ECOPHYSIOLOGY AND SCREENING FOR CLIMATE CHANGE RESILIENCE IN MANGO (*Mangifera indica* L.) GENOTYPES

by

ASWINI A.

(2015-22-009)

THESIS

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COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
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DECLARATION

I, hereby declare that the thesis entitled **"Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellayani

Date: 9/12/19

Aswini A.

(2015-22-009)

CERTIFICATE

Certified that the thesis entitled **"Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes"** is a record of research work done independently by **Ms. Aswini A. (2015-22-009)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

Vellayani
Date: 9/12/19

Dr. Jyothi Bhaskar
(Chairman, Advisory Committee)
Professor and Head
Department of Fruit Science
College of Horticulture
Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Aswini A. (2015-22-009)** a candidate for the degree of **Doctor of Philosophy in Horticulture** agree that this thesis entitled **"Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes"** may be submitted by Ms. Aswini A. (2015-22-09), in partial fulfilment of the requirement for the degree.

9/12/19
Dr. Jyothi Bhaskar
(Chairman, Advisory Committee)
Professor and Head
Department of Fruit Science
College of Horticulture Vellanikkara

9/12/19
Dr. Rafeekher M.
(Member, Advisory Committee)
Professor and Head
Department of Pomology and Floriculture
College of Agriculture, Vellayani

9/12/19
Dr. S. Krishnan
(Member, Advisory Committee)
Professor and Head (Rtd.)
Department of Agricultural Statistics
College of Horticulture, Vellanikkara

Dr. A.V. Santhoshkumar
(Member, Advisory Committee)
Professor and Head
Department of Forest Biology and Tree Improvement
College of Forestry, Vellanikkara

9/12/19
Dr. B. Ajithkumar
(Member, Advisory Committee)
Assistant Professor and Head
Department of Agricultural Meteorology
College of Horticulture, Vellanikkara

9/12/19
EXTERNAL EXAMINER
Dr. J. RAJANGAM.
Professor & Head
DFS, HC&RI, Periyakulam

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Introduction

1. INTRODUCTION

Mango (*Mangifera indica* L.), India's most popular and national crop, has been growing for over 4000 years. India does have at least one thousand named cultivars (Rajan *et al.*, 2001). Mango is produced in an area of 79,496 ha in Kerala during 2016-17 with a production of 4,200, 48 tones (FIB, 2019). Other than the delightful taste, magnificent flavour and alluring aroma, it is plentiful in Vitamin A and C. In India, mango farming and productiveness was 226.2 thousand ha in the region, 19686.9 thousand MT and 8.7 MT/ha in 2016-17 respectively. Uttar Pradesh was the state's leading mango producer with a share of 23.06% of India's overall mango production. The other major mango-growing states were Andhra Pradesh, Telangana, Bihar, Maharashtra, Gujarat, Odisha, Tamil Nadu, West Bengal and Kerala.

Mango fruit is utilized at all stages of its development both in its immature and mature state. Ripe fruits are utilized for making pickles, squeezes and chutney. In addition, the unripe fruits are used to set up a few things such as squashes, syrups, nectars, sticks, and jams, other than for a treat. Furthermore, the mango bit contains 8-10 percent high-quality fat that can be used for cleanser and in confectionery as a replacement for cola. The important things about agri-sending out from India are fresh mangoes and mango pulp. India's main mango export destinations are the United Arab Emirates, Kuwait and other Middle Eastern countries with limited quantities being exported to the European market. Despite India being the largest mango producing country, it accounts for around 60% of world production, Fruit exports are limited to Alphonso and Dashehari. India has a share of around 15 percent in the world mango showcase. Mango accounts for 40% of the nation's overall fruit trade. There's a perfect extension to increase the country's mango territories and productivity.

Climate and weather play a prevalent job in crop development and productivity. Climate decides the crop habitat while crop habitat depends on genotype and phenotype. Air temperature and precipitation sway vegetative and phenological mango stages and are two of the most important components that decide the suitability of an area's environment for mango production. Changes in climate have already resulted in widespread changes in mango flowering and fruiting patterns. In some areas, this had an adverse effect on fruit production.

The climate variability and the recurrence of outrageous occasions (burning warmth, substantial precipitation, drought, tropical storm) are likewise expected to ascend because of climate change. Climate change is, therefore, a great concern for agriculture. Mango is one of the most broadly developed and prominent fruit in these regions for its economic and nutritional benefits. It's the planet's fifth most produced fruit. Taking into account the impact of climate change on the mango tree and the outcomes of mango production and cultivation are thus defended. The absence of crop model for mango forestalls the forecast of the impacts of climate change on mango tree development and production.

Mango germplasm exhibits a specific ecogeographical requirement for adequate vegetative growth, flowering and development of proper quality. Commercial varieties of a region behave differentially when grown in other agroclimatic zones of the country. It is also observed that the growth pattern in mango germplasm is genetically controlled, but has strong environmental interaction.

Mango trees in Kerala's homes are an inevitable element. Commercial mango orchards are being developed in the district of Palakkad (Muthalamada), where climate conditions are more appropriate for their production. Climate change and unseasonal rain in November and January have dampened the prospects of mango farmers in this region, which is known for its early harvest and large-scale export. Late flowering and the resultant delay in harvest has hit the annual export market. In this scenario, a detailed study should be conducted to elucidate the phenological reason for the impact of climate change in mango production.

A Mango Research Centre was established in the main campus of the University with the objective of collection and evaluation of varieties, local types and hybrids of mango for commercial cultivation in Kerala. About 150 mango varieties/local types/hybrids were collected from different parts of the country and planted in Mango Orchard. In Kerala, commercial mango cultivation is confined to varieties introduced from other parts of the country. Most of these varieties are not perfectly acclimatized to our agro-climatic conditions. The major environmental, economic and social threat of our time is climate change. The rising temperatures and carbon dioxide and precipitation uncertainties associated with climate change can have a significant direct and indirect impact on plant production and food safety.

So, screening of varieties for climate change resilience will help the farming community in decision making and adaptation of proper technologies to mitigate the ill effects of climate change. Hence, the present investigation was carried out with an objective to study the ecophysiological responses to vegetative and reproductive character among selected mango genotypes and to identify the climate-resilient genotypes suitable for Kerala under the scenario of climate change.

Review of literature

2. REVIEW OF LITERATURE

Investigations on the 'Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes' were taken up to study the ecophysiological responses among selected genotypes of mango on vegetative and reproductive characters in selected genotypes and also to identify climate-resilient genotypes suitable for Kerala under climate change scenario.

The relevant literature on morphological, inflorescence, fruit, pollen studies, physiological, biochemical characters and regarding crop weather modelling, high-density planting has been reviewed.

2.1 Morphological characters

An evaluation of physical, morphological and biochemical characters of four varieties and two hybrids of mango were made under Kerala conditions. It was observed that Ratna fruits had the maximum length, breadth, weight, volume and circumference. The minimum contribution of stone to fruit weight was in Ratna and the maximum in Muvandan. Fruits of hybrids Ratna and H-151 recorded the highest values of TSS sugar and ascorbic acid contents. The overall perusal of the data revealed that hybrid variety Ratna had all the desirable characteristics in terms of length, breadth, weight, volume, circumference, minimum stone weight, TSS and sugar content (Anila and Radha, 2003).

Murti and Upreti (2004) found that in 1998 in Bangalore, Karnataka, India, both normal and irregular bearing mango cultivars showed extremely poor and delayed flowering. With negligible flowering in the second half of March 1998, the varieties of Totapuri and Alphonso showed predominantly vegetative growth. Bangalore's estimated peak floral bud differentiation period was set from November to early December. In the first week of December 1997, the night temperature during Bangalore (17 °C) was well above the 1994-97 (10 °C) averages as flower induction temperatures of 18/10 °C (near an average of 15 °C) are considered ideal. The steady night temperature (< 17 °C) during the period of floral induction in October to December seemed to have a detrimental effect on this parameter. Instead of inflorescence, even cold temperatures induced a vegetative flush when the bud growth didn't happen during this time. It was mainly the effect of

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high temperature, especially night temperature, which prevailed during flower induction and differentiation periods between October and December, likely accentuated by slightly higher rainfall in October-December, which resulted in poor mango flowering.

Ten cultivars of mango are evaluated, namely Anwar Retual, Alphonso, Dusehri, Fajri, Gulab-e-Khas, Sindhri, Langra, Malda, Sanglakhi and Suwarnareeka. The fruits of Langra, Alphonso and Fajri produced longer fruits (15.20 and 14.43 cm), while Anwar Retual (6.30 cm) recorded minimum fruit length. Compared to all other cultivars, Fajri exceeded the fruit weight (455.9 g), seed weight (48.67 g), peel weight (84.99 g) and pulp weight (329.63 g). Suwarnareeka revealed a higher percentage of pulp (92.40), while Gulab-e-Khas cultivar had the lowest percentage of pulp (61.41). In vitamin C and sugars, however, Gulab-e-Khas excelled. Such chemical characteristics ranged in the studied cultivars from 131-179.7 mg/100 g and 15-20 % respectively (Jilani *et al.*, 2010).

Rajwana *et al.* (2011) led concentrates to differentiate, represent and recommend new mango scion cultivars to expand the range of varieties from the gigantic indigenous germplasm accessible in Punjab, which is on the verge of extinction due to unconstrained practice. Information was accumulated from three noteworthy mango developing regions (Khanewal, Multan and Muzzaffargarh) of Punjab, Pakistan. The chose tests were depicted for different qualities of tree (development, propensity, shape), leaf (shading, size, shape and nature), inflorescence (shape, shading, size), organic product (skin, shape, size, weight, gathering season, keeping quality), stone (fiber, collection of stone) and mash biochemical characteristics (complete solvent solids, titratable acidity). Of the 17 genotypes, just five (Kala Chaunsa, Sufaid Chaunsa, Late Ratole No. 12, Camal Wala and Faiz Kareem) indicated particular organic product characters and market potential. The investigations created reasonable morphological and biochemical markers for the development of mango germplasm to build up appropriate assortments for residential and trade markets.

Morphological characters can be used as an efficient tool for proper identification of different mango cultivars well before the commencement of that cultivar to bearing stage (Joshi, 2013).

Ribeiro *et al.* (2013) characterised 103 mango accessions ranging from plant size to seed embryo were evaluated. Just the descriptors for leaf balance and organic product waxiness didn't show fluctuation among the promotions. Eight increases didn't show natural products with strands, while nine other accessions presented flesh firmness, which is a basic trademark to improve reproducing. The solvent solids content was high, over 14 °Brix for 95% of the promotions with Tommy Atkins demonstrating the most reduced worth, 12.5 °Brix. Within the shade of the epidermis, ranging from green to red, an exceptionally good range was found. The Amrapali and Salitre promotions showed a shading of dim orange tissue. The acquired informational index is the most complete so far in Brazil; it permits picking the best guardians to grow new cultivars and will likewise add to the assurance of mango cultivars in Brazil.

The investigation attempted to evaluate the impact of Mr. Trivedi's biofield vitality treatment on mango morphology attributes, performance, yield, and atomic evaluation. The overall results showed that the treatment of biofield vitality on the mango trees showed significant improvement in morphology, quality and overall productivity along with a 100 per cent decrease in the springy tissue problem. Ultimately, the treatment of biofield vitality could be used as an elective tool for expanding quality mangoes generation (Trivedi *et al.*, 2015).

2.1.1 Tree characters

Based on the crop's habit, Radha and Manjula (2000) identified the 12 polyembryonic mango varieties and graded them as erect, intermediate and spreading. Kotta Manga was classified as erect and Puliyan, and Nalla Nadan was classified as intermediate and Kolambu manga, Muvandan, Chappikudiyan, Vatta manga Gomanga and Kilichundan are classified as spreading species.

Simi (2006) described 50 varieties of mango in southern Kerala, with plant height ranging from 4.5 m to 30 m and trees displaying growth habit of erect (38%), medium (30%) and spread (32%).

Riberio *et al.* (2013) characterized 103 mango enlistees in Brazil and reported a semi-vertical development habit (60.1 per cent) that could streamline the maintenance of the orchards (Albuquerque *et al.*, 2002).

2.1.2 Leaf characters

Davenport and Elizea (1977) found that the color of young flushes of emerging vegetative shoots is usually green, but sometimes bronze-red or red shades, depending on cultivars. If they turn dark green, which takes place after two to three months, they are considered mature. In a survey carried out in the central part of Kerala, Radha and Manjula (2000) identified 12 distinct polyembryonic forms of mango. Such types showed significant variability in the vegetative characters (leaf form, size, color) and floral characters (position of inflorescence, size, shape, flower characters, color).

Leaf characters are important criteria for variety identification. Descriptors for the shape, tip and margin of the leaf are given (IBPGR, 1989). The crushed leaf aroma has a direct correlation to the flavour of the fruit (Majumder and Sharma, l990).

Simi (2006) identified a lanceolate style of leaf shape, and acuminate leaf tip character and light green with brown tinge colour of young flush existed predominantly in traditional Southern Kerala mango varieties.

National active germplasm site CISH, Lucknow maintaining 726 mango accessions from Sri Lanka, Brazil, Florida, Australia and India mango-growing regions (Rajan *et al.*, 2013), Of these 248 accessions (North and East (150), South (26), and West (72), 56 were documented in catalogue form (Rajan *et al.*, 2002). North Indian accessions recorded the most sizeable mean leaf length (19.6 cm) and width (5.6 cm), while the southern and western Indian accessions recorded the smallest leaf length (18.56 cm) and leaf width (5.05 cm).

Navprem *et al.* (2014) described nine sucking mango genotypes and observed color measurements of young emerging flex meter leaves, varying from brown-green to purple- brown.

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2.1.3 Floral characters

In mango, flowering begins in Andhra Pradesh and the west coast of India (Gandhi, 1955) in November or early December. Singh (1958) reported that mango flowering is preceded by floral bud differentiation, which takes place in October-December depending on the local climate.

Gunjate *et al.* (1977) noted the differentiation of the fruit buds began in August and continued until the end of October and under Konkan condition the flowering starts in December.

Thimmappaiah and Suman (1987) observed that length of the mango panicle ranged between 11.25 cm and 42.20 cm. In Alphonso, the length of the flower panicle ranged from 12.4 to 38.6 cm and when grown under coastal Karnataka conditions, the number of male flowers/panicles was peak (Uthaiah *et al.*, 1988).

Desai *et al.* (1994) studied Sai Sugandh's floral biology and recorded the inflorescence as a conical panicle and the light green to bright pink colored rachis.

South Indian mango varieties achieve the physiological status of flowering sooner than North Indian cultivars, according to Yadav and Singh (1985).

Inflorescence and flower characters were studied by Radha and Manjula (2000), including inflorescence location, form, size, sex ratio, and individual flowers characters.

Radha and Nair (2000) recorded that mango begins flowering in Kerala by November- December, assisted by Anila (2002) while studying flowering and fruit production in the varieties namely Alphonso, Neelum, Prior, Kalapady and Ratna and H-151 hybrids under the climatic conditions of Kerala.

Anila (2002) studied inflorescence characteristics such as percentage of hermaphrodite flowers, length and breadth of inflorescence, flowers density, rachis colour, inflorescence shape and hairiness and flower characteristics such as flower type, flower diameter, disc nature and number of stamens of chosen mango variants and hybrids in Kerala.

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Anila (2002) recorded that the length of the inflorescence varied between 15 and 30 cm. Ratna gave the maximum length and breadth of the inflorescence. Many inflorescences per square meter showed a significant difference between the varieties in which Prior showed the maximum number of inflorescences / square meter and Neelum and Alphonso reported the minimum number of inflorescences. It was noted that the number of hermaphrodite flowers in Ratna and H-151 was highest and the lowest in Muvandan.

In mango cultivars Anwar Rataul, Dashehari and Langra, Asif *et al.* (2002) investigated the total number and proportion of male to female flowers. Zardalu reported the highest percentage of hermaphrodite flowers (37.7%) (Hoda *et al.*, 2003). Simi (2006) researched various inflorescence characters and recorded that 84% of mango trees had a terminal bearing role, the pyramid shape of 52 per cent of the panicles ranged from 3 to 41 cm in length.

The flowering duration is concise and only extends for about two-three weeks. Mango inflorescence is primarily terminal, but frequently axillary inflorescences are made. Panicle size, a number of flowers and central axis color and flowers vary from variety to variety. Two types of flowers are seen in a panicle, i.e. male and bisexual. The total number of flowers ranges from 1000 to 6000, mainly varietal and also affected by the climatic conditions and tree's age (Balakrishnan and Vijayarahavan, 2009).

In different regions of India, the time of mango flowering varies mainly due to local weather conditions, particularly the temperature scale. The flowering season in India is gradually becoming late from South to North. The first mango flowering season in South India is November-December-January, while peak flowering occurs in North India during February- March. The peak harvesting time will also differ, respectively, from April-May to June-August (Balakrishnan and Vijayarahavan, 2009).

Jyothi *et al.* (2009) reported that over 70 per cent of mango trees had a broad pyramidal inflorescence and are densely flowered, giving them a bunch of appearances. Renisha (2012) reported Muvandan's inflorescence rachis was dark red while it was light red in Neelum and Alphonso. In Banganapalli and Vellaikolumban, light green colored inflorescence rachis was observed while in Priyur it was with light green colored red tinges. A research was conducted to investigate the suitability of three mango polleniser cultivars, namely ' Sensation, ' ' Tommy Atkins ' and ' Janardan Pasand ' for up to 24 weeks under four storage conditions (room temperature, −4 ºC −20 ºC and −196 ºC). Three methods have been used for testing pollen viability, i.e., germination in vitro, fluorescein diacetate (FDA) and recolouring acetocarmine. Techniques of capacity and coordination between resource strategies and long capacity spans had a profoundly enormous impact on the feasibility of pollen ($p \leq 0.0001$). In the three mango cultivars, room temperature pollen storage showed low pollen suitability after a month of production, after which pollen was not good. Irrespective of mango genotypes, cryo-putting away (−196 ° C) dusts displayed significantly greater suitability as compared to the different conditions of stockpiling. In comparison to FDA even acetocarmine trials, where germination was frequently overstated, the differential results obtained through the use of diverse pollen practicality measure indicated that the in vitro germination experiment was substantially stable.

The study recommended a −20ºC pollen capacity for fertilization among cultivars with non-synchronized seasonal flowering. Nonetheless, the ideal way to store pollen of mango would be to accumulate cryo procedure for a long stretch (Dutta *et al.*, 2013).

Navprem (2014) studied that, under Punjab's climate conditions, that start and the end of the flowering cycle was from the last week of February to mid-March respectively.

