61	4.17
69	Acc 69	14.95	0.16	4.23	6.56	10.79

70	Acc 70	15.05	1.20	2.12	2.71	4.83
71	Acc 71	12.00	1.00	1.17	2.22	3.39
72	Acc 72	17.85	0.15	5.22	7.48	12.70
73	Acc 73	13.95	0.23	4.21	9.02	13.23
74	Acc 74	17.95	0.40	2.99	3.94	6.93
75	Acc 75	18.95	0.29	4.85	3.91	8.76
76	Acc 76	15.95	0.13	4.42	6.18	10.60
77	Acc 77	16.15	0.20	3.71	5.32	9.03
78	Acc 78	14.25	0.30	4.49	15.75	20.24
79	Acc 79	23.05	0.35	5.65	8.12	13.77
80	Acc 80	17.10	0.23	4.25	10.28	14.53
81	Acc 81	14.95	0.25	2.82	2.28	5.10
82	Acc 82	9.10	0.60	0.88	1.22	2.10
83	Acc 83	12.85	0.61	1.32	0.95	2.27
84	Acc 84	10.45	0.42	1.00	1.97	2.97
85	Acc 85	13.90	0.31	2.71	6.23	8.94
86	Acc 86	16.80	0.14	4.33	6.26	10.59
87	Acc 87	12.50	0.21	1.03	2.84	3.87
88	Acc 88	10.55	0.21	1.00	2.87	3.87
89	Acc 89	12.30	0.73	4.71	4.73	9.44
90	Acc 90	14.60	0.72	5.21	4.94	10.15
91	Acc 91	19.40	0.65	6.10	5.29	11.39
92	Acc 92	21.10	0.36	5.72	7.89	13.61
93	Acc 93	18.50	0.30	5.74	4.40	10.14
94	Acc 94	11.40	0.20	1.00	2.87	3.87
95	Acc 95	20.10	0.36	6.22	9.25	15.47
96	Acc 96	20.05	0.39	6.17	9.30	15.47
97	Acc 97	20.45	0.37	6.15	9.32	15.47
98	Acc 98	13.25	0.22	3.03	3.25	6.28
99	Acc 99	20.55	1.21	6.10	9.37	15.47
100	Acc100	7.60	0.65	1.05	2.08	3.13
CD (5%)		0.56	0.11	0.30	0.74	0.70

Annexure-X

MATURITY OF HARVEST, YIELD, USE AND POLYEMBRYONY OF MANGO LANDRACES

S.No	Landraces	Maturity of harvest	Yield (Kg)	Use of mango	Polyembryony
1	Acc 1	Intermediate	1800	Table	-
2	Acc 2	Late	1000	Table	-
3	Acc 3	Intermediate	200	Table and curry preparation	4
4	Acc 4	Late	1000	Table	-
5	Acc 5	Intermediate	200	Table	2
6	Acc 6	Intermediate	500	Table and Pickle	-
7	Acc 7	Early	200	Table	4
8	Acc 8	Early	400	Table and Pickle	2
9	Acc 9	Intermediate	300	Table	-
10	Acc 10	Intermediate	250	Table	-
11	Acc 11	Intermediate	60	Table	-
12	Acc 12	Late	50	Table, Juice and Pickle	-
13	Acc 13	Intermediate	1200	Table	2
14	Acc 14	Intermediate	50	Pickling	2
15	Acc 15	Intermediate	600	Table	-
16	Acc 16	Intermediate	40	Table	-
17	Acc 17	Intermediate	380	Table	-
18	Acc 18	Early	450	Both	-
19	Acc 19	Late	50	Table, Juice and Pickle	-
20	Acc 20	Late	40	Table, Juice and Pickle	-
21	Acc 21	Intermediate	35	Table, juice	3
22	Acc 22	Intermediate	800	Table	-
23	Acc 23	Intermediate	40	Table	-
24	Acc 24	Intermediate	30	Table	3
25	Acc 25	Intermediate	400	Table	-
26	Acc 26	Intermediate	400	Table	-
27	Acc 27	Intermediate	70	Table	-
28	Acc 28	Intermediate	650	Table	3
29	Acc 29	Intermediate	450	Table	2
30	Acc 30	Intermediate	200	Pickle and Table	3
31	Acc 31	Intermediate	40	Table	-
32	Acc 32	Early	600	Both	-

33	Acc 33	Intermediate	450	Table	-
34	Acc 34	Intermediate	380	Pickle	-
35	Acc 35	Intermediate	550	Table	-
36	Acc 36	Intermediate	250	Pickle	-
37	Acc 37	Intermediate	800	Table	-
38	Acc 38 .	Intermediate	200	Table	-
39	Acc 39	Late	900	Table	-
40	Acc 40	Intermediate	800	Table	-
41	Acc 41	Late	500	Table	-
42	Acc 42	Intermediate	150	Pickle	-
43	Acc 43	Intermediate	550	Table	2
44	Acc 44	Intermediate	770	Table	2
45	Acc 45	Intermediate	40	Table	4
46	Acc 46	Intermediate	250	Table	2
47	Acc 47	Late	400	Table	-
48	Acc 48	Intermediate	450	Table	-
49	Acc 49	Intermediate	350	Table and curry	-
50	Acc 50	Intermediate	800	Table and curry	-
51	Acc 51	Intermediate	750	Table	-
52	Acc 52	Intermediate	80	Table	-
53	Acc 53	Intermediate	50	Table	-
54	Acc 54	Intermediate	1200	Table	-
55	Acc 55	Intermediate	250	Table	-
56	Acc 56	Intermediate	400	Table and juice	-
57	Acc 57	Intermediate	25	Table	-
58	Acc 58	Intermediate	15	Table	-
59	Acc 59	Intermediate	450	Table	4
60	Acc 60	Intermediate	60	Table and pickle	3
61	Acc 61	Late	100	Table	-
62	Acc 62	Intermediate	120	Table	-
63	Acc 63	Intermediate	60	Table	-
64	Acc 64	Intermediate	650	Table	2
65	Acc 65	Intermediate	1100	Table	-
66	Acc 66	Intermediate	450	Table	-
67	Acc 67	Intermediate	120	Pickling	-
68	Acc 68	Intermediate	80	Both	2
69	Acc 69	Intermediate	400	Table	-

70	Acc 70	Intermediate	1400	Table	-
71	Acc 71	Intermediate	70	Table	-
72	Acc 72	Intermediate	1200	Table and Curry	-
73	Acc 73	Intermediate	140	Table	-
74	Acc 74	Intermediate	1200	Table	-
75	Acc 75	Early	200	Table	-
76	Acc 76	Intermediate	250	Table	-
77	Acc 77	Intermediate	1500	Table	-
78	Acc 78	Late	1400	Table	-
79	Acc 79	Intermediate	850	Table	-
80	Acc 80	Late	1800	Table	-
81	Acc 81	Intermediate	1400	Table	-
82	Acc 82	Early	400	Table and Pickle	-
83	Acc 83	Intermediate	1300	Table and Pickle	2
84	Acc 84	Intermediate	150	Pickle	-
85	Acc 85	Intermediate	100	Table	-
86	Acc 86	Early	80	Table	-
87	Acc 87	Intermediate	600	Table	-
88	Acc 88	Intermediate	550	Table	-
89	Acc 89	Early	400	Table and Pickle	-
90	Acc 90	Early	400	Table and Pickle	-
91	Acc 91	Early	400	Table and Pickle	-
92	Acc 92	Intermediate	400	Table	-
93	Acc 93	Intermediate	800	Table	-
94	Acc 94	Early	200	Table	-
95	Acc 95	Intermediate	1800	Table and Pickle	3
96	Acc 96	Intermediate	1600	Table and Pickle	2
97	Acc 97	Intermediate	1700	Table and Pickle	3
98	Acc 98	Intermediate	300	Table	2
99	Acc 99	Intermediate	1600	Table and Pickle	3
100	Acc100	Intermediate	850	Pickle	3