2.1.4 Fruit characters

Kumar (2000) studied the analysis of mango fruit weight elements to evaluate their interrelation between different characteristics and their fruit weight impacts. The report revealed a strong correlation during both years between fruit weight, fruit size, fruit diameter, fruit volume and length of seed stone. The findings also showed positive but un-significant correlations during both years with shoot length, leaf width, petiole length, panicle diameter, seed stone weight and seed stone diameter.

In H-151 and Alphonso next to Ratna, Anila and Radha (2003) reported high total and reduced sugars. Higher acidity values were observed in Alphonso and Neelum fruit.

Diversity in mango cultivars revealed that the most significant and reliable characteristic was the fruit shape to differentiate between cultivars. Other fruit characters also have a differing degree of identifying importance. Beak presence, fruit size, sinus, stalk insertion cavity is essential for the study of mango germplasm variability (Ram and Rajan, 2003).

The size length and width of the fruit measured by Simi (2006) ranged from 37.5 g to 826 g, 4.4 cm to 18.1 cm, and 3.9 to 12 cm.

Pradeepkumar *et al.* (2006) reported that among 31 mango genotypes in North Kerala, TSS ranged from 12.7 to 25.2 ° Brix. Satyavati *et al.* (1972) reported that Kerala's ripe fruit TSS varied from 10 ° Brix to 24 ° Brix. The two main genotypes were ' Heralappa ' (25.2 ° Brix) and ' Kalapady ' (24.7 ° Brix). ' Ratnagiri Alphonso ' fruits showed higher acidity and low TSS compared to the widely known ' Alphonso ' variety, in ' Alphonso ' TSS was at 21.8 ° Brix. The skin colours of the varieties ' unripe fruits are brown, light green, greenish, greenish-yellow and light yellow, while ripe fruit skin colors were green, light green, greenish-yellow, yellowish-green, light yellow and yellow (Bhuyan and Kobra, 2007).

Physicochemical attributes are the critical quality indicators for fresh consumption of any fruit. The quality of juice and other canned products is measured by total soluble solids (Bhuyan and Kobra 2007).

Navprem *et al.* (2012) analyzed 28 elite mango lines and reported fruit weights, fruit lengths and widths ranging from 50.3 g to 380.4 g, 4.63 cm to 12.52 cm, and 3.83 cm to 7.77 cm. The maximum pulp weight of 267.5 g in the Jogiya Chhalli variety and the lowest of 18.3 g were recorded in the Ber amb variety (Navprem *et al.*, 2012).

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Riberio *et al.* (2013) defined 103 mango accessions based on a Brazilian adopted descriptor and a wide range of epidermis colors ranging from green to red.

Fruits were the primary descriptors for identifying different fruit crop varieties (Toili *et al.*, 2013). Navprem (2014) described nine genotypes of sucking mango and observed ovate, oblong and ovate shapes. Mango shapes, round and oblong, dominated by different shapes (Jyothi *et al.*, 2009). Four types of fruit shapes such as round, oblong, ellipsoid and oblong ellipsoid were observed by Simi (2006).

Mango pulp fruit color varied from yellow to orange (Navprem *et al.*, 2014). Different pulp colors have been registered in Amrapali such as white, creamy yellow, light yellow, lemon yellow and orange (Navprem et a., 2012) and dark orange pulp (Riberio *et al.*, 2013).

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

2.1.5 Yield

Kumar and Singh (2005) obtained the best yield of fruit per plant in Mallika (171.00 kg) followed by Bangalora (130.57 kg/crop) while Alphonso produced the lowest yield in Sabour (Bihar).

In Amrapali, Sengupta *et al.* (2006) recorded maximum yield of fruit (44.03 kg / plant) followed by Mallika (40.92 kg / plant) and Prabhashankar (38.71 kg / plant). Minimum yield was observed in Ratna (19.58 kg / plant), followed by Langara and Sabri (19.86 kg/plant).

Abdullah *et al.* (2013) studied mango cultivar Chok Anan fruit variance. Characteristics of fruit such as fruit weight, size (length, width and thickness) and total soluble solids (TSS) have also been calculated. They noted that Chok Anan mango's fruit weight, length, and TSS at harvest varied greatly among trees. The harvest weight ranged from 144 g to 315 g. In contrast, the TSS also varied between 16.3 and

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21.2°Brix.

2.1.6 Stone characters

In two consecutive years, Prasad and Nalini (1977) recorded that stone weights were 38.8 g and 38.6 g in Banglora, 39.1 g and 39.3 g in Bombay Green, 40.7 g and 44.2 g in Amprapali and 47.3 g in Mallika mango cultivars in Kanpur climatic condition. Whereas in Sabour (Bihar), Kumar (2000) recorded Bombai's stone weight of 15.6 g, Kalapady 19.0 g, Mahmoodbahar 14.7 g, and Prabha Shankar 18.8 g.

Bains and Dhillon (1999) researched ten sub-mountainous Panjab mango cultivars and documented different fruit sizes such as Mallika (14.5 x 7.6 cm), Fazali (14.0 x 7.7 cm), S.B. Chausa (12.3 x 6.6 cm), Dashehari (10.3 x 5.7 cm) and Langra (10.1 x 6.9 cm), While in S.B. Rampur it was a minimum (7.5 X 3.5 cm). The stone's maximum weight was found in S.B.Chausa (52.0 g), Fazali (45.0 g), Mallika (30.0 g), while in Alphonso and Dashehari (28.0 g) the minimum weight was found in Hoshiarpur.

2.2 Quality attributes of mango fruits

Gangwar and Tripathi (1973) recorded 0.240 per cent acidity of the Langra mango variety at Basti (UP). Mannan *et al.* (2003) observed that Dashehari and Langara green fruits had an acid value below 1.00 and 1.35% respectively. Singh *et al.* (1976) analyzed Neelum mango variant at Basti (UP) and documented acidity of 0.510% to 0.536%.

At Patiala conditions, Singh *et al.* (1988) observed TSS and TSS acid proportion levels in mango cultivars Langra, Banarasi and Totapuri. Researcher observed that in Langra Banarasi and Totapuri, respectively, the TSS content was 19.4 and 12.0 percent and the TSS acid ratio was 17.70 and 8.16.

Kumar and Singh (2005) documented Kesar (0.20%), Bangalora (0.83%), Mallika (0.33%), Alphonso (0.47%), Langra (0.48%) and Bombay (0.56%) under Sabour climatic condition. Chatterjee *et al.* (2007) recorded Neeleshan maximum acidity (0.265 per cent) and Prabhashankar minimum acidity (0.158 per cent).

The surveys were carried out to classify conventional varieties of mango from the southern Kerala region (Simi and Rajmohan, 2013). the report revealed that there could be Fifty traditional types of mango in this region. Based on the survey, three utility categories, i.e. pickling, table and dual-purpose categories, are defined on evaluation. Variation of floral, fruit and quality attributes could be observed. In Vellari Type-1, Thali, Kizhakkan Thali and Ambalathara Local, flowers were observed during the year. Karpoora Varikka has been identified with a higher carotenoid content than most leading, inferior varieties. Perakka manga, Nedungolan, Karpooram manga, Vellari Type-2, Neenda Karpooram, Muthalamookan, Inamanga, Ambalathara Local, Kotookonam Varikka and Velutha Muvandan are ranked among the top in cumulative acceptability in the organoleptic assessment. It is possible to use conventional varieties with desirable characteristics to produce molecular markers to identify specific genes of relevance and transfer them through genetic engineering to suitable cultivars.

Paclobutrazol was found to be predominantly helpful for early flowering induction and thus discovering scope for off-season mango production. The study was conducted by Upreti *et al.* (2013) to investigate the hormonal relationships involved in mango induction following treatment with paclobutrazol. During the 3rd week of August, paclobutrazol applied as a soil drench, @ 3.0 ml / m canopy diameter advanced fruit harvest period by 22 days compared to untreated trees by encouraging early blossoming. The results embroiled that paclobutrazol other than influencing gibberellins also expands ABA and corresponding cytokinin substance with C: N proportion and leaf water potential in mango buds to evoke flowering reactions.

Moovandan was a very common cultivar in homesteads of Kerala. A survey conducted by Kumar and Parameswaran (2015) spotted five Moovandan types of mango *viz*., Enna Moovandan, Cheriya Moovandan, Pachha Moovandan, Vella Moovandan and Ezikode Moovandan. The high variation was noticed in tree characters, leaf, fruit characters. The fruit weight ranged from 106 to 250 g; Fruit length varied from 6.8 to 12.74 cm, fruit pulp per cent ranged from 54.54 to 67.23 per cent, stone from 16.04 to 27.94 per cent and peel from 14.86 to 22.92 per cent, and fruit total soluble solids ranged from 10.6 °Brix to 13.3 °Brix. Fruit colour showed three variants *viz*., Green, Yellow, Greenish Yellow and pulp showed two variants *viz*., Yellow and

Yellow-orange. Quantity of stone fibre showed two variants *viz*., low and high.

The vegetative growth *viz*., shoot length, shoot diameter, no. of leaves was suppressed significantly by the paclobutrazol application. The paclobutrazol application in second forth nighty of July has resulted in highest yield 206.07 fruits/tree (45.73 kg), and the estimated yield was 4.47 fruits/tree with early flowering by 51.58 days and harvesting by 35.39 days with maximum net returns of Rs. 2, 47,862.40 per ha with 2.51 B:C ratio (Shinde, 2015).

2.3 Pollen characters

2.3.1 Pollen morphology

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

Renisha (2012) noted the round shape of pollen in Neelum, Priyur, Alphonso and Vellaikolumban along with oval and oblong-shaped pollen in Banganapalli and Muvandan, respectively. The pollen size varied from 27.29 μm to 33.34 μm and the most abundant pollen identified under Kerala conditions in the Muvandan variety.

2.3.1 Pollen viability

Simi (2006) reported that pollen fertility in local traditional southern Kerala varieties ranged from 47.92% to 100%.

During the period from December to March, Renisha (2012) reported the considerable variation in pollen fertility. It was 80.70 – 93.52 percent in January and declined under Kerala conditions to 40.70 – 60.00 per cent in March 2011.

2.3.2 Pollen production

Ilgin (2007) used a haemacytometric method and recorded pollen production ranged from 4355 to 7169 pollen grains and the lowest in 46 EI 03 and 46 EI 02 caprifig types, calculating the amount of pollen per flower in chosen caprifig kinds.

Renisha (2012) recorded the highest degree of pollen production in Vellaikolumban and Banganapalli (500) in January, whereas in Priyur, Neelum, Alphonso and Muvandan the projections were 400, 300, 250 and 250, decreasing to 188, 218, 70, 89, 223, 198 in Vellaikolumban, Banganapalli, Priyur, Neelum, Alphonso and Muvandan in March respectively.

2.3.3 Pollen storage

Carreno *et al.* (2009) stored pollen from Vitis vinifera L's various cultivars. At -20 °C, -40 °C and -80 °C, strong pollen germination was observed at -80 °C.

Imani *et al.* (2011) reported the viability of 4 apple varieties for 3 and 7 months after three temperature levels (4 °C, -20 °C and -80 °C) were maintained. It revealed that 3 months after preservation, highest germination was in prim gold pollen stored at -80 °C with 96.21% and lowest germination (58.33%) in Northern Spy pollen stored at 4 °C, but 7 months after storage, maximum germination was preserved in Primgold Pollen at -80 °C with 90.66% and lowest germination (36.67%) in Northern Spy pollen stored at 4 °C.

The mango pollen stored in refrigerated situations helped preserve a viability of 67.64 percent for 72 hours, whereas it was 70.93 percent when preserved in a desiccator on calcium chloride (Renisha, 2012).

Dutta *et al.* (2013) reported that the best long-term storage approach for effective preservation of genetic resources could be -196 °C cryostorage of mango pollen.

2.3.4 Pollen germination

Singh (1954) recorded pollen inability to germinate at a temperature of 75 °F to 80 °F in 25% sugar, 0.5% agar and other media concentrations.

In mango var. Chausa, Randhawa and Damodaran (1961) recorded the highest pollen germination in a sugar solution of 10% (28.2%).

In the hanging drop and agar plate test Bolat and Pirlak (1997) observed the highest pollen germination in 15 per cent sucrose solution, ranging from 49.77-72.90 per cent to 57.83-84.42 per cent in apricot, 47.92-57.38 per cent in sweet cherry and 52.40-66.60 per cent in tart cherry and 49.16 percent and 53.82 percent in sour cherry.

Jutamanee *et al.* (2000) observed that pollen germination in Nam Dok Mai and Khiew Sawoey mango cultivars ranged from 24.10% to 32.51%, Almaguer *et al.* (2004) studied the development of Mandarin's pollen tube and found that pollen germination ranged from 1% to 4%.

Ilgin *et al.* (2007) calculated the germination of fig pollen using a variety of concentrations of sucrose supplemented with H3Bo3, KNO3 or GA3 in agar medium and noticed that germination in media comprising 20% sucrose with inclusion of H3Bo3, KNO_3 but not GA_3 was higher than 74%.

Khan and Praveen (2009) researched the germination ability of three mango cultivars *viz.*, Chausa, Dashehari and Langra by hanging drop methodology in different concentrations of sucrose solution (5 percent-50 percent) with 1 percent agar and 0.01 percent boric acid, of which Langra pollen displayed improved germination even when retained up to 48 weeks.

It is reported that artificial mango pollen germination is complicated by various workers. In Sensation, Tommy Atkins and Janardhan Pasand, up to 4 weeks of storage, pollen storage at room temperature showed only 2.1, 1.80 and 1.03 per cent pollen germination (Dutta *et al.*, 2013).

2.3.5 Sex ratio

The sexual ratio differs around cultivars of mango and is also determined by the climate. The South Indian mangoes were identified by Naik and Gangolly (1950), and a monograph was drafted accordingly. The highest percentage of perfect flowers in Neelum and the lowest in Malgoa was recorded by Kalyansundaram (1978). The average of 947.9 flowers / panicle were noted in the Sai Sugandh variety, among which 75.73% were perfect flowers (Desai *et al.*, 1994).

Afifi *et al.* (2000) studied Langra and Fajri Kalan's flowering behaviour and reported that Langara's male/perfect flower proportion was lower than Fajri Kalan, especially in the Langra ' on ' year and the Fajri Kalan ' off ' year.

Sex-ratio analyses of cultivars Anwar Rataul, Langra and Deshehari revealed a higher number of male flowers in Anwar Rataul and Deshehari than Langra on the southern and western sides of the plant and Langra with more hermaphrodite flowers on the southern sides (Muhammad *et al.*, 2001).

Anila (2002) reported that, under Kerala conditions, the percentage of hermaphrodite flowers in Muvandan and Alphonso ranged from 15.77 to 43.39.

Muhammad *et al.* (2002) observed that their genetic makeup, flowering time, reaction to prevailing climatic conditions, and endogenous growth hormones may cause a difference in the sex ratio. He also noted that in determining the fruit set the percentage of hermaphrodite flowers is critical. The percentage of flowers among the varieties varied significantly, varying from 21.1 to 90.6 per cent, with a greater number of flowers in cv. Langra and Samar Behisht. Chatterjee (2007) reported the percentage of ideal flowers per panicle in Amrapali, Mahmud Bahar , Mallika, Prabhasankar, Alfazli, Sunder Langra, Neelgoa, Neelashan, Ratna, Arka Puneet and Arka Anmol and noted that Amrapali have the highest percentage of perfect flowers per panicle, while Neelashan have the largest number of flowers per panicle.

Shu (2009) observed the percentage of mango varieties in sex distribution, sex ratio and natural pollination *viz.*, Haden, Irwin, Keitt and Tsai Suan and it was reported that Kiett had the best sex ratio of 1.44%, while Haden had the weakest sex ratio of 0.2%. Hermaphrodite flowers were highest in the western direction (22.20-42.91 percent) and male flowers were highest in the southern direction during the studies (77.63-86.97 percent).

2.3.6 Pollen morphology

The pollen size in different mango variants differed from 24 µm to 30 µm (Mukherjee, 1950) and Singh (1954), respectively, the average pollen size in Langra and Dasheri was 27.3 and 28.11 m.

The amount of viable pollen in mango is quite small. All mango varieties have been reported to have oblong to oval pollen grains that are slightly wider in some varieties and narrower in others, but are of the same form in all when in normal dry condition. The grains are spherical when they are moistened. They are nearly oblong in the usual dry state. The other mango pollen forms are oval shaped, triangular, elliptic, rhomboidal, and round (Singh, 1954; Randhawa, 1961).

Pollen grains of 50 Indian mango cultivars were examined by Singh (1961) and the length ranged from 25.3 µm to 28.3 µm. Pareen and Qaiser (2010) observed that the pollen size in the Anacardiaceae family is 22.5 µm -32.31 µm respectively.

2.3.7 Pollen viability

Pollen viability has excellent importance in crop improvement through hybridization. Zirke (1937) described the method of mounting acetocarmine pollen, and the stained pollen is considered viable and non-viable.

In order to indicate viability, Stanley and Linskens (1974) listed other stains such as aniline blue, potassium iodide, methyl green, etc. The pollen viability of stone fruits using TTC was calculated by Bolat and Pirlak (1997).

Desai *et al.* (1994) observed Sai Sugandh's pollen viability while studying its floral biology and found 93.75 percent pollen viability. Dag *et al.* (1999) used a scanning electron microscope to study pollen viability of ' Kent ' mango in Israel, and it has been discovered that the percentage of stained pollen grains significantly increased from 23-96%.

Jutamanee *et al.* (2000) determined viability using flurochromatic reaction (FCR) testing in mango varieties like Khiew Sawoey, Choke Anan and Dok Mai, and

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the researchers concluded that almost all cultivars had higher pollen viability between 81.33-91.29 per cent, and no impact on pollen viability was found as all three varieties have about the similar viability.

The viability of pollen was assessed using acetocarmine staining in diploid bananas (Soares *et al*., 2008). Ferrare *et al*. (2007) registered 13 olive cultivars ' pollen viability. Pollen viability was established using acetocarmine in Ziziphus mauritiana (Li *et al*., 2005). Tosun and Koyuncu (2007) analyzed sour cherries pollen using TTC and reported pollen viability ratios of 80% to 93%.

2.3.8 Pollen production

Nair *et al*. (1964) studied the pollen production and other pollen characters of guava. According to Godini (1979), the pollen production of l0 Almond cultivars showed significant difference per anther. He noted that in the particular season the number of pollen grains substantially decreased in all the cultivars because of reduced sporogenesis due to cold spells and frost. Ferrante, Genco, Scorze verde and Texas were good pollen producers while Fragiulio grande, Non-pareil and Tuono were poor pollen producers.

Rajashekar (2003) recorded that Cricket Ball and CO2 variety of sapota showed maximum pollen production per anther than others.

The number of pollens per flower in chosen caprifig forms has been calculated utilizing haemocytometric method (Ilgin, 2007). He observed that in 46 EI 03 and 46 EI 02 caprifig types pollen production ranged from 4355 to 7169 pollen grains and the highest.