DIVERSITY REGISTER FOR SPOTTED MANGO LANDRACES AT PAZHAYANNUR REGION

S.No	Mango landracess	Local name	Existence history (years unwards)	Source of plant	Extent and distribution of diversity	Method of use	Bearing history	Bearing habit	Information on custodians	Village	Incident of pest and disease
1	Acc 1	Gundu manga	30	Neighbourhood	Rare	Table	Regular	Mid	Ponnumani Urauamadakalam	Maruthampadam	-
2	Acc 2	Neela manga	20	Neighbourhood	Vulnerable	Table	Regular	Mid to late	Ponnumani Urauamadakalam	Maruthampadam	-
3	Acc 3	Enna Moovandan	8	Neighbourhood	Rare	Table and curry preparation	Regular	Mid	Ponnumani Urauamadakalam	Maruthampadam	-
4	Acc 4	Pacha manga Marathakam	20	Near by villages	Vulnerable	Table	Regular	Mid to late	Ponnumani Urauamadakalam	Maruthampadam	-
5	Acc 5	-	9	Relative	Rare	Table	Regular	Mid	Ponnumani Urauamadakalam	Maruthampadam	-
6	Acc 6	Kanni manga	12	Relative	Rare	Dual	Regular	Early	Ponnumani Urauamadakalam	Maruthampadam	-
7	Acc 7	Cheriya moovandan	10	Relative	Rare	Table	Regular	Early	Ponnumani Urauamadakalam	Maruthampadam	-
8	Acc 8	Ammini Pulichi	40	Own	Rare	Dual	Regular	Early	Ponnumani Urauamadakalam	Maruthampadam	-
9	Acc 9	Nadan mavu	40	Own	Rare	Table	Regular	Early to Mid	Saju P T panaphuthoffatil	Maruthampadam	-
10	Acc 10	-	45	Neighbourhood	Rare	Table	Regular	Early to Mid	Saju P T panaphuthoffatil	Maruthampadam	-
11	Acc 11	-	10	Near by villages	Rare	Table	Regular	Early to Mid	Sibbu Thadathil	Neelumpaliyal	-
12	Acc 12	-	9	Own	Rare	Table, Juice	Regular	Late	Ajish Thazhathuerambil	Neelumpaliyal	-

						and Pickle					
13	Acc 13	Kattu mavu	65	Own	Common	Table	Regular	Mid	Ramkumar thonur house	Neelumpaliyal	-
14	Acc 14	Puliyan mavu	8	Own	Rare	Pickling	Regular	Mid	Ramkumar thonur house	Neelumpaliyal	-
15	Acc 15	Sundhari mavu	40	Own	Rare	Table	Regular	Mid	Anitha Rariyamkandatha	Karimakuzhy	-
16	Acc 16		11	Neighbourhood	Rare	Table	Regular	Mid	Anitha Rariyamkandatha	Karimakuzhy	-
17	Acc 17		20	Relative	Rare	Table	Alternate	Mid	Santha pallissery	Karimakuzhy	-
18	Acc 18		35	Relative	Rare	Both	Regular	Early	Govindankutty	Karimakuzhy	-
19	Acc 19	Kilichundan -1	8	Relative	Rare	Table, Juice and Pickle	Regular	Mid to Late	Padmini sreesadan	Thrikanya	-
20	Acc 20	Kilichundan - 2	8	Relative	Rare	Table, Juice and Pickle	Regular	Mid to Late	Padmini sreesadan	Thrikanya	Stem end rot (*Diplodianata lensis*)
21	Acc 21		8	Relative	Rare	Table, Juice	Regular	Mid	Remadevi kokkuri	Thrikanya	-
22	Acc 22	Karpura manga	50	Relative	Rare	Table	Regular	Mid	Sreeja	Paruthipra	-
23	Acc 23	Chindhura manga	8	Relative	Rare	Table	Regular	Mid	Sivanarayana Pulluttukallam	Paruthipra	-
24	Acc 24	Puliyan	10	Neighbourhood	Rare	Table	Regular	Early	M. S. Chandran Mekkonnath	Meenakshipath	-
25	Acc 25	Kalapadi	25	Neighbourhood	Rare	Table	Regular	Mid to late		Meenakshipath	-
26	Acc 26	Kalapadi	20	Neighbourhood	Rare	Table	Regular	Mid to late		Meenakshipath	-
27	Acc 27	Perakkamavu	10	Neighbourhood	Rare	Table	Alternate	Early to Mid	M. S. Krishnan Kutty Kannath	Paruthipra	-
28	Acc 28		35	Neighbourhood	Rare	Table	Regular	Mid	Krishnan Kutty Kunnath	Meenakshipath	-
29	Acc 29	Pulichi	18	Own	Rare	Table	Regular	Mid	Baiju T.S. Pannikadu	Meenakshipath	-
30	Acc 30	Naaran manga	35	Own	Rare	Pickle and Table	Regular	Mid	Rajan Kattiammal	Velladi	-