2.3.9 Pollen storage

Rhee *et al*. (2003) estimated the pollen storage conditions of eight lily genotypes stored in dark chamber with the temperature at 4°C, -20°C, -70°C and ambient room temperature for a year and found that -20°C was the best storage temperature.

According to Rajashekar (2003), pollen viability was maximum when stored in a refrigerator at 4 ° C, preceded by pollen contained in a desiccator on calcium chloride at 5 days after storage, While pollen viability was lowest in pollen stored over calcium chloride in a desiccator in the refrigerator at 4 ° C, control was followed. Deng and Harbaugh (2004) reported that caladium pollen stored at 4°C were viable for 2 to 4 days and effected successful pollination. According to Aslantas and Purlak (2002), the pollen of Aliso, Brio, Cruz strawberry cultivars maintained germination ability up to 20 months when stored at -18°C, while pollen stored at 4°C lost germination ability after eight months in all cultivars.

Carreno *et al*. (2009) contained pollen from various Vitis vinifera L. cultivars at temperatures of -20 ° C, -40 ° C and -80 ° C and the findings show that pollen contained at 80 ° C developed strong germination.

Imani *et al*. (2011) monitored the viability of 4 apple cultivars for 3 and 7 months after three temperature points (4 ° C, -20 ° C and -80 ° C) were preserved. It reveals the maximum germination in Primgold pollen stored at -80 ° C with 96.21% and the lowest germination (58.33%) in Northern Spy pollen stored at 4 ° C, three months after storage, The highest germination in Primgold pollen stored at -80 ° C with 90.66% and the lowest germination (36.67%) in Northern Spy pollen stored at 4 ° C, however, was seven months after processing.

2.3.10 Pollen germination

Several staff say that artificial mango pollen germination is difficult. Singh (1954) documented pollen failure to germinate at a temperature of 75 ° F to 80 ° F in 25 percent sugar, 0.5 percent agar, and other media concentrations.

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

The effect of temperature on pollen viability was studied by Issarakraisila and Considina (1994) in Mango cv. Kensington under specific conditions. They found that viability was maximum (85%) when the temperature was between 20-25 °C, but when

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temperature increased from 33°C to 36°C, it fell from 85 to 60 per cent.

In the hanging drop and agar plate test Bolat and Pirlak (1997) reported the highest pollen germination in 15% sucrose solution, ranged from 49.77 -72.90% to 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. Jutamanee *et al.* (2000) reported that in Nam Dok Mai and Khiew Sawoey mango cultivars, pollen germination ranged from 24.10 to 32.51 per cent. Gomez *et al.* (2004) studied the development of Mandarin's pollen tube and observed that pollen germination ranged from 1% to 4%.

During the progamic phase, temperature is a critical factor affecting pollen efficiency (Hedhly et a., 2004). High flowering temperatures significantly impact the viability of pollen (Kakani *et al.*, 2005). It is regarded that the ideal temperature varies among the species for pollen germination and pollen tube growth. Temperature variations and ideal temperature levels for pollen germination and development of pollen tubes were analyzed in various fruit species previously in pears (Mellenthin *et al.*, 1972; Vasilakakis and Porlingis, 1985), jojoba (Lee et a., 1985), papaya (Cohen et a., 1989), and Cherimoya (Rosell *et al.*, 1999).

Ilgin *et al.* (2007) defined the germination of fig pollen using a variety of concentrations of sucrose supplemented with $H3BO_3$, KNO_3 or GA_3 in agar medium and discovered that germination in media comprising 20% sucrose with addition of H_3BO_3 or KNO_3 but not GA_3 was larger than 74%.

Germination trial of eight apricot genotypes was completed utilizing sucrose with concentrations of l0 per cent, 15 per cent or 20 per cent with 1 per cent agar, 15 per cent sucrose focus indicated most noteworthy germination rate (Asma, 2008).

Soares *et al.* (2008) used media containing 15 per cent sucrose, 0.01 per cent H_3BO_3, 0.01 per cent KNO_3, 0.03 per cent Ca (NO_3), 0.02 per cent, $MgSO_4$. $7H_2O$ solidified with 0.8 per cent agar showed the highest germination up to 90 per cent in genotypes 9187-01 and M-53 of banana diploids.

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Khan and Praveen (2009) studied the pollen germination potential of three mango cultivars *viz.*, Chausa, Dashehari and Langra by hanging drop methods in different concentrations of sucrose solution (5-50 percent) with 1 percent agar and 0.01 percent boric acid, of which Langra pollen showed improved germination even when held up to 48 weeks.

Prakash *et al.* (2010) analyzed the germination of Punica granatum in vitro pollen in different concentrations of sucrose and found up to 45.58 per cent and 42.25 per cent of the total percentage of germination in 15 per cent of the solution.

2.4 Physiological characters

Singh and Rajan (2009) evaluated the variation in photosynthetic rate (Pn) of mango. Specific leaf weight (SLW), total sugar and reducing sugar contents in leaves were additionally assessed in five commercially grown mango assortments, *viz.*, Dashehari, Langra, Chausa, Amrapali and Mallika. Total sugar and reducing sugar substance were commonly low during November, while SLW was seen at a lower level in March in every one of the cultivars, indicated better photosynthate movement from leaves in March and SLW level increased sugar content likewise from morning to noon and decreased gradually till evening. Higher photosynthates production and more significant translocation were observed in Chausa and Langra, and its maximum level was recorded during full bloom stage (March). Diurnal changes in SLW, total and reducing sugar in fully expanded leaves of mango, therefore, SLW may be used as one of the selection criteria for screening the photosynthate translocation efficient mango genotypes under north Indian condition. A strong association of SLW with leaf sugar contents have also been reported in other crops.

The relationship between chlorophyll, specific leaf weight and net mango photosynthetic rate was studied by Rui *et al.* (2010). They noticed that the leaf's chlorophyll and specific leaf weight (SLW) of different ages had a strong relationship with photosynthetic, chlorophyll and specific leaf weight (SLW), but there was no relationship between photosynthetic and chlorophyll and SLW in mature leaves.

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Investigations are conducted at the seedling stage to evaluate the mango genotypes for their vigour. Twelve polyembryonic and ten monoembryonic genotypes with various physiological criteria such as stomatal size, phenolic content, chlorophyll percentages, bark percentage and relative water content were screened for their vigour at nursery stage Among the various parameters of phenolic content, bark percentage and chlorophyll proportions were noticed to be very helpful in forecasting nursery-stage mango rootstocks vigour (Abirami *et al.*, 2011). For ten mango cultivars namely Chausa, Langra, Amrapali, Kesar, Rajapuri, Alphanso, Dashehari, DC-1, CISH-M-1 and Mallika; Singh and Bhargava (2011) had explored on mango genotypes for morphological and physiological qualities. They found that, under unfavourable climatic conditions, cultivar Kesar had less field mortality and better growth quality than Amrapali. Langra and Dashehari had the highest specific leaf areas (SLA), and Kesar had the highest net photosynthesis (a, b, and total) (5.38 μmol m_{-2} s_{-1}) and transpiration (2.27 μmol m_{-2} s_{-1}) material. Ultimately, in the first year of establishment, ' Kesar, ' ' Amrapali ' and ' Rajapuri ' exhibited better genotypes under the warm arid environment (Singh and Bhargava, 2011).

Mango fruits presented to water-stress-induced conditions during development adjust their working by decreasing their transpiration. Additionally, oxidative pressure was constrained as an outcome of the expansion in antioxidant content and enzyme activities. This versatile reaction of organic mango product to its climatic condition during development could influence post-harvest conduct and quality (Léchaudel *et al.*, 2015).

Tommy Atkins, Zill, Peach, Sabre, Rosa and Phiva mango cultivars have been tested for their quality parameters (fruit weight, flesh color chroma, total soluble solids [TSS]/titratable acidity [TA], firmness), bioactive compounds (total phenols, carotenoids, ascorbic acid, antioxidant activity) and polyphenol oxidase (PPO) function. Cv. Sabre had the highest total phenolic content (76.43 mg gallic acid/100 g FW), carotenoids (9.90 mg/100 g FW), ascorbic acid (69.71 mg/100 g FW) and antioxidant activity (1.2 mg gallic acid / g FW), although cv. Higher bioactive compounds are found in peach mango (Sellamuthu *et al.*, 2013).

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Inflorescence per square meter (32.10 and 26.40), hermaphrodite flower per cent (37.95 and 33.25), hermaphrodite flower per cent (47.97 and 52.60), and fruit percentage (0.67 and 0.63) are high in cv. Neelum both during the primary season and offseason. With regard to physiological parameters, the most prominent soluble protein (12,55 and 11,94 mg100 g_{-1}) and total phenols (3,510 and 3,250 mg100 g_{-1}) and the least concentration of IAA oxidase (169,85 and 178,20 μg g_{-1}) and gibberellic acid (1,05 and 1,06 μg g_{-1}) were registered in cv. (Kumar *et al.*, 2014).

Fully mature physiological fruits of eight mango cultivars were selected and subjected to environmental and regional study. Amongst the eight cultivars, Fajri yielded the maximum weight of green and mature fruit, the length and perimeter of the fruit and the loss of physiological weight (453.0 g, 403.0 g, 13.80 cm, 21.57 cm and 10.97%) respectively. Aman Dusahri found the higher softness values. While in the pulp of Langra, Samar Bahisht Chaunsa and Anwar Ratual, significantly higher total sugar content was observed. 20.67% respectively, 20.43% and 20.33% respectively. TSS was estimated in Langra at 19.83% and 0.64% protein content, while the Fajri contained higher fat content. Langra obtained higher scores out of eight cultivars, while Anwar Ratual was highly satisfied, followed by Samar Bahisht Chunsa for flavor and taste (Naz *et al.*, 2014).

A study was conducted to classify eight different cultivars of mango, namely ' Alphonso, ' ' Borsha, ' ' Himsagar, ' ' Fazli, ' ' Langra, ' ' Dashehari, ' ' Totapuri ' and ' Neelum, ' popularly grown in various agro-climate regions in India. Significant differences were found between cultivars in the exchange of gas and morphological characters of the plant. Higher rate of photosynthesis (PN) has been reported in ' Borsha, ' ' Himsagar, ' ' Langra ' and ' Neelum. ' PN and CE (carboxylation capacity) were the highest in ' Neelum ' throughout the cultivars, followed by ' Borsha. In ' Totapuri ' and ' Dashehari ' respectively, the SLA and SLW were peak. The maximum content of epicuticular wax (ECW) in ' Totapuri ' was observed. The content in ' Alphonso ' was maximum in Chl a, Chl b, total chlorophyll and carotenoids. In ' Totapuri ' and ' Langra ' respectively, the adaxial and abaxial stomatal numbers were maximum. The variations in leaf morphology, gas exchange and related characteristics may be attributed to genotypical variations appropriate for various agro-climatic regions in India (Rymbai *et al.*, 2014).

Mango fruit should be harvested at 110 DAA after physiological maturity when the fruit reaches the optimum size, weight and starch content including the maximum firmness value, TSS, fructose content, minimum TA value, low respiration and lowest ethylene production (Wongmetha *et al.*, 2015).

2.5 Biochemical analysis of plants

Shafique *et al.* (2006) observed that at mature stages all ten mango varieties had a higher sugar content than at immature and mature stages. Also developed in ripe stages, the attractive flavor and pleasant taste differed from each other due to the unique variety. The odor feature which emerged during maturation is attributed to ester and carbonyl types components.

At the physiological and biochemical level, the impact of various chemical treatments on mango fruit maturation (Mangifera indica) was investigated (Singh *et al.*, 2007). In terms of modifications in respiration, firmness, pH, total soluble sugar and the cell wall degrading enzyme pectate lyase (PEL), treatment with 1-methyl cyclopropane (1-MCP), silver nitrate ($AgNO_3$), gibberellic acid (GA_3), sodium metabisulphite (SMS) and ascorbic acid caused by the maturing process While the cycle was stimulated by ethrel and calcium chloride ($CaCl_2$). Mango PEL was considered to be inhibited by specific metabolites present in the extract of dialysed ammonium sulfate enzyme and EDTA. There was an essential requirement for Ca_2 + and an optimal pH of 8.5 for mango PEL activity.

2.6 High-density planting

Architecture and form of a tree vary with cultivars and keep on changing with the tree age, climate, cultural practices, training and pruning etc. The high-density orcharding in some cultivars of mango have been standardized, *viz.*, 'Amrapali' (2.5 m×2.5 m) (Sharma and Singh, 2006), 'Mallika' (6 m×6 m) and 'Dashehari' (3.0 m×2.5m) with pruning and also with the application of paclobutrazol. Nonetheless, after 10 –12 years of fruiting, the above cultivars showed a sharp decline in yield and quality due to overlapping / mixing of branches, poor light interception, reduced photosynthetic level, high relative humidity and proneness to diseases and pests, etc. (Lal and Mishra, 2007). Pruning as a method is not just about managing volume, but also about boosting yield.

Growth, flowering and fruiting were documented during the age of 6. At the age of 7, mango production per tree and per ha were the highest in Kesar (15.0 t/ha) followed by Totapuri (14.88 t/ha), Mallika (14.45 t/ha), Maya (14.11 t/ha) and Tommy Atkins (13.68 t/ha) respectively. Tommy Atkins produced the largest (435 g) fruit, followed by Mallika (422 g). Kesar variety fruits are medium in size (290 g). The sweetest (27.20 ° Brix) fruits of Doodh Pedha are followed by Goa Mankur (25.4 ° Brix) and Ratna (24.6 ° Brix). All the exotic varieties are less sweet when compared. With such early productivity, this rare and one of Asia's largest mango plantations is set to revolutionize mango production and profitability in India (Gunjate *et al.*, 2009).

In two consecutive years, high-density planting with a spacing of 2.5 m x 10 m recorded an average of 42 fruits / tree and an average fruit yield of 16.9 kg / tree in the same treatment as well. The maximum yield of fruit (6.4 t / ha) was recorded in 5 mx 5 m spacing, while the lowest yield of fruit (1.12 t / ha) was recorded in standard spacing. High density orcharding with spacings of 2.5 m x 10 m, 5 m x 5 m and 5 m x 7.5 m appears promising in the initial years. So many plants/unit area resulted in more fruit / plant number, higher yield / ha yield, and hence more tonnage from the same unit area (Dalvi *et al.*, 2010).

In three mango cultivars ('Amrapali', ' Mallika ' and ' Dashehari ') grown under high-density planting, the effects of four pruning treatments on fruit performance parameters were examined. Intensities of pruning (unpruned, mild pruning: branches separated from the apex up to 30 cm, moderate pruning: Branches removed up to 60 cm and extreme pruning: branches removed up to 90 cm ($p<0.05$) significantly influenced fruit weight and volume with the highest fruit weights (194 g and 186 g respectively in 2006 and 2007) and Volumes (165 mi and 164 ml respectively in 2006 and 2007) in light trees and heavily pruned trees. However, in both years, the highest pulp was found in moderately pruned ' Amrapali ' trees: stone ratio (3.6). Total soluble solids (TSS) were the highest in severe pruned trees while TSS: acid ratios in moderately pruned trees were the highest. No-pruning (control) produced high acidity and low TSS: ratio of acidity. The reducing sugars improved under moderate pruning intensities while the intensity of pruning did not affect total fruit sugars. Light and severe pruning also severely affected reducing sugars and total carotenoid. contents, suggests that mild pruning may be sufficient to improve the fruit quality of mango planted under high density and that these effects were more pronounced in the second year after pruning (Singh *et al.*, 2010).

2.7 Crop weather modelling

During the 2008-09 season, both normal and irregular mango cultivars in bearing showed extremely poor flowering in South Gujarat. During the year, the varieties of Kesar and Alphonso had placed excessive vegetative growth with negligible flowering. In the agroclimatic region of South Gujarat, the estimated period of peak floral bud differentiation is from December to January. Parmar *et al.* (2012) observed that physiological changes were occurring due to temperatures affected crop production. Since temperatures below 17^{0}C are regarded ideal for flower induction, night temperatures over 17^{0}C prevailing during the December flower induction period appear to have a detrimental effect resulting in poor flowering and ultimately affecting mango crop yield.

The earliest emergence of flower and maximum size of panicle was observed in Sundarja. Maximum hermaphrodite flowers were obtained in temperature maximum 33.47 ^{0}C to 35.4 ^{0}C and minimum in 18.4 ^{0}C to 18.7 ^{0}C respectively and other weather parameters that increased the fruit set in all variables studied. Dashehari, Mallika and Totapuri gave significant higher fruit weight as compared to Sundarja and Langra. (Singh *et al.*, 2014)

Ten diverse cultivars of mango were selected from the Kanyakumari and Tenkasi locations of Tamil Nadu during both primary seasons and off-season during 2010– 2012 to determine the correlation along with their weather parameters *viz.*, maximum temperature, relative humidity, minimum temperature and rainfall of independent characters and dependent variables of flowering characters *viz.*, number of

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inflorescence m-2, hermaphrodite flower per cent, fruit set percent, number of fruits tree-1 and yield of fruits per tree through correlation coefficients analysis in mango as to estimate the contribution of most essential characters towards yield. The result revealed that the maximum temperature (32 ºC), minimum temperature (20.3 ºC), relative humidity (84.50 per cent) and average rainfall (130.00 mm) had a highly significant and positive correlation with all the flowering and fruiting parameters of both primary and off- season of mango cultivars. At Tenkasi location, the maximum temperature (33 ºC), minimum temperature (20.7 ºC) and average rainfall (115.00 mm) showed the positive and significant association with all the flowering and fruiting characters of mango cultivars during both the seasons. In combination with weather parameters and flowering and fruiting characters of a correlation coefficient, It was found that the weather parameters had significantly affected the number of inflorescences m-2, hermaphrodite flower level, fruit set percentage of fruits per plant had major positive yield coefficients and also had a high positive direct impact. Thus, it was clear that the number of inflorescence m-2, hermaphrodite flower per cent, fruit set per cent and the number of fruits per tree is the significant component of fruit yield in mango (Kumar et al., 2014).