31	Acc 31	-	10	Own	Rare	Table	Regular	Mid	Rajan Kattiammal	Velladi	-
32	Acc 32	Thean manga	100	Own	Rare	both	Regular	Mid	Rajan Kattiammal	Velladi	-
33	Acc 33	Gomanga	50	Relatives	Vulnarable	Table	Regular	Mid	Rajan Kattiammal	Velladi	-
34	Acc 34	-	80	Neighbourhood	Rare	Pickle	Regular	Mid	Rajan Kattiammal	Velladi	-
35	Acc 35	-	40	Near by village	Rare	Table	Alternate	Mid	Joy Kattiammal	Velladi	-
36	Acc 36	-	25	Neighbourhood	Rare	Pickle	Regular	Mid	Ravindran Kannasserykalam	Kannasserykalam	-
37	Acc 37		37	Neighbourhood	Rare	Table	Regular	Mid	Ravindran Kannasserykalam	Kannasserykalam	-
38	Acc 38		16	Near by village	Rare	Table	Alternate	Mid	Ravindran Kannasserykalam	Kannasserykalam	-
39	Acc 39		25	Own	Rare	Table	Alternate	Mid	Ravindran Kannasserykalam	Kannasserykalam	-
40	Acc 40		25	Neighbourhood	Rare	Table	Alternate	Mid	Ravindran Kannasserykalam	Kannasserykalam	-
41	Acc 41		30	Near by village	Rare	Table	Alternate	Mid	Pramod Muthalamkodekalam	Muthalamkode	-
42	Acc 42		20	Own	Rare	Pickle	Alternate	Mid	Wilson Kunnassery	Muthalamkode	-
43	Acc 43		30	Own	Rare	Table	Alternate	Mid	Saju Manjali Kongothupadam	Muthalamkode	-
44	Acc 44		40	Own	Rare	Table	Regular	Early	Sabu Vattamthara	Muthalamkode	-
45	Acc 45	Pachhamuvandan	8	Own	Common	Table	Regular	Early to mid	Kuttan Kodakkatil	Vennur	-
46	Acc 46		35	Own	Rare	Table	Alternate	Mid	Joy Thandassery	Manchadi	-
47	Acc 47		45	Own	Rare	Table	Regular	Mid to late	Ramachandran	Manchadi	-

48	Acc 48		50	Own	Common	Table	Regular	Mid	Shibu Pazhayakulam	Vennur	-
49	Acc 49		30	Neighbourhood	Rare	Table and curry	Regular	Mid	Shibu Pazhayakulam	Vennur	-
50	Acc 50		60	Near by village	Rare	Table and curry	Regular	Mid	Uniikrishnan Chengathukalam	Manchadi	-
51	Acc 51		50	Neighbourhood	Rare	Table	Regular	Mid	Narayana Menon Konnamkundathu	Vennur	-
52	Acc 52		8	Own	Rare	Table	Regular	Early to mid		Vennur	-
53	Acc 53		9	Own	Rare	Table	Regular	Mid		Vennur	-
54	Acc 54	Nadasala	110	Own	Rare	Table	Alternate	Mid		Vennur	-
55	Acc 55		20	Neighbourhood	Rare	Table	Regular	Early to mid	Heasnar Vendokinparambu	Vendokinparambu	-
56	Acc 56		11	Near by village	Rare	Table and juice	Regular	Early to mid	Bikutty Vendokinparambu	Vendokinparambu	-
57	Acc 57	Attanari	10	Neighbourhood	Rare	Table	Regular	Mid	Baby Thepala	Kuzhikakulambu	-
58	Acc 58	Sapota mavu	10	Own	Rare	Table	Alternate	Mid	Baby Thepala	Kuzhikakulambu	-
59	Acc 59	Vella moovandan	30	Neighbourhood	Common	Table	Regular	Early	Heasnar Vetanchadi	Vattapara	-
60	Acc 60	Pulichi	10	Near by village	Common	Table and pickle	Regular	Mid	Sibi Nelliknel	Vattapara	Sooty mould
61	Acc 61		10	Own	Rare	Table	Alternate	Mid	Kunjali Vattapara	Vattapara	-
62	Acc 62		10	Own	Rare	Table	Regular	Mid	Pitambran Kuruvapadam	Vennur	-
63	Acc 63	Chindoora manga	11	Own	Rare	Table	Alternate	Mid	Vasantha Kuruvapadam	Vennur	-
64	Acc 64		20	Own	Rare	Table	Regular	Early	Shivaraman SNDP sagagogam	Potta	-
65	Acc 65		25	Relatives	Rare	Table	Regular	Mid		Potta	Anthracnose
66	Acc 66		10	Relatives	Rare	Table	Regular	Mid		Potta	-

67	Acc 67	Kannimanga	10	Relatives	Rare	Pickling	Regular	Early to mid	Abdulla Kootupura	Potta	Anthracnose
68	Acc 68		12	Own	Common	Both	Regular	Mid		Potta	-
69	Acc 69		25	Neighbourhood	Other distinct group	Table	Regular	Mid	Ravuni Panayanpadutha	Potta	-
70	Acc 70		50	Neighbourhood	Rare	Table	Alternate	Mid	Madhavan Panayampadam	Potta	-
71	Acc 71		11	Relatives	Rare	Table	Alternate	Early to mid	Gopalamenon Gosssiri	Nelichira	-
72	Acc 72		35	Relatives	Rare	Table and Curry	Regular	Mid	Vijay kumar O.K Ottayil veedu	Nelichira	-
73	Acc 73	Panchasara mavu	12	Neighbourhood	Rare	Table	Alternate	Mid		Nelichira	-
74	Acc 74		30	Neighbourhood	Rare	Table	Regular	Early	Sugutha Vadhkoot	Kallepadam	-
75	Acc 75		10	Neighbourhood	Rare	T	Regular	Early	Vasu Manamplavil	Kumbalamkode	-
76	Acc 76		18	Neighbourhood	Rare	Table	Regular	Early	Prakash Manamplavil	Kumbalamkode	-
77	Acc 77		25	Near by village	Rare	Table	Regular	Mid	Gopala Krishnan Thekkekulam	Kumbalamkode	-
78	Acc 78		50	Near by village	Rare	Table	Regular	Mid	Sivaraman Vadakekolumbil	Plazhy	-
79	Acc 79	Vellari mavu	50	Near by village	Rare	Table	Alternate	Mid	Sivaraman Vadakekolumbil	Plazhy	-
80	Acc 80	Mundappa	35	Neighbourhood	Rare	Table	Alternate	Mid	Prasad	Pazhayannur	-
81	Acc 81		30	Neighbourhood	Rare	Table	Regular	Late	Prasad	Pazhayannur	-
82	Acc 82		20	Neighbourhood	Common	Dual	Regular	Early	Prasad	Pazhayannur	-
83	Acc 83	Karpoora mavu	105	-	Rare	Dual	Regular	Mid	Bhagavathi Temple palace compound	Vadakkathara	-
84	Acc 84		15	Own	Rare	Pickle	Regular	Early to Mid	Vishnu Nambudhari	Vadakkathara	-
85	Acc 85	Swarnamookkan	15	Own	Rare	Table	Regular	Mid		Vadakkathara	-