Jignasa *et al*. (2018) reported that nine different varieties of mango were selected during the year 2016-2017 for determining the correlation of dependent variables of flowering characters along with their weather parameters *viz*., maximum & minimum temperature, day & night temperature, rainfall, Relative humidity, wind speed and bright sunshine hours of independent characters through correlation coefficients analysis in mango as to estimate the contribution of most essential characters towards yield. The results revealed that, the temperatures (max/min & day/ night) and bright sunshine hours had highly significant and negative correlation with days to flower initiation, fruit set and male flower (%) while, it showed highly significant positive relation with width of panicle, no. of panicle/tree and hermaphrodite flower (%). Similarly, relative humidity had a highly significant positive association with days to flower initiation, fruit set and male flower (%) while; it showed highly significant negative relation with no. of panicle/tree and hermaphrodite flowers (%). Post-monsoon rain was not a significant correlation, but it was positive, i.e. later rain resulted in late flowering. All climatic parameters except relative humidity and wind speed

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showed significant positive correlation total no. of flowers/panicle and non-significant but positive with various panicle characters in mango.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation on 'Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes' was conducted at College of Horticulture, Vellanikkara, Kerala from March 2016 to June 2018. The main objective was to study the ecophysiological responses among selected genotypes of mango on vegetative and reproductive characters in selected genotypes and also to identify climate resilient genotypes suitable for Kerala under climate change scenario. The materials used and methodology adopted for the studies are described in this chapter.

3.1 Experimental site

The present experiments were conducted for the period from March 2016 to June 2018. Under the plan project on "Collection and evaluation of mango varieties hybrids for commercial cultivation" at College of Horticulture, Kerala Agricultural University (KAU) Vellanikkara, about 123 varieties were collected from different parts of the country. Their grafts were planted and maintained in the mango orchard. Among these twenty-four varieties planted under normal spacing (9x9m) and six varieties planted under high density (3x3m) planting maintained in the mango orchard of Dept. of Fruit Science, College of Horticulture, K.A.U. Vellanikkara, Thrissur were utilised for the study.

3.1.1 Location

The mango orchard of College of Horticulture, Vellanikkara where the experiment was conducted lies at a latitude of 10_{o} 31' N and longitude of 76_{o} 3' E. The area lies 22.25 m above MSL.

3.1.2 Climate

The climate is tropical humid climate. The climatological data during the period of investigation are given as Appendix I.

3.2. Materials

Experiment I. Evaluation of mango genotypes

The study was conducted utilizing 24 diverse mango germplasm maintained at mango orchard of College of Horticulture, Vellanikkara, Thrissur, Kerala. All the genotypes are in the age group of 23 years. Trees are maintained under uniform cultural practices to ensure yield with quality fruits. Three healthy and uniform trees of each genotype were utilized for the study.

Experiment II. Evaluation of selected mango genotypes in HDP

The study was conducted utilizing six diverse mango genotypes planted in HDP in mango orchard of College of Horticulture, Vellanikkara, Thrissur, Kerala. All the genotypes were of five years old and in bearing stage.

Experiment III. Development of a crop weather model for mango and screening of genotypes for climate resilience

Crop weather models were developed using primary/secondary data on growth and environmental parameters to test the performance of different genotypes under varied weather conditions. Besides three-year data taken on project, 10 to 15 previous year data were used for making crop weather model.

3.3. Methods

Experiment I. Evaluation of mango genotypes

Details of experimental layout

Design of experiment – CRD

Number of treatments/varieties – 24

Number of replications – 3

Total number of trees - 24 x 3= 72

Years of observation – 2016, 2017, 2018

List of selected mango genotypes

Hybrids	Parents involved in crossing	Local types
Arka Aruna	Banganapalli	Tholikaippan
Amrapali	Alphonso	Chandrakaran *
Mallika	Dashehari	Vellaikolumban *
Ratna	Neelum	Prior
Sindhu	Himayuddin	Muvandan *
H45	Bennet Alphonso	
H 151	Kalepady	
PKM1	Swarnarekha	
PKM 2	Mulgoa	
Neelgoa		

*Polyembryonic mango genotypes

Experiment II. Evaluation of selected mango genotypes in HDP

Details of experimental layout

Design of experiment – CRD

Number of treatments – 6

Number of replications – 5

Total number of trees - 6 x 5 = 30

Years of observation - 2016, 2017, 2018

List of mango genotypes selected for the study

Sl. No.	Genotype
1	Prior
2	Mallika
3	Vellaikolamban
4	Ratna
5	Chandrakaran
6	Muvandan

Experiment III. Development of a crop weather model for mango and screening of genotypes for climate resilience.

Development of a crop weather model for mango and screening of genotypes for climate resilience in which crop weather models was developed using primary/secondary data on growth and environmental parameters to test the performance of different genotypes under varied weather conditions. Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using ECHAM model and the performance of the various genotypes under projected climatic conditions were evaluated using the developed model.

3.4. Observations

3.4.1. Morphological characterization

Tree characters, inflorescence characters and fruit characters were recorded. Mature fruits were collected. Standard descriptors prescribed by IPGRI (2006) were used as the guideline to describe the vegetative, inflorescence, fruit and stone characters.

3.4.1.1 Tree characters

3.4.1.1.1 Age of tree

Age of the tree was calculated from the date of planting in the basic records maintained in the college and expressed in years.

3.4.1.1.2 Height of the tree

Height of the tree was recorded from the ground level to the top of the tree with multimeter and expressed in meter (m).

3.4.1.1.3 Trunk circumference

Trunk circumference was recorded from 50 cm above the ground level of the trees and expressed in centimetre (cm).

3.4.1.1.4 Crown diameter

Measured the diameter in two directions (North-South and East- West) at ground level and expressed in meter (m).

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3.4.1.1.5 Crown shape

Crown shape of the trees were recorded and classified into four groups namely oblong, broadly pyramidal, semi-circular and spherical (Fig.1).

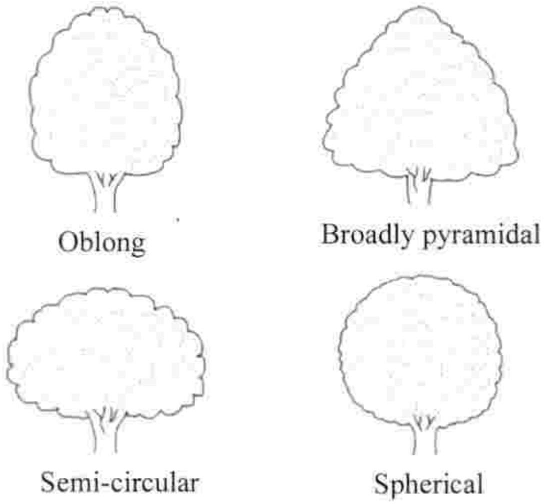

Fig. 1 Crown shape

3.4.1.1.6 Tree growth habit

Growth habits of the trees were recorded and classified into three groups namely erect, spreading and drooping (Fig.2).

Fig. 2 Tree growth habit

3.4.1.1.7 Foliage density

Foliage density of the trees recorded and classified into 3 groups namely sparse, intermediate and dense.

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3.4.1.2 Leaf characters

3.4.1.2.1 Leaf blade shape

Leaf blade shapes of the trees were recorded and classified into six groups namely elliptic, oblong, ovate, obovate, lanceolate and oblanceolate (Fig. 3).

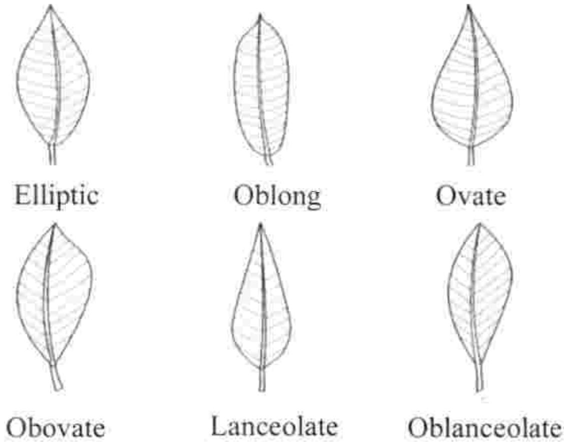

Fig. 3 Leaf base shapes

3.4.1.2.2 Leaf blade length

Leaf blade length were recorded as the average of 10 mature leaves measured from the base to the tip of the leaf blade and expressed in centimetre (cm).

3.4.1.2.3 Leaf blade width

Leaf blade width was recorded as the average of 10 mature leaves measured at the widest point and expressed in centimetre (cm).

3.4.1.2.4 Petiole length

Petiole length was recorded as the average length of 10 mature leaves measured from the stem to the base of leaf blade and expressed in centimetre (cm).

3.4.1.2.5 Leaf apex shapes

Leaf apex shapes of the trees were recorded and classified into three groups namely obtuse, acute and acuminate (Fig. 4).

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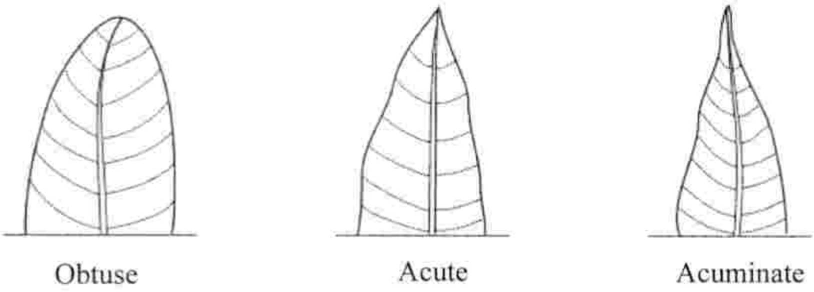

Fig. 4 Leaf apex shapes

3.4.1.2.6 Leaf base shape

Leaf base shapes of the trees were recorded and classified into three groups namely acute, obtuse and round (Fig. 5).

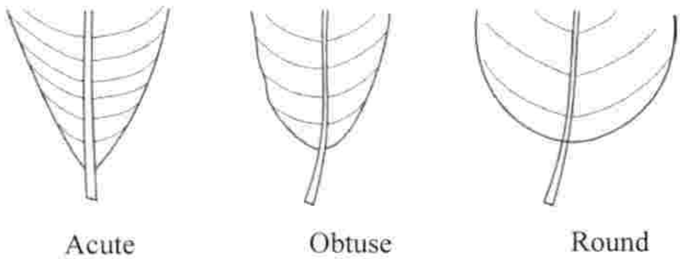

Fig. 5 Leaf base shapes

3.4.1.2.7 Leaf margin

Leaf base shapes of the trees were recorded and classified into two groups namely entire and wavy (Fig. 6).

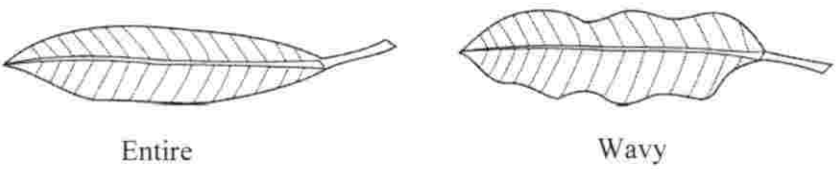

Fig. 6 Shape of leaf margin

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3.4.1.2.8 Leaf pubescence

Leaf pubescence was recorded as either present or absent.

3.4.1.2.9 Colour of young leaf

Colour of young leaves (five to ten days old) were recorded and classified into five groups namely light green, light green with brownish tinge, light brick red, reddish brown and deep coppery tan.

3.4.1.2.10 Colour of fully developed leaf

Colour of fully developed leaves were recorded and classified into three groups namely pale green, green and dark green.

3.4.1.2.11 Leaf fragrance

Leaf fragrance of fully developed mature leaves were recorded after crushing and classified as absent, mild and strong.

3.4.1.3 Inflorescence characters

3.4.1.3.1 Flowering duration

Time of flowering was recorded as number of days from first inflorescence opening to the end of flowering.

3.4.1.3.2 Secondary/off season flowering

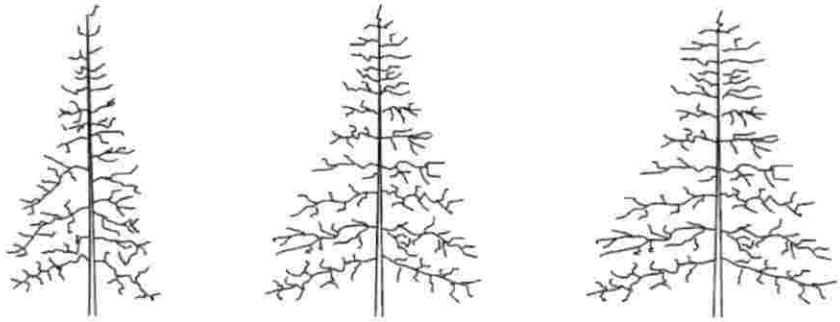
Secondary/off season flowering was recorded and classified into 4 groups namely absent, rare, intermediate and frequent.

3.4.1.3.3 Inflorescence position

Inflorescence positions were recorded and classified to terminal and axillary.

3.4.1.3.4 Inflorescence shape

Inflorescence shape was recorded and classified into three categories namely conical, pyramidal and broadly pyramidal (Fig. 7).



Conical Pyramidal Broadly pyramidal

Fig. 7 Inflorescence shape

3.4.1.3.5 Inflorescence length

Inflorescence length was recorded as the average of 10 inflorescences and expressed in centimetre (cm).

3.4.1.3.6 Inflorescence width

Inflorescence width was recorded as the average of 10 inflorescences and expressed in centimetre (cm).

3.4.1.3.7 Hermaphrodite flowers in the inflorescence

Hermaphrodite flowers in the inflorescence was recorded from the average of 10 inflorescences taken from all directions including centre of tree and expressed in per cent.

3.4.1.3.8 Density of flowers in the inflorescence

Density of flowers in the inflorescence was recorded and classified into three categories namely sparse, medium and dense.

3.4.1.3.9 Inflorescence colour

Inflorescence colour of the main and secondary axis were recorded and classified into 13 groups namely whitish, yellowish green, yellow, light green, green with red patches, light orange, pink, dark pink, purple, light red, red, dark red and crimson.

3.4.1.3.10 Length of stamen in relation to pistil

Length of stamen in relation to pistil was recorded and classified into three categories namely shorter, equal and longer.

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3.4.1.3.11 Nature of disc

Nature of disc was recorded and classified in to swollen, broader than ovary and narrow, reduced or absent.

3.4.1.3.12 Number of stamens per flower

Total stamens in a flower were counted and expressed in number.

3.4.1.4 Fruit characters

3.4.1.4.1 Fruiting duration

Time of fruiting was recorded in each tree.

3.4.1.4.2 Fruit bearing intensity

Fruit bearing intensity was recorded and classified in to low, medium and high.

3.4.1.4.3 Fruit length

Fruit length was recorded as the average of 20 fruits measured from the base to the tip of the fruit and expressed in centimetre (cm).

3.4.1.4.4 Fruit diameter

Fruit diameter was recorded as the average of 20 fruits measured at the widest point and expressed in centimetre (cm).

3.4.1.4.5 Fruit weight

Fruit weight was recorded as the average of 20 fruits and expressed in gram (g).

3.4.1.4.6 Fruit shape

Fruit shape was recorded and classified into five groups namely oblong, elliptic, roundish, ovoid and obovoid (Fig. 8).

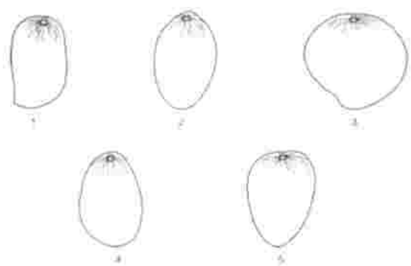

Fig. 8 Fruit shape (1. Oblong 2. Elliptic 3. Roundish 4. Ovoid 5. Obovoid)

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3.4.1.4.7 Shape of fruit apex

Shape of fruit apex was recorded and classified into three groups namely acute, obtuse and round (Fig. 9).

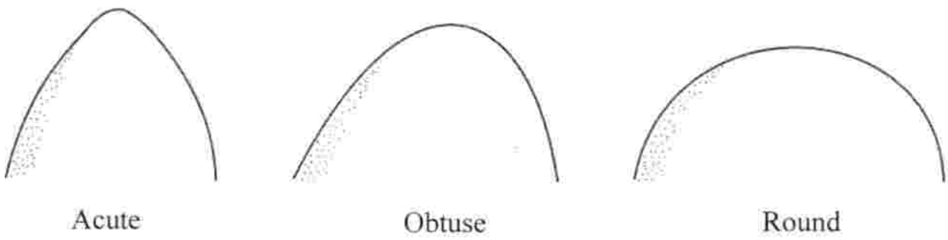

Fig. 9 Shape of fruit apex

3.4.1.4.8 Fruit attractiveness

Fruit attractiveness was recorded as a combined assessment of shape, size and appearance, colouration *etc.* and classified as poor, average, good and excellent.

3.4.1.4.9 Skin colour of unripe fruit

Skin colour of unripe fruit was recorded and classified as green, yellow, orange, purple and red.

3.4.1.4.10 Skin colour of ripe fruit

Skin colour of ripe fruit was recorded and were classified as green, greenish yellow, yellow, green with red blush and green with purple patches.

3.4.1.4.11 Depth of fruit stalk cavity

Depth of fruit stalk cavity was measured and categorised into five groups namely absent, shallow, medium, deep and very deep (Fig. 10).

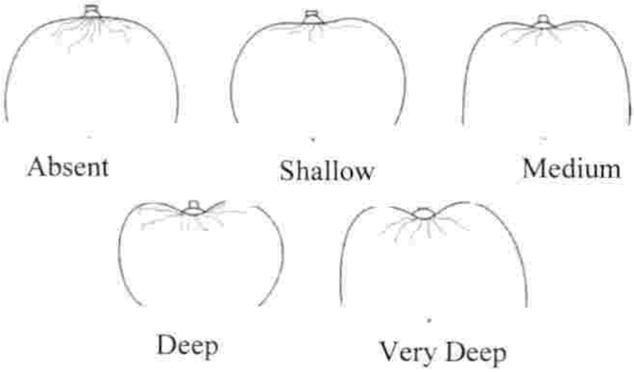

Fig. 10 Depth of fruit stalk cavity

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3.4.1.4.12 Fruit neck prominence

Fruit neck prominence was recorded and categorised into four groups namely absent, slightly prominent, prominent and very prominent (Fig. 11).

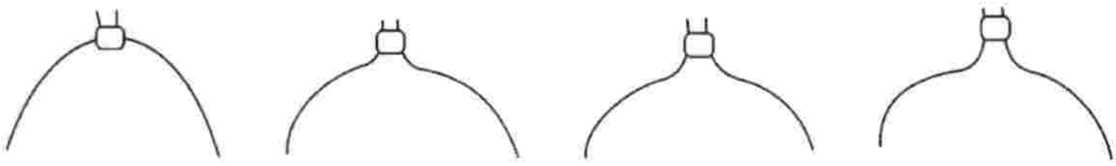

Fig.11 Fruit neck prominence

3.4.1.4.13 Fruit beak type

Fruit beak type was observed and categorised into four groups namely perceptible, pointed, prominent and mammiform (Fig. 12).