No.	Acc	Name	No.	Source	Rarity	Type	Frequency	Season	Person	Place	
86	Acc 86		10	Own	Vulnarable	Table	Regular	Early	Vishnu Nambudhari	Vadakkathara	-
87	Acc 87	Chakiriyan	100	-	Rare	Table	Alternate	Early	College of Applied Science	Cherakuzhy	-
88	Acc 88		80	-	Rare	Table	Alternate	Early	College of Applied Science	Cherakuzhy	-
89	Acc 89		15	-	Common	Dual	Regular	Early	Vinodkumar	Vattapara	-
90	Acc 90		8	Neighbourhood	Rare	Dual	Regular	Early	Vinodkumar	Vattapara	-
91	Acc 91		16	Relatives	Rare	Dual	Regular	Early to Mid	Vinodkumar	Vattapara	-
92	Acc 92		20	Relatives	Rare	Table	Regular	Mid to late	Vijayan Thrithala	Puthirithara	-
93	Acc 93		40	Neighbourhood	Rare	Table	Regular	Mid to late	Rukmini Korambuth	Puthirithara	-
94	Acc 94		12	Neighbourhood	Rare	Table	Perpetual	Early	Sankaran kutty	Puthirithara	-
95	Acc 95	Chandrakaran	65	Neighbourhood	Rare	Table	Regular	Early to Mid	M. Parameswaran	Kuthampilly Tiruvilvamala	-
96	Acc 96	Pudhuvaya mavu	52	Neighbourhood	Rare	Table	Regular	Early to Mid	M. Parameswaran	Kuthampilly Tiruvilvamala	-
97	Acc 97		60	Neighbourhood	Rare	Table	Regular	Early to Mid			-
98	Acc 98	Ezikodemoovandan	15	Neighbourhood	Rare	Table and Pickle	Perpetual	Early to Mid	Shankar	Painkulam Panjal	-
99	Acc 99	Chandrakkaran	52	Neighbourhood	Rare	Table	Regular	Early to Mid	Shankar		-
100	Acc100	Nattumavu	31	Neighbourhood	Rare	Pickle	Alternate	Mid	Shankar		-

DIVERSITY MAPPING AND CHARACTERIZATION OF LANDRACES OF MANGO [*Mangifera indica*. L]

by

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ABSTRACT OF THE THESIS

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DEPARTMENT OF POMOLOGY AND FLORICULTURE
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ABSTRACT

The project entitled "Diversity mapping and characterization of landraces of mango [*Mangifera indica*. L]" was undertaken at Pazhayannur region of Thrissur district of Kerala and under the department of Pomology and Floriculture, College of Horticulture,Vellanikkara, KAU during November 2012 to March, 2016. Selection of Pazhayannur region as the site of the present studies was based on a primary assessment conducted in this region earlier. The present investigations broadly envisaged the diversity mapping and digitization of mango LRs of this region, their characterisation, preparation of diversity registers and descriptors, documentation of associated indigenous traditional knowledge (ITK) and evolving appropriate integrated conservation and improvement strategies for the rare LRs spotted during the project implementation.