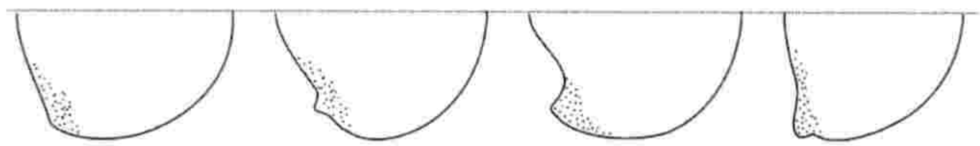

Fig. 12 Fruit beak type

3.4.1.4.14 Pulp colour of ripe fruit

Pulp colour of ripe fruit was recorded and categorised into eight groups namely light yellow, golden yellow, yellow orange, orange, greenish yellow, yellow, light orange and dark orange.

3.4.1.4.15 Aroma of fruit

Aroma of the ripe fruit was judged and categorised into three groups namely mild, intermediate and strong.

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3.4.1.4.16 Yield per tree

Total yield was recorded for each tree and expressed in kg tree^{-1}.

3.4.1.4.17 Shelf life

Shelf life was recorded as the number of days the fruits retained their good condition at room temperature.

3.4.2 Stone characters

3.4.2.1 Stone length

Stone length was recorded as the average of 20 seeds and expressed in centimetre (cm).

3.4.2.2 Stone width

Stone width was recorded as the average of 20 seeds and expressed in centimetre (cm).

3.4.2.3 Stone thickness

Stone thickness was recorded as the average of 20 seeds and expressed in centimetre (cm).

3.4.2.4 Stone weight

Stone weight were recorded as the average of 20 seeds and expressed in gram (g).

3.4.2.5 Quantity of fibre on stone

Quantity of fibre on stone was observed and categorised into three groups namely low, intermediate and high.

3.4.2.6 Adherence of fibre to stone

Adherence of fibre to stone was observed and categorised into three groups namely weak, intermediate and strong.

3.4.2.7 Texture of stone fibre

Texture of stone fibre was observed and categorised into two groups namely soft and coarse.

3.4.2.8 Seed length

Seed length was recorded as the average of 20 seeds and expressed in centimetre

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(cm).

3.4.2.9 Seed width

Seed width was recorded as the average of 20 seeds and expressed in centimetre.

3.4.2.9 Seed weight

Seed weight was recorded as the average of 20 seeds and expressed in centimetre (cm).

3.4.2.10 Seed shape

Seed shape was recorded and categorised into three groups namely ellipsoid, oblong and reniform (Fig. 13).

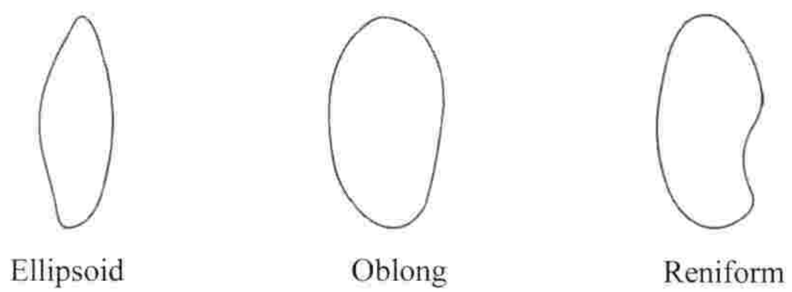

Fig. 13 Seed shape

3.4.3 Quality attributes of fruits

3.4.3.1 TSS

TSS of mango pulp was recorded with the help of digital refractomet and expressed in °Brix.

3.4.3.2 Acidity

Acidity was determined by the method of Ranganna (1997) by titrating pulp from 1 g of fruit sample against 0.1 N sodium hydroxide and expressed in per cent (%).

$$\text{Acidity} = \frac{1 \times \text{Equivalent weight of acid} \times \text{Normality} \times \text{Titre value} \times 100}{10 \times \text{Weight of the sample}}$$

3.4.3.3 Ascorbic acid

Ascorbic acid was determined by the method of Sadasivam and Manickam (1996) using oxalic acid, 2,6-dichloro phenol indophenol dye and standard sock solution and titrating 5 g of fruit sample against the dye and expressed in mg $100g^{-1}$.

$$\text{Ascorbic acid} = \left\{ \frac{0.5 \text{ mg} \times V_2 \times 100 \text{ ml}}{V_1 \text{ ml} \times 5 \text{ ml} \times \text{weight of the sample}} \right\} \times 100$$

3.4.3.4 Total carotenoids

Total carotenoids was determined by the method of Ranganna (1997) using acetone and petroleum ether as extracting solvents and measuring the absorbance at 452 nm and expressed in mg $100g^{-1}$.

3.4.3.5 β carotene

β carotene was estimated by AOAC (1975) method as described below. Ten gram of mango pulp was taken in 150 ml conical flask and 40 ml water saturated butanol (WSB) was added. The contents of the flask were mixed vigorously for 1 minute and kept overnight (16-18 h) at room temperature under dark for complete extraction of β carotene. Next day, the contents were shaken again and filtered completely through the Whatman No.1 filter paper into a 100 ml volumetric flask. The optical density of the clear filtrate was measured at 440 nm using spectrophotometer. Pure WSB was used as blank. The β carotene content was calculated from the calibration curve from known amount of β carotene as discussed below and expressed as parts per million (ppm). Standard solution of β carotene (Sigma) was prepared in WSB at the concentration of 5 μg/ml. WSB is prepared by mixing n-butanol with distilled water in 8:2 ratio. Calibration curve was made from known amount of pure β carotene from 0.25 μg/ml which were prepared after suitable dilution of original stock with WSB in calibrated 10 ml volumetric flask (from 0.5 ml to 3 ml of standard solution in 10 ml). Absorbance of each dilution was measured and a calibration curve was established. β carotene content of unknown samples were calculated from standard curve.

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3.4.3.6 Total sugars

For the estimation of total sugars, 50 ml of the clarified solution (filtrate of reducing sugars) was boiled gently after adding citric acid and water. It was neutralized using NaOH and volume made up to 250 ml and the made-up solution was titrated against a mixture of Fehling's solution A and B and total sugars was expressed as percentage (Ranganna, 1997).

$$\text{Total sugars (\%)} = \frac{\text{Titrel value x 0.1 x Volume made up x 0.064x 100}}{\text{Volume of the sample x Weight of the sample}}$$

3.4.3.7 Reducing sugars

Reducing sugars were determined by adopting the method given by Lane and Eynon (Ranganna, 1997). The fruit sample was crushed in a grinder and filtered through No.4 Whatman paper. An aliquot of 25 ml filtered juice was transferred to a 250 ml volumetric flask, mixed with distilled water and neutralized with NaOH. Solution was clarified with neutral lead acetate. Excess lead acetate was removed by adding potassium oxalate and volume was made up to 250 ml. The solution was filtered and aliquot of the filtrate was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator and the reducing sugar was expressed as percentage.

$$\text{Reducing sugars (\%)} = \frac{\text{0.05 x Volume made up x 100}}{\text{Titre value x weight of the sample}}$$

3.4.3.8 Crude fibre

Crude fibre was determined by the method of Sadasivam and Manickam (1996) using solutions of sulphuric acid and sodium hydroxide and these titrating against the dye and expressed as percentage.

$$\text{Crude fibre (\%)} = \left[\frac{\text{Loss in weight on ignition } (W_2\text{-}W_1) - (W_3\text{-}W_1)}{\text{Weight of the sample}} \right] \text{x 100}$$

A2

3.4.4 Sensory evaluation

Sensory evaluation was conducted on the characters *viz.,* taste, flavour, colour, texture, sweetness and appearance were recorded.

3.4.4.1 Selection of judges

Then a series of sensory evaluation were carried out using nine point hedonic scale at laboratory level. A panel of ten judges between the age group of 18-40 years were chosen as the sensory evaluators.

3.4.4.2 Preparation of score card

Score card including the quality attributes like taste, flavour, colour, texture, sweetness and appearance was prepared for sensory evaluation of mango fruit. Each of the above mentioned qualities was assessed by nine-point hedonic scale. Total score was calculated separately using the average of above mentioned quality attributes. The score card used for the evaluation of fruits as given in Appendix II.

3.4.4.2 Organoleptic evaluation

Organoleptic evaluation of fruits were carried out using the score card by a panel of ten selected judges. Hedonic rating scale method measures the level of liking of any product based on a test which relays on the people's ability to communicate their feelings of like or dislike. Hedonic ratings were converted to rank scores and rank analysis was done as per Kendall's coefficient of concordance.

3.4.5 Pollen studies

3.4.5.1 Size of pollen grains

Size pollen grains were measured using stereo microscope.

3.4.5.2 Shape of pollen grains

Shape of pollen grains were observed using stereo microscope.

3.4.5.3 Pollen fertility

Pollen fertility was calculated by counting the normal well stained grains and expressed as percentage. One per cent acetocarmine solution was used for the estimation.

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

3.4.5.4 In *vitro* pollen germination

In vitro pollen germination was tried using sucrose and agar medium. Since the attempts did not succeed the experiment was repeated with varying levels of agar and sucrose.

3.4.5.5 Estimation of pollen production

Pollen grains from a known number of anthers were suspended in a known quantity of water. This suspension was poured into the well of haemocytometer. The number of pollen grains per well as counted and the number of pollen grains per anther was calculated. A drop of suspension was transferred to each of the two counting chambers of haemocytometer. Each chamber has an area of nine square millimetres ruled into small divisions. The counting chambers are 0.1 mm in depth so that the volume over one mm^3 is 0.1 mm^3. On this basis the number of pollen grains were arrived at. The contents of 100 anthers were suspended in 2.5 ml of solution. Thus, the contents of each anther were suspended in 0.025 ml of the solution or 25 mm^3.

If, N =average number of pollen grains counted per square and

X= Number of pollen grains per anther

$N:X = 0.1:25$

$0.1X = 25\ N$

$X = 250\ N$

The pollen grains in each of the four corner squares of each counting chambers were counted using low power (10X) objective of the microscope.

3.4.5.6 Pollen storage

Male flowers were collected from the field and kept under different storage treatments as given below.

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

T_2 - Refrigerator at 4^{o} C

T_3 - Keeping over calcium chloride in a desiccator in refrigerator

T_4 - Room temperature

Later viability test was done by acetocarmine technique and expressed in percentage.

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3.4.6 Physiological characters

3.4.6.1 Relative water content

Relative water content was estimated by taking leaf bits and weighing them (fresh weight FW). Then the turgid weight TW was measured after floating them in water for five hours. After recording the turgid weight, the samples were dried in hot air oven to a constant weight and recorded as dry weight DW and expressed in percentage.

$$\text{Relative water content (\%)} = \frac{FW - DW}{TW - DW} \times 100$$

3.4.6.2 Radiation interception

Radiation interception was measured using quantum sensor (LICOR radiation sensors, model LI-190SA) and expressed in μ mol m^{-2} s^{-2}.

3.4.6.3 Stomatal index

Number of stomata was counted using research microscope.

3.4.6.4 Stomatal frequency

Stomatal frequency was calculated as the number of stomata present per unit area of a leaf.

3.4.6.5 Stomatal conductance

Stomatal conductance was measured using portable photosynthetic system(PPS) (Model-LI-6400 of LICOR Inc. Lincoln, Nebraska, USA). Leaf was inserted in the leaf chamber and reading were taken between 8 and 11 am using the instrument and expressed in μ mol m^{-2} s^{-2}.

3.4.6.6 Stomatal resistance

Stomatal resistance = 1 / Stomatal conductance and expressed in μ mol m^{-2} s^{-2}.

3.4.6.7 Photosynthetic rate

Photosynthetic rate (μ mol m^{-2} s^{-2}) was measured using portable photosynthetic system (PPS) (Model-LI-6400 of LICOR Inc. Lincoln, Nebraska, USA). Leaf was inserted in the leaf chamber and reading were taken between 8 and 11 am using the instrument and expressed in μ mol m^{-2} s^{-2}.

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3.4.6.7 Transpiration

Transpiration was measured using portable photosynthetic system (PPS) (Model-LI-6400 of LICOR Inc. Lincoln, Nebraska, USA). Leaf was inserted in the leaf chamber and reading were taken between 8 and 11 am using the instrument and expressed in mol $m^{-2} s^{-2}$.

3.4.6.8 Leaf area index

Leaf area index (LAI) was measured using canopy analyser (LAI-2200C).

3.4.6.9 Atmospheric pollution tolerance index

Atmospheric pollution tolerance index (APTI) was calculated after determining the four parameters viz., ascorbic acid, total chlorophyll, relative water content and leaf extract pH. The plants were categorized into sensitive ($\leq$10), intermediate (11 to 14), moderately tolerant (15 to 18) and tolerant ($\geq$18) based on APTI values. Atmospheric pollution tolerance index was computed and plants were categorized by the method suggested by Singh *et al.* (1991) using the equation:

$$APTI = [A(T+P)+R]/10$$

Where, A= Ascorbic acid content (mg/g)

T= Total chlorophyll (mg/g)

P=pH of leaf extract

R=Relative water content of the leaf (%)

3.4.7 Biochemical analysis of plants

3.4.7.1 Total phenol content

Total phenol content was determined by the method of Sadasivam and Manickam (1996) using folin-ciocalteau reagent and 20% sodium carbonate and expressed as mg g^{-1}.

3.4.7.2 Soluble protein content

Soluble protein content was determined by the method of Sadasivam and Manickam (1996) using folin-ciocalteau reagent and expressed as mg g^{-1}.

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3.4.7.3 Ascorbic acid

Ascorbic acid was determined by the method of Sadasivam and Manickam (1996) using oxalic acid, 2,6-dichloro phenol indophenol dye and standard sock solution and titrating against the dye and expressed as mg100g-1.

3.4.7.4 pH of the leaf

Fresh leaf 0.5 g sample was homogenised using 50 ml distilled water and the supernatant was fed into digital pH meter for the detection of pH.

3.4.7.5 Chlorophyll content

Chlorophyll content was determined by using dimethyl sulphoxide method of Shoaf and Lium (1976) and expressed as mg g-1.

3.4.8 Incidence of pests and diseases

3.4.8.1 Per cent pest incidence/severity index of pests and disease

Incidence of pest and diseases were also recorded during the period of study and proper control measures were taken.

3.4.9 Meteorological data

3.4.9.1 Weather observations (on daily basis)

Daily observations on maximum and minimum temperature (oC), rainfall (mm), number of rainy days, relative humidity (%) and solar radiation were recorded.

3.4.9.2 Soil analysis

Soil samples were taken from the experimental area. The composite samples from the experimental site prior to the experiment were analysed for mechanical and chemical composition. Composite samples were collected from each plot, air dried, powdered and passed through a 2 mm sieve and analysed for organic carbon content, nitrogen, available phosphorous and available potassium.

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Methodologies for soil analysis

Parameter	Method	Reference
Organic carbon	Walkley and Black method	Walkley and Black,1934
Available nitrogen	Alkaline permanganate method	Subbiah and Asija, 1956
Available phosphorous	Ascorbic acid reduced molybdophosphoric blue colour method	Watanabe and Olsen, 1965
Available potassium	Neutral normal ammonium acetate using photometry	Jackson,1958

3.4.9.3 Climate change projections by 2030, 2040 and 2050

Daily observations on rainfall (mm), maximum and minimum temperature (oC) and solar radiation were generated using the ECHAM model.

3.4.10 Statistical analysis

For the experiment I and II, 2 x 2 factorial (CRD) was carried out using OPSTAT software. Data based on qualitative characters were compared with Jaccard's similarity coefficients and was clustered by the Unweighed Pair Group Average Method (UPGAM) using NTsys pc 2.02 software. Similarity matrix was computed and the dendrogram was constructed accordingly. For sensory evaluation hedonic ratings were converted to rank scores and rank analysis was done by Kendall's coefficient of concordance.

For experiment III, Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using ECHAM model and the performance of the various genotypes under projected climatic conditions was evaluated using the developed model. Correlation among different meteorological and phenological characters of mango genotypes were done and it was helpful in determining the factors responsible for complex trait like yield. From the correlated data regression equations were formulated and the yield was predicted from the scenario. Three phenophases *viz.,* flower initiation, fruit initiation and fruit maturation were taken for the study. In each phenophase, seven, fifteen and thirty days from the date of expression were averaged for correlation.

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Results

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4. RESULTS

The results of the study pertaining to the "Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes" are presented in this chapter. Twenty-four mango varieties/cultivars were evaluated and the results are presented under the heads, morphological characters namely tree characters, leaf characters, inflorescence characters, fruit characters and stone characters. Morphological characters were recorded based on IPGRI descriptor. Data were subjected to multivariate analysis utilizing cluster analysis using NTsys software.

Experiment I. Evaluation of mango genotypes

The study was conducted utilizing 24 diverse mango germplasm maintained at mango orchard of College of Horticulture, Vellanikkara, Thrissur, Kerala. All the genotypes are in the age group of 23 years. Trees are maintained under uniform cultural practices to ensure yield with quality fruits. Three healthy and uniform trees of each genotype were utilized for the study.

Details of experimental layout

Design of experiment – CRD

Number of treatments/varieties – 24

Number of replications – 3

Total number of trees - 24 x 3= 72

Years of observation – 2016, 2017, 2018

Plate 1. General view of mango genotypes under normal planting system

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List of selected mango genotypes

Hybrids	Parents involved in crossing	Local types
Arka Aruna	Banganapalli	Tholikaippan
Amrapali	Alphonso	Chandrakaran *
Mallika	Dashehari	Vellaikolumban *
Ratna	Neelum	Prior
Sindhu	Himayuddin	Muvandan *
H45	Bennet Alphonso	
H 151	Kalepady	
PKM1	Swarnarekha	
PKM 2	Mulgoa	
Neelgoa		

*Polyembryonic mango genotypes

4.1 Morphological Characters

Various observations on morphological characters *viz.*, tree characters, leaf characters, inflorescence characters, fruit characters and seed characters were recorded, analysed and the results are presented in Tables 1 to 58.

4.1.1 Tree Characters

4.1.1.1 Age of Tree

The trees of same age group (27 years) were selected for the study (Table 1).

4.1.1.2 Height of the tree

The data presented in Table 2 shows the variation in plant height of different genotypes during three seasons. Among the hybrids Sindhu recorded the highest plant height (11.93 m) followed by Neelgoa (11.36 m). H 151 recorded the lowest plant height (7.61m) which was on par with Arka Aruna (8.17 m), PKM 1 (8.23 m) and Ratna (8.27 m).

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Table 1. Age (years) of different mango genotypes

Sl. No.	Genotypes	Year		
		2015-16	2016-17	2017-18
1	Arka Aruna	23	24	25
2	Amrapali	23	24	25
3	Mallika	23	24	25
4	Ratna	23	24	25
5	Sindhu	23	24	25
6	H45	23	24	25
7	H 151	23	24	25
8	PKM1	23	24	25
9	PKM 2	23	24	25
10	Neelgoa	23	24	25
11	Banganapalli	23	24	25
12	Alphonso	23	24	25
13	Dashehari	23	24	25
14	Neelum	23	24	25
15	Himayuddin	23	24	25
16	Bennet Alphonso	23	24	25
17	Kalepady	23	24	25
18	Swarnarekha	23	24	25
19	Mulgoa	23	24	25
20	Tholikaippan	23	24	25
21	Chandrakaran	23	24	25
22	Vellaikolumban	23	24	25
23	Prior	23	24	25
24	Muvandan	23	24	25

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Table 2. Plant height (m) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.17	8.20	8.13	8.17
2	Amrapali	8.87	8.60	8.67	8.71
3	Mallika	10.30	9.57	9.83	9.90
4	Ratna	8.83	8.27	7.70	8.27
5	Sindhu	12.57	12.17	11.06	11.93
6	H45	7.93	7.17	7.73	7.61
7	H 151	10.00	9.57	9.77	9.78
8	PKM1	8.40	8.10	8.20	8.23
9	PKM 2	9.50	9.30	8.93	9.24
10	Neelgoa	11.13	12.47	10.47	11.36
11	Banganapalli	10.43	9.87	10.07	10.12
12	Alphonso	11.57	11.10	10.27	10.98
13	Dashehari	11.03	10.53	11.70	11.09
14	Neelum	9.10	9.03	8.70	8.94
15	Himayuddin	11.23	10.70	9.97	10.63
16	Bennet Alphonso	8.83	8.20	8.03	8.36
17	Kalepady	12.53	12.10	12.30	12.31
18	Swarnarekha	11.73	11.00	10.57	11.10
19	Mulgoa	9.97	9.70	10.40	10.02
20	Tholikaippan	10.97	10.33	11.17	10.82
21	Chandrakaran	12.90	12.33	12.23	12.49
22	Vellaikolumban	9.43	9.33	9.10	9.29
23	Prior	9.87	9.30	10.23	9.80
24	Muvandan	12.13	11.67	12.03	11.95
	Mean	10.31	9.94	9.89	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.71	0.36	0.25	
	Year x Genotype	NS	0.62	0.44	

Kalepady recorded the highest tree height (12.31m), followed by Swarnarekha (11.10 m), Dashehari (11.09 m), Alphonso (10.98 m), and Himayuddin (10.63 m) among the parents involved in breeding. Bennet Alphonso recorded the lowest plant height (8.36 m) which was on par with Neelum (8.94 m).

Chandrakaran recorded the highest plant height (12.49m) followed by Muvandan (11.95m) among the local types. Vellaikolumban recorded the lowest plant height (9.29m) which was on par with Prior 99.80m).

4.1.1.3 Trunk circumference

The observation on trunk circumference of mango trees were presented in Table 3. The maximum trunk circumference was recorded for Mallika (168.13 cm) which was significantly different from rest of the hybrids. H 151 has registered the least trunk circumference (95.17 cm) which was on par with Sindhu (106.22 cm) and PKM 2 (107.09 cm).

Swarnarekha (196.53 cm) recorded the highest trunk circumference followed by Mulgoa (184.01 cm) among the parents involved in breeding. Neelum recorded the lowest value of 103.79 cm.

Prior recorded the highest trunk circumference of 153.53 cm which was significantly different among the local types. The lowest trunk circumference was recorded for Muvandan (91.63 cm) which was on par with Chandrakaran (94.94 cm).

4.1.1.4 Crown diameter

The crown diameter (North–South) and (East-West) of mango was measured and presented in Table 4a and Table 4b. The variety H 45 recorded the highest crown diameter (North –South) followed by Ratna (10.94 m) and Mallika (10.75 m). The lowest crown diameter (North –South) was recorded by H 151 (7.07 m).

Mulgoa (13.40 m) recorded the highest value followed by Banganapalli (12.08 m) among the parents involved in breeding. The lowest value was recorded by Alphonso (8.23 m) which was on par with Dashehari (8.79 m) and Himayuddin (8.99 m).

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Table 3. Trunk circumference (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	138.33	141.33	141.83	140.50
2	Amrapali	128.33	128.63	133.17	130.04
3	Mallika	166.33	167.40	170.67	168.13
4	Ratna	145.33	147.90	150.47	147.90
5	Sindhu	105.00	107.47	106.20	106.22
6	H45	126.67	128.60	130.63	128.63
7	H 151	93.33	95.60	96.57	95.17
8	PKM1	132.33	133.30	133.07	132.90
9	PKM 2	105.00	108.03	108.23	107.09
10	Neelgoa	120.00	123.50	121.90	121.80
11	Banganapalli	142.00	141.00	143.93	142.31
12	Alphonso	160.00	163.43	159.40	160.94
13	Dashehari	145.00	149.37	150.20	148.19
14	Neelum	102.33	106.00	103.03	103.79
15	Himayuddin	150.00	154.43	154.67	153.03
16	Bennet Alphonso	150.00	152.13	152.43	151.52
17	Kalepady	150.00	154.80	154.80	153.20
18	Swarnarekha	195.00	196.07	198.53	196.53
19	Mulgoa	183.67	185.73	182.63	184.01
20	Tholikaippan	135.00	138.50	137.07	136.86
21	Chandrakaran	94.00	93.20	97.63	94.94
22	Vellaikolumban	115.00	119.40	113.70	116.03
23	Prior	149.00	152.13	156.47	152.53
24	Muvandan	90.00	90.80	94.10	91.63
	Mean	134.24	136.62	137.14	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	13.00	6.57	4.65	
	Year x Genotype	NS	11.38	8.05	

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Table 4a. Crown diameter (North-South) (m) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.93	7.91	9.77	8.87
2	Amrapali	8.77	8.85	9.65	9.09
3	Mallika	10.77	11.81	9.66	10.75
4	Ratna	10.30	9.91	12.60	10.94
5	Sindhu	7.90	9.81	10.67	9.46
6	H45	11.30	12.59	11.57	11.82
7	H 151	6.10	8.33	6.78	7.07
8	PKM1	10.00	10.35	9.93	10.10
9	PKM 2	8.10	10.52	10.50	9.71
10	Neelgoa	9.77	10.51	9.48	9.92
11	Banganapalli	12.40	11.56	12.27	12.08
12	Alphonso	7.20	8.81	8.67	8.23
13	Dashehari	7.97	9.67	8.73	8.79
14	Neelum	10.90	10.52	9.26	10.23
15	Himayuddin	8.03	8.51	10.44	8.99
16	Bennet Alphonso	10.60	12.34	10.27	11.07
17	Kalepady	11.07	11.16	12.29	11.51
18	Swarnarekha	9.27	10.55	9.86	9.89
19	Mulgoa	13.13	12.48	14.59	13.40
20	Tholikaippan	9.83	8.92	9.54	9.43
21	Chandrakaran	7.03	6.59	9.42	7.68
22	Vellaikolumban	10.40	11.89	12.55	11.61
23	Prior	10.00	12.57	12.60	11.72
24	Muvandan	6.40	7.83	7.55	7.26
	Mean	9.42	10.17	10.36	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.36	0.69	0.48	
	Year x Genotype	NS	1.19	0.84	

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Table 4b. Crown diameter (East-West) (m) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.80	8.87	8.60	8.76
2	Amrapali	8.03	8.67	8.47	8.39
3	Mallika	8.03	8.27	8.13	8.14
4	Ratna	10.27	10.27	10.77	10.43
5	Sindhu	8.07	8.47	8.60	8.38
6	H45	8.50	9.07	8.43	8.67
7	H 151	5.43	5.63	5.63	5.57
8	PKM1	7.13	7.92	7.30	7.45
9	PKM 2	7.57	9.33	7.43	8.11
10	Neelgoa	10.20	10.33	10.27	10.27
11	Banganapalli	8.67	8.77	8.93	8.79
12	Alphonso	7.60	7.80	7.53	7.64
13	Dashehari	6.83	7.10	6.70	6.88
14	Neelum	8.57	7.90	8.53	8.33
15	Himayuddin	6.87	7.20	6.37	6.81
16	Bennet Alphonso	6.93	6.83	6.47	6.74
17	Kalepady	10.20	10.35	10.27	10.27
18	Swarnarekha	8.83	8.70	8.80	8.78
19	Mulgoa	8.17	8.70	8.57	8.48
20	Tholikaippan	5.93	6.10	5.80	5.94
21	Chandrakaran	5.60	6.67	5.67	5.98
22	Vellaikolumban	8.87	8.42	8.70	8.66
23	Prior	11.57	11.57	11.63	11.59
24	Muvandan	6.70	6.57	6.57	6.61
	Mean	8.06	8.31	8.09	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.02	0.52	0.37	
	Year x Genotype	NS	0.90	0.63	

Prior (11.72 m) recorded the highest crown diameter (North-South) followed by Vellaikolumban (11.61 m) among the local types. Muvandan (7.26 m) recorded the lowest value which was on par with Chandrakaran (7.68 m).

The crown diameter (East-West) of mango hybrids were measured and the highest value was registered by Ratna (10.43 m) followed by Neelgoa (10.27 m). H 151(5.57 m) recorded the lowest value from all other hybrids.

Kalepady (10.27 m) recorded the highest value of 10.27 m which was significantly different from the rest of the cultivars, among the parents involved in breeding, whereas the lowest value was registered by Bennet Alphonso (6.74 m) which was on par with Himayuddin (6.81m), Dashehari (6.88 m) and Alphonso (7.64 m).

Prior (11.59 m) recorded the highest crown diameter (East – West) which was significantly different from the other types among the local types, and Tholikaippan recorded the lowest value of 5.94 m which was on par with Chandrakaran (5.98 m) and Muvandan (6.61 m).

4.1.1.5 Crown shape

Different crown shapes like oblong, semi-circular, spreading, broadly pyramidal and spherical were noticed among the varieties/cultivars (Table 5).

Grouping the hybrids, cluster I included trees with oblong crown shape. Cluster II had trees with broadly pyramidal crown shape and cluster III included trees with spherical and broadly pyramidal crown shape (Table 6 and Table 7).

Grouping the parents involved in breeding, cluster I included trees with semicircular, oblong and broadly pyramidal crown shape. Cluster II had trees with drooping crown shape. Cluster III had trees with spherical and oblong crown shape while cluster IV included trees with oblong crown shape (Table 8 and Table 9).

Grouping the local types, cluster I had trees with spherical and oblong crown shape. Cluster II had tree with broadly pyramidal crown shape and cluster III included tree with semicircular crown shape (Table 10 and Table 11).

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Table 5. Crown shape, tree growth habit and foliage density of different mango genotypes

Sl. No.	Genotypes	Crown shape	Tree growth habit	Foliage density
1	Arka Aruna	Oblong	Erect	Dense
2	Amrapali	Oblong	Erect	Dense
3	Mallika	Spherical	Spreading	Dense
4	Ratna	Oblong	Erect	Dense
5	Sindhu	Spherical	Drooping	Dense
6	H45	Broadly pyramidal	Spreading	Dense
7	H 151	Spherical	Spreading	Dense
8	PKM1	Oblong	Erect	Dense
9	PKM 2	Broadly pyramidal	Spreading	Dense
10	Neelgoa	Broadly pyramidal	Erect	Intermediate
11	Banganapalli	Semi circular	Spreading	Dense
12	Alphonso	Oblong	Drooping	Dense
13	Dashehari	Spherical	Erect	Dense
14	Neelum	Oblong	Erect	Intermediate
15	Himayuddin	Oblong	Erect	Intermediate
16	Bennet Alphonso	Oblong	Spreading	Dense
17	Kalepady	Broadly pyramidal	Drooping	Dense
18	Swarnarekha	Oblong	Erect	Dense
19	Mulgoa	Broadly pyramidal	Spreading	Dense
20	Tholikaippan	Spherical	Erect	Dense
21	Chandrakaran	Broadly pyramidal	Drooping	Dense
22	Vellaikolumban	Semi Circular	Spreading	Dense
23	Prior	Oblong	Erect	Dense
24	Muvandan	Oblong	Erect	Dense

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Table 6. Cluster wise listing of hybrids according to tree characters

Clusters		
I	**II**	**III**
Arka Aruna	Neelgoa	Mallika
Amrapali		H 151
Ratna		Sindhu
Pkm 1		H 45
		PKM 2

Table 7. Cluster wise summary statistics of hybrids according to tree characters

Characters	Clusters		
	I	**II**	**III**
Crown shape	Oblong	Broadly pyramidal	Spherical, Broadly pyramidal
Tree growth habit	Erect	Erect	Spreading, Drooping
Foliage density	Dense	Intermediate	Dense

Table 8. Cluster wise listing of parents involved in breeding according to tree characters

Clusters			
I	**II**	**III**	**IV**
Banganapalli	Alphonso	Dashehari	Neelum
Bennet Alphonso	Kalepady	Swarnarekha	Himayuddin
Mulgoa			

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Table 9. Cluster wise summary statistics of parents involved in breeding according to tree characters

Characters	Clusters			
	I	II	III	IV
Crown shape	Semi-circular, Oblong, Broadly pyramidal	Drooping	Spherical, Oblong	Oblong
Tree growth habit	Spreading	Drooping	Erect	Erect
Foliage density	Dense	Dense	Dense	Intermediate

Table 10. Cluster wise listing of local types according to tree characters

Clusters		
I	II	III
Tholikaippan	Chandrakaran	Vellaikolumban
Prior		
Muvandan		

Table 11. Cluster wise summary statistics of local types according to tree characters

Characters	Clusters		
	I	II	III
Crown shape	Spherical, Oblong	Broadly pyramidal	Semi circular
Tree growth habit	Erect	Drooping	Spreading
Foliage density	Dense	Dense	Dense

Plate 2. Mango genotypes Arka Aruna, Amrapali, Mallika, Ratna and Sindhu selected under normal planting system

Plate 3. Mango genotypes H45, H151, PKM1, PKM 2 and Neelgoa selected under normal planting system

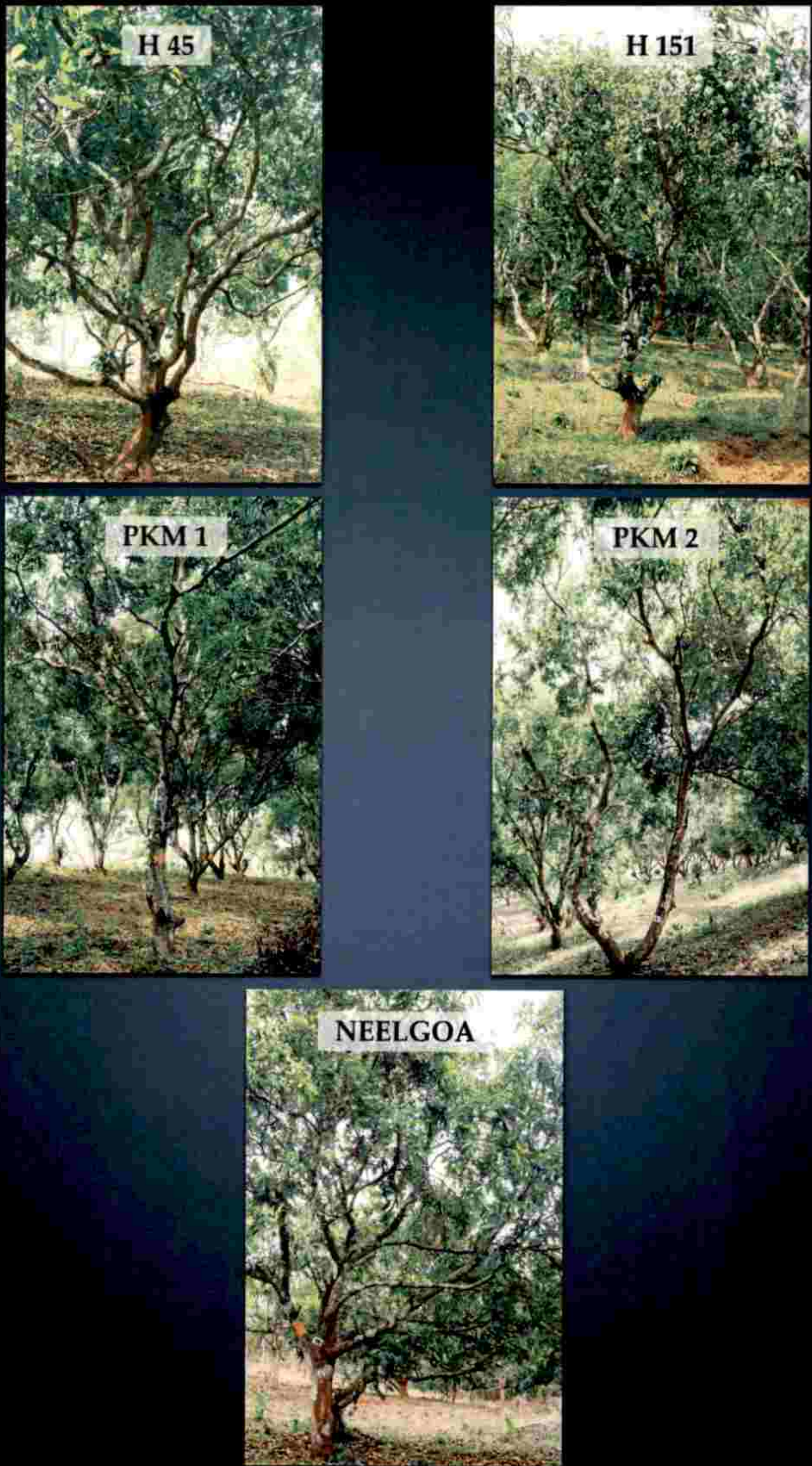

Plate 4. Mango genotypes Banganapalli, Alphonso, Dashehari, Neelum and Himayuddin selected under normal planting system