Snow ball sampling method was used for locating the seedling mango LRs in different villages of the region and their spatial distribution was depicted through a series of GIS maps as per the geo co-ordinate readings. A total of 100 LRs could be thus located in the region and could be grouped in five GIS maps primarily based on their geographical position and further into the different rural hamlets of the major villages of the study site. A homestead based land use practice was largely noted in all these villages surveyed with many annual and perennial species planted and maintained around the homesteads where mango diversity confining to the homestead peripheries either as single plant or a component of poly crop system.

The morphological characterisation was carried out as per the standard descriptor for mango by IPGRI (2006) for different tree, leaf, inflorescence, fruit and biochemical parameters.

Age of the trees surveyed spanned over a range of less than 20 years to more than 100 years and the trees were erect, spreading or drooping in their growth habit. A wide variation among the young leaves was noted with respect to the colour and it varied from light green, light green with brownish tinge, light brick red, reddish brown, and deep coppery tan. Flowering was noted from November to March making into early (November to December), midseason (January to February) and

late season (from March) as noted among the different accessions and two intermediate periods between the seasons. Regular bearing was predominantly noticed in majority of the accessions but for few accessions which exhibited secondary/perpetual type of flowering. All most all the accessions produced terminal borne inflorescences but few accessions showed axillary and terminal emergence of inflorescence. The inflorescences were predominantly pyramidal in shape, followed by broadly pyramidal and conical in few. Inflorescence colour ranged from light green to crimson.

Based on maturing period, the trees could be classified as early - if the fruits become mature for harvest by February, as intermediate - if ready for harvest by March to May, and as late - if ready by June. For pickling purpose, the stage for harvest varied from marble stage (for Kadu/tender manga pickle), to pre-mature (three-fourth) mature stage for Chethu manga.

Fruit shapes varied from round, elliptic, obovoid, ovoid and oblong. Fruit colour was distinct and as a rare occurrence brownish colouration of the skin could also be noted in one of the accessions. Fruit weight varied from 44 g. to 634.82 g., pulp weight from 19.80 g to 419.50 g. and the thickness of the skin from 0.55 mm to 4.05 mm. With respect to the pulp colour, a great variation was observable viz., light yellow, yellow, yellow orange, light orange, dark orange, and greenish yellow. Presence of fibre in the fruit pulp was a unique feature of all the accessions. Pulp aroma was mild, intermediate or strong. Turpentine flavour which interferes with the edible quality of fruit was also noted in few . TSS of the ripe fruits varied from 7.6 to 23.65°brix and acidity from 0.1 to 1.49 percent.

Polyembryony was also notable in few accessions with emerging seedlings per stone ranging from two to four.

Principal component analysis and cluster analysis was carried out culminating in constructing a mathematical base for the entire survey.

Four cell participatory analysis (FCA) conducted at the different villages, enabled the confirmatory identification of the common and rare mango LRs of the villages primarily and the region as a whole.

Overall diversity assessment clearly noted the predominance of the type Moovandan throughout the entire Pazhayannur region. Among the different villages maximum number of rare landraces could be spotted in Elanad village (39) followed by Vennur (19), Pazhayannur (19) and Vadakkethara (12). Accessions spotted from the extended locations of the survey (Tiruvilwamala and Panjal) were also added in to the rare group.

ITK associated with these mango LRs with special reference to the conventional and traditional processing of fruits were also documented.

A conceptual model for *in situ* conservation of the spotted LRs for the region could also worked out finally and a comprehensive village diversity register of mango LRs of the region in the specified format was prepared as a material for future reference.

Initiatives were also taken up for the *ex situ* conservation of some rare mango LRs spotted. Scion material of rare LRs were collected and grafted plants prepared for planting in the mango gene sanctuary maintained by the department.

Crossing and hybridization were also taken up during the project period involving selected LRs of the region as male parents with Moovandan and Neelum types maintained at the orchard of the college as female parents.