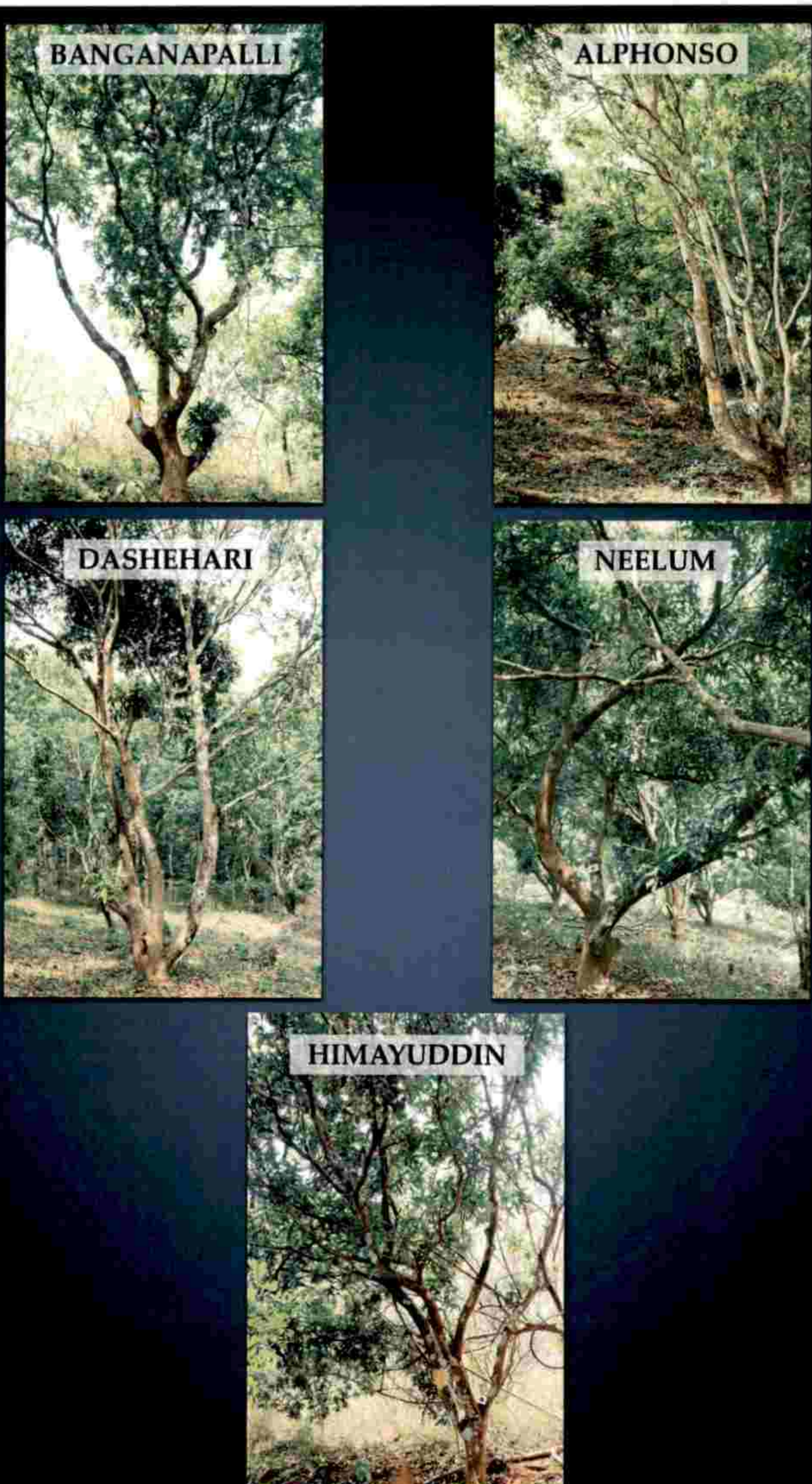

Plate 5. Mango genotypes Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa selected under normal planting system

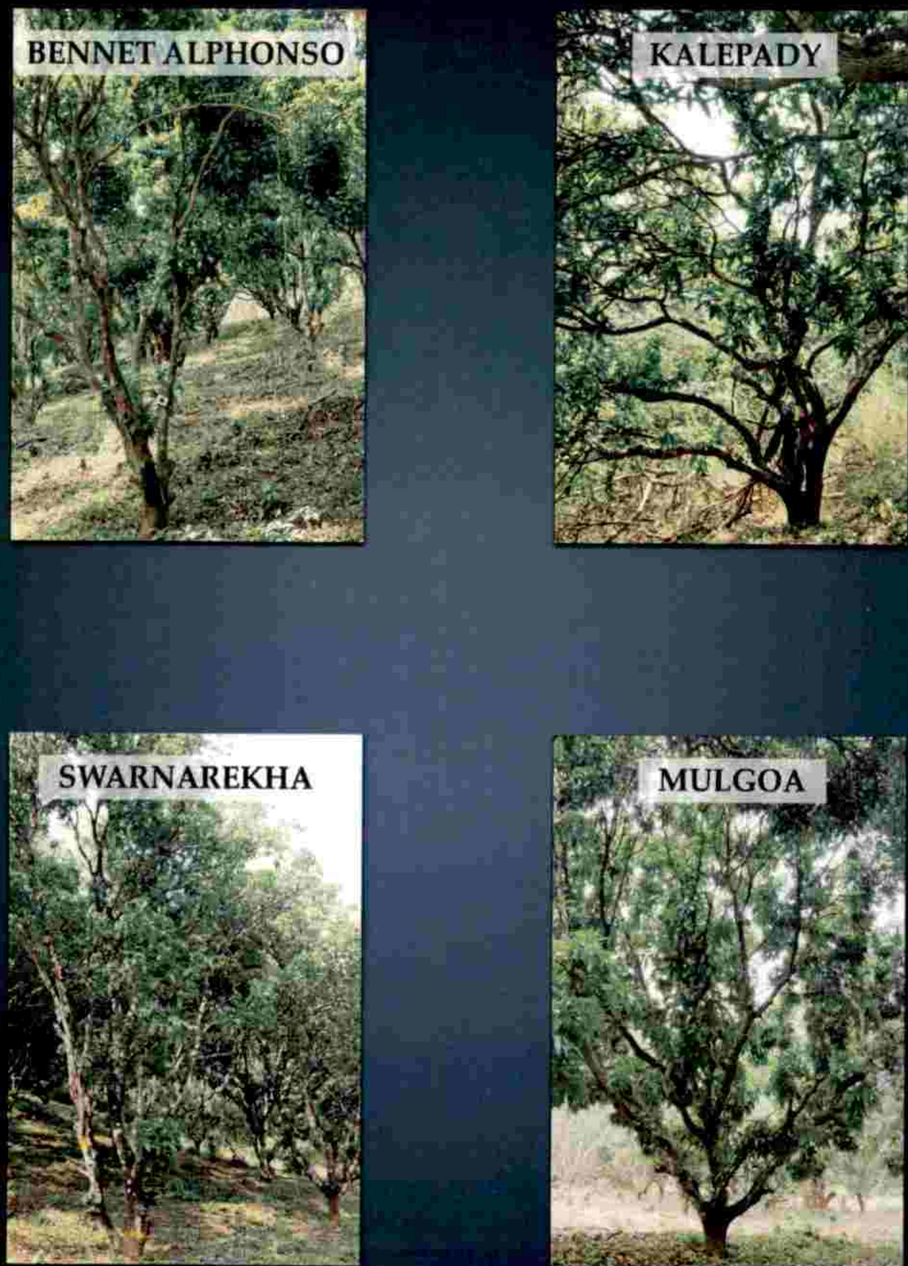

Plate 6. Mango genotypes Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan selected under normal planting system

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4.1.1.6 Tree growth habit

Different tree growth habit like erect, drooping and spreading were noticed among the varieties/cultivars (Table 5).

Grouping the hybrids, cluster I and Cluster II had trees with erect growth habit. Cluster III included trees with spreading and drooping growth habit (Table 6 and Table 7).

Grouping the parents involved in breeding, cluster I included trees with spreading growth habit. Cluster II had trees with drooping growth habit. Cluster III and cluster IV included trees with erect growth habit (Table 8 and Table 9).

Grouping the local types, cluster I had trees with erect growth habit. Cluster II had tree with drooping growth habit and cluster III included tree with spreading growth habit (Table 10 and Table 11).

4.1.1.7 Foliage density

Dense and erect foliage density were noticed among the varieties/cultivars (Table 5).

Grouping the hybrids, cluster I and Cluster III had trees with dense foliage density. Cluster II included tree with intermediate foliage density (Table 6 and Table 7).

Grouping the parents involved in breeding, cluster I, II and III included trees with dense foliage density while cluster III included trees with intermediate foliage density (Table 8 and Table 9).

Grouping the local types, cluster I, II and III included trees with dense foliage density (Table 10 and Table 11).

4.1.2 Leaf characters

4.1.2.1 Leaf blade shape

Elliptic, obovate, ovate, lanceolate and oblong leaf blade shape were noticed among the varieties/cultivars (Table 12).

Grouping the hybrids, cluster I had trees with elliptic leaf blade shape. Cluster II included trees with obovate leaf blade shape, cluster III with ovate leaf blade shape and cluster IV with oblong shapes (Table 13 and Table 14).

Grouping the parents involved in breeding, cluster I and II included trees with oblong leaf blade shape. Cluster I and III included trees with lanceolate leaf blade shape, cluster II included trees with elliptic leaf blade shape and cluster IV had trees with oblanceolate leaf blade shape (Table 15 and Table 16).

Grouping the local types, Cluster I included trees with ovate leaf blade shape, Cluster II with obovate leaf blade shape and cluster III had trees with oblong leaf blade shape (Table 17 and Table 18).

4.1.2.2 Leaf apex shape

Obtuse, acuminate and acute leaf apex shape were noticed among the varieties/cultivars (Table 12).

Grouping the hybrids, cluster I had trees with obtuse leaf apex shape. Cluster II, III and IV included trees with acuminate leaf apex shape, cluster IV and V with acute leaf apex shape (Table 13 and Table 14).

Grouping the parents involved in breeding, cluster I had trees with obtuse leaf apex shape. Cluster II included trees with acute leaf apex shape. Cluster III and IV included trees with acuminate leaf apex shape (Table 15 and Table 16).

Grouping the local types, all the three clusters included trees with acuminate leaf apex shape (Table 17 and Table 18).

4.1.2.3 Leaf base shape

Round, acute and obtuse leaf base shape were noticed among the varieties/cultivars (Table 12).

Grouping the hybrids, cluster I had trees with round leaf base shape. Cluster II and V included trees with acute leaf base shape. Cluster III and IV with obtuse leaf base shape (Table 13 and Table 14).

Grouping the parents involved in breeding, cluster I, II and III had trees with acute leaf base shape. Cluster II, III and IV included trees with obtuse leaf base shape (Table 15 and Table 16).

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Grouping the local types, Cluster I included trees with round leaf base shape, cluster II had trees with acute leaf base shape and cluster III included trees with obtuse leaf base shape (Table 17 and Table 18).

4.1.2.4 Leaf margin

Wavy and entire leaf margin were noticed among the varieties/cultivars (Table 12).

Grouping the hybrids, cluster I, II and III had trees with wavy leaf margin. Cluster II, IV and V included trees with entire leaf margin (Table 13 and Table 14).

Grouping the parents involved in breeding, cluster I, III and IV had trees with entire leaf margin. Cluster I and II included trees wavy leaf margin (Table 15 and Table 16).

Grouping the local types, Cluster I, II and III included trees wavy leaf margin. Cluster III included trees with entire leaf margin (Table 17 and Table 18).

4.1.2.5 Leaf pubescence

Leaf pubescence was absent among all the varieties/cultivars (Table 12).

4.1.2.6 Colour of young leaf

Coppery red, light brick red, reddish brown, light green and coppery tan colour of young leaf were noticed among the varieties/cultivars (Table 12).

Grouping the hybrids, cluster I had trees with coppery red young leaf. Cluster II and IV included trees with light brick red young leaf. Cluster, II and III had trees with reddish brown young leaf. Cluster IV and V had trees with light green young leaves and cluster IV also included trees with coppery tan young leaves (Table 13 and Table 14).

Grouping the parents involved in breeding, cluster I, III and IV had trees with light green young leaf. Cluster II had tress with deep coppery tan young leaf. Cluster II and III had trees with reddish brown young leaf (Table 15 and Table 16).

Table 12. Leaf blade shape, leaf apex shape, leaf base shape, leaf margin, leaf pubescence, colour of young leaf, colour of fully developed leaf and leaf fragrance of different mango genotypes

Sl. No.	Genotypes	Leaf blade shape	Leaf apex shape	Leaf base shape	Leaf margin	Leaf pubescence	Colour of young leaf	Colour of fully developed leaf	Leaf fragrance
1	Arka Aruna	Obovate	Acuminate	Acute	Entire	Absent	Light brick red	Green	Mild
2	Amrapali	Lanceolate	Acuminate	Obtuse	Entire	Absent	Light green	Green	Mild
3	Mallika	Lanceolate	Acuminate	Obtuse	Entire	Absent	Light brick red	Green	Mild
4	Ratna	Obovate	Acuminate	Acute	Wavy	Absent	Reddish brown	Green	Mild
5	Sindhu	Lanceolate	Acute	Obtuse	Entire	Absent	Coppery tan	Green	Mild
6	H45	Lanceolate	Acuminate	Acute	Entire	Absent	Light green	Green	Mild
7	H 151	Ovate	Acuminate	Obtuse	Wavy	Absent	Reddish brown	Green	Mild
8	PKM1	oblong	Acute	Acute	Entire	Absent	Light green	Green	Mild
9	PKM 2	oblong	Acute	Acute	Entire	Absent	Light green	Green	Mild
10	Neelgoa	Elliptic	Obtuse	Round	Wavy	Absent	Coppery red	Green	Mild
11	Banganapalli	oblong	Obtuse	Acute	Entire	Absent	Light green	Green	Mild
12	Alphonso	Lanceolate	Obtuse	Acute	Entire	Absent	Light green	Dark green	Mild
13	Dashehari	Oblong	Acute	Acute	Wavy	Absent	Deep coppery tan	Green	Mild
14	Neelum	Elliptic	Acute	Obtuse	Wavy	Absent	Reddish brown	Green	Mild
15	Himayuddin	oblong	Obtuse	Acute	Wavy	Absent	Light green	Dark green	Mild
16	Bennet Alphonso	Lanceolate	Acuminate	Obtuse	Entire	Absent	Light green	Dark green	Dense
17	Kalepady	Oblanceolate	Acuminate	Obtuse	Entire	Absent	Light green	Green	Mild
18	Swarnarekha	Lanceolate	Acuminate	Acute	Entire	Absent	Reddish brown	Green	Dense
19	Mulgoa	Oblong	Acute	Acute	Wavy	Absent	Reddish brown	Green	Mild
20	Tholikaippan	Ovate	Acuminate	Round	Wavy	Absent	Coppery tan	Dark green	Mild
21	Chandrakaran	Oblong	Acuminate	Obtuse	Wavy	Absent	Light green	Dark green	Mild
22	Vellaikolumban	Oblong	Acuminate	Obtuse	Wavy	Absent	Light green brown tinch	Dark green	Dense
23	Prior	Oblong	Acuminate	Obtuse	Entire	Absent	Coppery tan	Dark green	Dense
24	Muvandan	Obovate	Acuminate	Acute	Wavy	Absent	Coppery tan	Dark green	Dense

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Table 13. Cluster wise listing of hybrids according to leaf characters

Clusters				
I	**II**	**III**	**IV**	**V**
Neelgoa	Arka Aruna	H 151	Amrapali	PKM 1
	Ratna		Mallika	PKM 2
			H 45	
			Sindhu	

Table 14. Cluster wise summary statistics of hybrids according to leaf characters

Characters	**Clusters**				
	I	**II**	**III**	**IV**	**V**
Leaf blade shape	Elliptic	Obovate	Ovate	Lanceolate	Oblong
Leaf apex shape	Obtuse	Acuminate	Acuminate	Acuminate, Acute	Acute
Leaf base shape	Round	Acute	Obtuse	Obtuse	Acute
Leaf margin	Wavy	Entire, Wavy	Wavy	Entire	Entire
Leaf pubescence	Absent	Absent	Absent	Absent	Absent
Colour of young leaf	Coppery red	Light brick red, Reddish brown	Reddish brown	Light green, Light brick red, Coppery tan	Light green
Colour of fully developed leaf	Green	Green	Green	Green	Green
Leaf fragrance	Mild	Mild	Mild	Mild	Mild

Table 15. Cluster wise listing of parents according to leaf characters

Clusters			
I	**II**	**III**	**IV**
Banganappalli	Dashehari	Bennet Alphonso	Kalepady
Alphonso	Mulgoa	Swarnarekha	
Himayuddin	Neelum		

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Table 16. Cluster wise summary statistics of parents according to leaf characters

Characters	Clusters			
	I	II	III	IV
Leaf blade shape	Oblong, Lanceolate	Oblong, Elliptic	Lanceolate	Oblanceolate
Leaf apex shape	Obtuse	Acute	Acuminate	Acuminate
Leaf base shape	Acute	Acute, Obtuse	Obtuse, Acute	Obtuse
Leaf margin	Entire, Wavy	Wavy	Entire	Entire
Leaf pubescence	Absent	Absent	Absent	Absent
Colour of young leaf	Light green	Deep coppery tan, Reddish brown	Light green, Reddish brown	Light green
Colour of fully developed leaf	Green, Dark green	Green	Dark green, Green	Green
Leaf fragrance	Mild	Mild	Dense	Mild

Table 17. Cluster wise listing of local types according to leaf characters

Clusters		
I	II	III
Tholikaippan	Muvandan	Chandrakaran
		Vellaikolumban
		Prior

Table 18. Cluster wise summary statistics of local types according to leaf characters

Characters	Clusters		
	I	II	III
Leaf blade shape	Ovate	Obovate	Oblong
Leaf apex shape	Acuminate	Acuminate	Acuminate
Leaf base shape	Round	Acute	Obtuse
Leaf margin	Wavy	Wavy	Wavy, Entire
Leaf pubescence	Absent	Absent	Absent
Colour of young leaf	Coppery tan	Coppery tan	Light green, Light green brown tinch, Coppery tan
Colour of fully developed leaf	Dark green	Dark green	Dark green
Leaf fragrance	Mild	Dense	Mild, Dense

Grouping the local types, Cluster I, II and III included trees coppery tan young leaf. cluster III also included trees with light green and light green with brown tinch (Table 17 and Table 18).

4.1.2.7 Colour of fully developed leaf

All the hybrids had green color for fully developed leaves (Table 12).

Grouping the parents involved in breeding, cluster I, II, III and IV had trees with green fully developed leaf. Cluster I and III had tress with dark green fully developed leaf (Table 15 and Table 16).

Grouping the local types, Cluster I, II and III included trees dark green fully developed leaf (Table 17 and Table 18).

4.1.2.8 Leaf fragrance

All the hybrids and parents involved in breeding had mild leaf fragrance (Table 12).

Grouping the local types, Cluster I and III included trees with mild leaf fragrance. Cluster II and III had trees with dense leaf fragrance (Table 17 and Table 18).

4.1.2.9 Leaf blade length

The data presented in Table 19 shows the variation in leaf lade length of different genotypes during three seasons. Among the hybrids, Amrapali (29.32 cm) gave significantly higher leaf blade length compared to other hybrids. H 151 (20.24 cm) recorded the lowest leaf blade length which was on par with PKM 1 (20.89 cm), H 45 (21.73 cm) and Sindhu (23.06 cm).

Neelam (25.08 cm) recorded significantly higher leaf blade length followed by Bennet Alphonso (24.60 cm), Alphonso (24.60 cm), Mulgoa (24.50 cm), Swarnarekha (23.78 cm) and Dashehari (21.83 cm) among the parents involved in breeding. Kalepady (21.29 cm) recorded the lowest leaf blade length which was on par with Banganapalli (0.08 cm) and Himayuddin (21.41 cm).

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Table 19. Leaf blade length (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	24.23	27.57	20.33	24.04
2	Amrapali	27.08	30.23	30.63	29.32
3	Mallika	24.56	24.50	24.67	24.58
4	Ratna	22.96	23.53	26.43	24.31
5	Sindhu	25.13	21.17	22.87	23.06
6	H45	26.35	19.23	19.60	21.73
7	H 151	24.18	18.40	18.13	20.24
8	PKM1	24.92	21.33	16.43	20.89
9	PKM 2	23.51	24.20	25.57	24.43
10	Neelgoa	28.27	23.40	23.27	24.98
11	Banganapalli	19.18	23.13	21.80	21.37
12	Alphonso	21.79	26.47	25.53	24.60
13	Dashehari	25.28	18.53	21.67	21.83
14	Neelum	25.08	22.50	27.67	25.08
15	Himayuddin	22.36	21.27	20.60	21.41
16	Bennet Alphonso	27.53	24.13	22.13	24.60
17	Kalepady	23.52	21.57	18.80	21.29
18	Swarnarekha	24.04	25.67	21.63	23.78
19	Mulgoa	25.64	24.67	23.20	24.50
20	Tholikaippan	21.08	22.33	21.67	21.69
21	Chandrakaran	23.03	19.20	17.10	19.78
22	Vellaikolumban	31.08	24.57	23.20	26.28
23	Prior	23.96	24.53	28.20	25.56
24	Muvandan	22.53	25.67	20.03	22.74
	Mean	24.47	23.24	22.55	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.25	1.64	1.16	
	Year x Genotype	5.64	2.85	2.01	

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Vellaikolumban (26.28 cm) gave significantly higher leaf blade length among the local types. Chandrakaran (19.78 cm) recorded the lowest leaf blade length which was on par with Tholikaippan (21.69 cm) and Muvandan (22.74 cm).

4.1.2.10 Leaf blade width

The data presented in Table 20 shows the variation in leaf lade width of different genotypes during three seasons. Amrapali (6.70 cm) recorded significantly higher leaf blade width compared to others hybrids, whereas H 151 (5.29 cm) recorded the lowest leaf blade width.

Neelum (7.13 cm) gave significantly higher leaf blade than all other parents except Banganapalli (5.30 cm) and Alphonso (5.33 cm) which is on par with Kalepady (4.77 cm), which showed the lowest leaf blade width.

Vellaikolumban (8.12 cm) recorded the highest leaf blade width followed by Tholikaippan (7.04 cm) among the local types. Chandrakaran (4.85 cm) recorded the lowest leaf blade width which was on par with Muvandan (5.43 cm).

4.1.2.11 Petiole length

The data presented in Table 21 shows the variation in petiole length of different genotypes during three seasons. Amrapali (3.70 cm) recorded the highest petiole length followed by Ratna (3.66 cm), Sindhu (3.36 cm), Mallika (3.27 cm) and Arka Aruna (3.25 cm) among the hybrids.

Dashehari (3.16) recorded the highest petiole length followed by Alphonso (3.11 cm), Mulgoa (3.01 cm), Neelum (2.90 cm), Kalepady (2.86 cm) and Himayuddin (2.74 cm) among the parents. Banganapalli (2.25 cm) recorded the lowest petiole length which was on par with Bennet Alphonso (2.38 cm).

Tholikaippan recorded the highest petiole length followed by Chandrakaran (3.18 cm) and Vellaikolumban (0.42 cm) among the local types. Muvandan (2.32 cm) recorded the lowest petiole length which was on par with Prior (2.54 cm).

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Table 20. Leaf blade width (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	6.05	7.27	6.13	6.48
2	Amrapali	6.88	6.27	6.97	6.70
3	Mallika	5.75	6.50	6.97	6.41
4	Ratna	6.26	5.67	7.00	6.31
5	Sindhu	5.65	5.93	6.03	5.87
6	H45	7.01	5.07	5.83	5.97
7	H 151	6.47	4.73	4.67	5.29
8	PKM1	5.33	5.23	5.73	5.43
9	PKM 2	5.27	6.60	7.40	6.42
10	Neelgoa	6.16	5.80	6.07	6.01
11	Banganapalli	4.19	6.63	5.07	5.30
12	Alphonso	4.95	5.17	5.87	5.33
13	Dashehari	6.83	6.33	5.43	6.20
14	Neelum	7.11	6.83	7.43	7.13
15	Himayuddin	7.90	5.63	5.07	6.20
16	Bennet Alphonso	5.32	6.23	6.33	5.96
17	Kalepady	4.43	4.93	4.93	4.77
18	Swarnarekha	6.49	5.90	5.53	5.97
19	Mulgoa	6.17	6.07	6.13	6.12
20	Tholikaippan	6.88	7.57	6.67	7.04
21	Chandrakaran	5.46	4.80	4.30	4.85
22	Vellaikolumban	8.33	8.10	7.93	8.12
23	Prior	6.84	6.33	6.80	6.66
24	Muvandan	5.38	5.77	5.13	5.43
	Mean	6.13	6.06	6.06	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.77	0.39	0.28	
	Year x Genotype	1.33	0.67	0.48	

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Table 21. Petiole length (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	3.61	3.23	2.90	3.25
2	Amrapali	3.24	3.37	4.50	3.70
3	Mallika	2.50	3.43	3.87	3.27
4	Ratna	3.24	3.50	4.23	3.66
5	Sindhu	4.44	2.87	2.77	3.36
6	H45	1.38	1.73	1.57	1.56
7	H 151	2.99	2.47	2.77	2.74
8	PKM1	2.38	2.43	3.00	2.60
9	PKM 2	2.23	2.37	2.73	2.44
10	Neelgoa	1.54	1.87	2.13	1.85
11	Banganapalli	2.21	2.10	2.43	2.25
12	Alphonso	2.50	2.83	4.00	3.11
13	Dashehari	3.62	3.57	2.30	3.16
14	Neelum	2.49	3.40	2.80	2.90
15	Himayuddin	2.17	3.30	2.77	2.74
16	Bennet Alphonso	2.27	2.80	2.07	2.38
17	Kalepady	2.40	3.07	3.10	2.86
18	Swarnarekha	2.43	2.90	2.17	2.50
19	Mulgoa	3.02	2.83	3.17	3.01
20	Tholikaippan	3.44	2.90	4.33	3.56
21	Chandrakaran	4.14	3.10	2.30	3.18
22	Vellaikolumban	2.44	3.17	3.80	3.14
23	Prior	1.30	2.83	3.50	2.54
24	Muvandan	2.27	2.80	1.90	2.32
	Mean	2.68	2.87	2.96	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.53	0.27	0.19	
	Year x Genotype	0.92	0.46	0.33	

4.1.3 Inflorescence characters

4.1.3.1 Flowering duration

Different flowering durations like January – February, December – February, December – January, November to January and February – March were noticed among the varieties/cultivars (Table 22a and b).

Grouping the hybrids, cluster I and cluster II included trees with flowering duration from January – February. Cluster III and IV included trees with flowering duration from December - February (Table 23 and Table 24).

Grouping the parents involved in breeding, cluster I had trees with flowering duration from December to February, December to January and November to January. Cluster II included the trees with flowering duration from December-February. Cluster III included the trees with flowering duration from February to March. (Table 25 and Table 26).

Grouping the local types, Cluster I included trees with flowering duration from December to January. Cluster II had trees with flowering duration from January-February. Cluster III had trees with flowering duration from November – January and December – January (Table 27 and Table 28).

4.1.3.2 Secondary/off season flowering

Secondary/off season flowering were absent among all the varieties/cultivars (Table 22 a and b).

4.1.3.3 Inflorescence position

All the hybrids trees had terminal inflorescence position (Table 22 a and b).

Grouping the parents involved in breeding, cluster I, II and III had trees with terminal inflorescence position and cluster I also included trees with both terminal and axillary inflorescence position (Table 25 and Table 26).

Grouping the local types, Cluster I, II and III included trees with terminal inflorescence position. Cluster III included trees with both terminal and axillary inflorescence position (Table 27 and Table 28).

4.1.3.4 Inflorescence shape

Broadly pyramidal, pyramidal and conical inflorescence shape were noticed among the varieties/cultivars (Table 22 a and b).

Grouping the hybrids, cluster I, II and III included trees with broadly pyramidal inflorescence shape, cluster I and IV included trees with pyramidal inflorescence shape. Cluster I and IV included trees with conical inflorescence shape (Table 23 and Table 24).

Grouping the parents involved in breeding, cluster I had trees with conical and pyramidal inflorescence shape. Cluster II had trees with pyramidal inflorescence shape and cluster III included trees with broadly pyramidal and conical inflorescence shape (Table 25 and Table 26).

Grouping the local types, all the clusters included trees with conical inflorescence shape (Table 27 and Table 28).

4.1.3.5 Density of flowers in the inflorescence

Sparse, medium and dense flowers were observed among the inflorescence of different varieties/cultivars (Table 22 a and b).

Grouping the hybrids, cluster I had trees with sparse density of flowers. Cluster I and III included trees with medium density of flowers. Cluster II and IV included trees with dense flowers in the inflorescence (Table 23 and Table 24).

Grouping the parents involved in breeding, cluster I had trees medium and dense flowers in the inflorescence. Cluster II and III had tress with dense flowers in the inflorescence (Table 25 and Table 26).

Grouping the local types, cluster I and II included dense flowers in the inflorescence. Cluster III included trees with sparse flowers in the inflorescence (Table 27 and Table 28).

4.1.3.6 Inflorescence colour

Yellowish green, yellow, light green and greenish with red patches were the inflorescence colour observed among the different varieties/cultivars (Table 22 a and b).

Grouping the hybrids, cluster I had trees with yellowish green inflorescence colour, cluster II had trees with yellow inflorescence colour, cluster III included trees with light green inflorescence colour and cluster IV had trees with greenish with red patched inflorescence colour (Table 23 and Table 24).

Grouping the parents involved in breeding, cluster I had trees with yellow, greenish with red patch, yellowish green and greenish with red patch inflorescence colour. Cluster II had tress with light red inflorescence colour. Cluster II had tees with yellow and greenish with red patch inflorescence colour (Table 25 and Table 26).

Grouping the local types, cluster I, II and III included trees with light greenish with red patches inflorescence. Cluster I also included trees with yellow inflorescence colour. Cluster III included trees with greenish inflorescence colour (Table 27 and Table 28).

4.1.3.7 Length of stamen in relation to pistil

All the hybrids/parents involved in breeding had equal length of stamen in relation to pistil (Table 22). All the local types had shorter stamen in relation to pistil.

4.1.3.8 Nature of disc

All the hybrids/parents involved in breeding had swollen disc which was border than ovary (Table 22 a and b). All the local types had trees with narrow, reduced or the discs are even absent.

Table 22a. Flowering duration, secondary/off season flowering, inflorescence position, inflorescence shape, density of flowers in the inflorescence, inflorescence colour, length of stamen in relation to pistil, nature of disc of different mango genotypes

Sl. No	Genotypes	Flowering duration	Secondary/off season flowering	Inflorescence position	Inflorescence shape	Density of flowers in the inflorescence	Inflorescence colour	Length of stamen in relation to pistil	Nature of disc
1	Arka Aruna	Jan - Feb	Absent	Terminal	Broadly pyramidal	Sparse	Yellowish green	Equal	Swollen, broader than ovary
2	Amrapali	Dec - Jan	Absent	Terminal	Broadly pyramidal	Medium	Light green	Equal	Swollen, broader than ovary
3	Mallika	Jan - Feb	Absent	Terminal	Pyramidal	Medium	Yellowish green	Equal	Swollen, broader than ovary
4	Ratna	Jan - Feb	Absent	Terminal	Conical	Dense	Green with red patches	Equal	Swollen, broader than ovary
5	Sindhu	Jan - Feb	Absent	Terminal	Conical	Medium	Yellowish green	Equal	Swollen, broader than ovary
6	H45	Dec -Jan	Absent	Terminal	Pyramidal	Dense	Greenish with red patch	Equal	Swollen, broader than ovary
7	H 151	Nov 24 - Jan	Absent	Terminal	Conical	Dense	Greenish with red patch	Equal	Swollen, broader than ovary
8	PKM1	Dec -Feb	Absent	Terminal	Conical	Dense	Greenish with red patch	Equal	Swollen, broader than ovary
9	PKM 2	Jan - Feb	Absent	Terminal	Broadly pyramidal	Dense	Yellow	Equal	Swollen, broader than ovary
10	Neelgoa	Jan - Feb	Absent	Terminal	Broadly pyramidal	Dense	Yellow	Equal	Swollen, broader than ovary
11	Banganapalli	Dec - Feb	Absent	Terminal	Conical	Medium	Yellow	Equal	Swollen, broader than ovary
12	Alphonso	Dec- Feb	Absent	Terminal	Pyramidal	Dense	Light red	Equal	Swollen, broader than ovary
13	Dashehari	Feb -Mar	Absent	Terminal	Broadly pyramidal	Dense	Yellow	Equal	Swollen, broader than ovary

Table 22b. Flowering duration, secondary/off season flowering, inflorescence position, inflorescence shape, density of flowers in the inflorescence, inflorescence colour, length of stamen in relation to pistil, nature of disc of different mango genotypes

Sl. No	Genotypes	Flowering duration	Secondary/off season flowering	Inflorescence position	Inflorescence shape	Density of flowers in the inflorescence	Inflorescence colour	Length of stamen in relation to pistil	Nature of disc
14	Neelum	Feb -Mar	Absent	Terminal	Conical	Dense	Greenish with red patch	Equal	Swollen, broader than ovary
15	Himayuddin	Dec - Jan	Absent	Terminal	Conical	Sparse	Greenish with red patch	Equal	Swollen, broader than ovary
16	Bennet Alphonso	Nov- Jan	Absent	Terminal and axillary	Conical	Sparse	Yellowish green	Equal	Swollen, broader than ovary
17	Kalepady	Dec - jan	Absent	Terminal and axillary	Pyramidal	Sparse	Greenish with red patch	Equal	Swollen, broader than ovary
18	Swarnarekha	Dec - Jan	Absent	Terminal	Conical	Sparse	Yellow	Equal	Swollen, broader than ovary
19	Mulgoa	Dec - Jan	Absent	Terminal	Conical	Medium	Yellow	Equal	Swollen, broader than ovary
20	Tholikaippan	Dec-Jan	Absent	Terminal	Conical	Dense	Yellow	Shorter	Narrow, reduced or absent
21	Chandrakaran	Dec - Jan	Absent	Terminal	Conical	Dense	Light greenish with red patches	Shorter	Narrow, reduced or absent
22	Vellaikolumban	Nov - Jan	Absent	Terminal	Conical	Sparse	Light greenish with red patches	Shorter	Narrow, reduced or absent
23	Prior	Dec - Jan	Absent	Terminal and axillary	Conical	Sparse	Greenish	Shorter	Narrow, reduced or absent
24	Muvandan	Jan - Feb	Absent	Terminal	Conical	Dense	Light greenish with red patches	Shorter	Narrow, reduced or absent

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Table 23. Cluster wise listing of hybrids according to inflorescence characters

Clusters			
I	**II**	**III**	**IV**
Arka Aruna	PKM 2	Amrapali	Ratna
Mallika	Neelgoa		H 151
Sindhu			PKM 1
			H 45

Table 24. Cluster wise summary statistics of hybrids according to inflorescence characters

Characters	Clusters			
	I	**II**	**III**	**IV**
Flowering duration	Jan - Feb	Jan - Feb	Dec - Jan	Dec -Feb
Secondary/off season flowering	Absent	Absent	Absent	Absent
Inflorescence position	Terminal	Terminal	Terminal	Terminal
Inflorescence shape	Broadly pyramidal, Pyramidal, Conical	Broadly pyramidal	Broadly pyramidal	Conical, Pyramidal
Density of flowers in the inflorescence	Sparse, Medium	Dense	Medium	Dense
Inflorescence colour	Yellowish green	Yellow	Light green	Greenish with red patches
Length of stamen in relation to pistil	Equal	Equal	Equal	Equal
Nature of disc	Swollen, broader than ovary	Swollen, broader than ovary	Swollen, broader than ovary	Swollen, broader than ovary

Table 25. Cluster wise listing of parents according to inflorescence characters

Clusters		
I	**II**	**III**
Banganapalli	Alphonso	Dashehari
Mulgoa		Neelum
Swarnarekha		
Himayuddin		
Kalepady		
Bennet Alphonso		

Table 26. Cluster wise summary statistics of parents according to inflorescence characters

Characters	Clusters		
	I	II	III
Flowering duration	Dec – Feb, Dec – Jan, Nov- Jan	Dec- Feb	Feb -Mar
Secondary/off season flowering	Absent	Absent	Absent
Inflorescence position	Terminal, Terminal and axillary	Terminal	Terminal
Inflorescence shape	Conical, Pyramidal	Pyramidal	Broadly pyramidal, Conical
Density of flowers in the inflorescence	Medium, Sparse	Dense	Dense
Inflorescence colour	Yellow, Greenish with red patch, Yellowish green, Greenish with red patch	Light red	Yellow, Greenish with red patch
Length of stamen in relation to pistil	Equal	Equal	Equal
Nature of disc	Swollen, broader than ovary	Swollen, broader than ovary	Swollen, broader than ovary

Table 27. Cluster wise listing of local types according to inflorescence characters

Clusters		
I	II	III
Tholikaippan	Muvandan	Vellaikolumban
Chandrakaran		Prior

Table 28. Cluster wise summary statistics of local types according to inflorescence characters

Characters	Clusters		
	I	II	III
Flowering duration	Dec-Jan	Jan - Feb	Nov – Jan, Dec - Jan
Secondary/off season flowering	Absent	Absent	Absent
Inflorescence position	Terminal	Terminal	Terminal, Terminal and axillary
Inflorescence shape	Conical	Conical	Conical
Density of flowers in the inflorescence	Dense	Dense	Sparse
Inflorescence colour	Yellow, Light greenish with red patches	Light greenish with red patches	Light greenish with red patches, Greenish
Length of stamen in relation to pistil	Shorter	Shorter	Shorter
Nature of disc	Narrow, reduced or absent	Narrow, reduced or absent	Narrow, reduced or absent

Plate 8. Variations in inflorescence characters of mango genotypes Arka Aruna, Amrapali, Mallika, Ratna and Sindhu selected under normal planting system

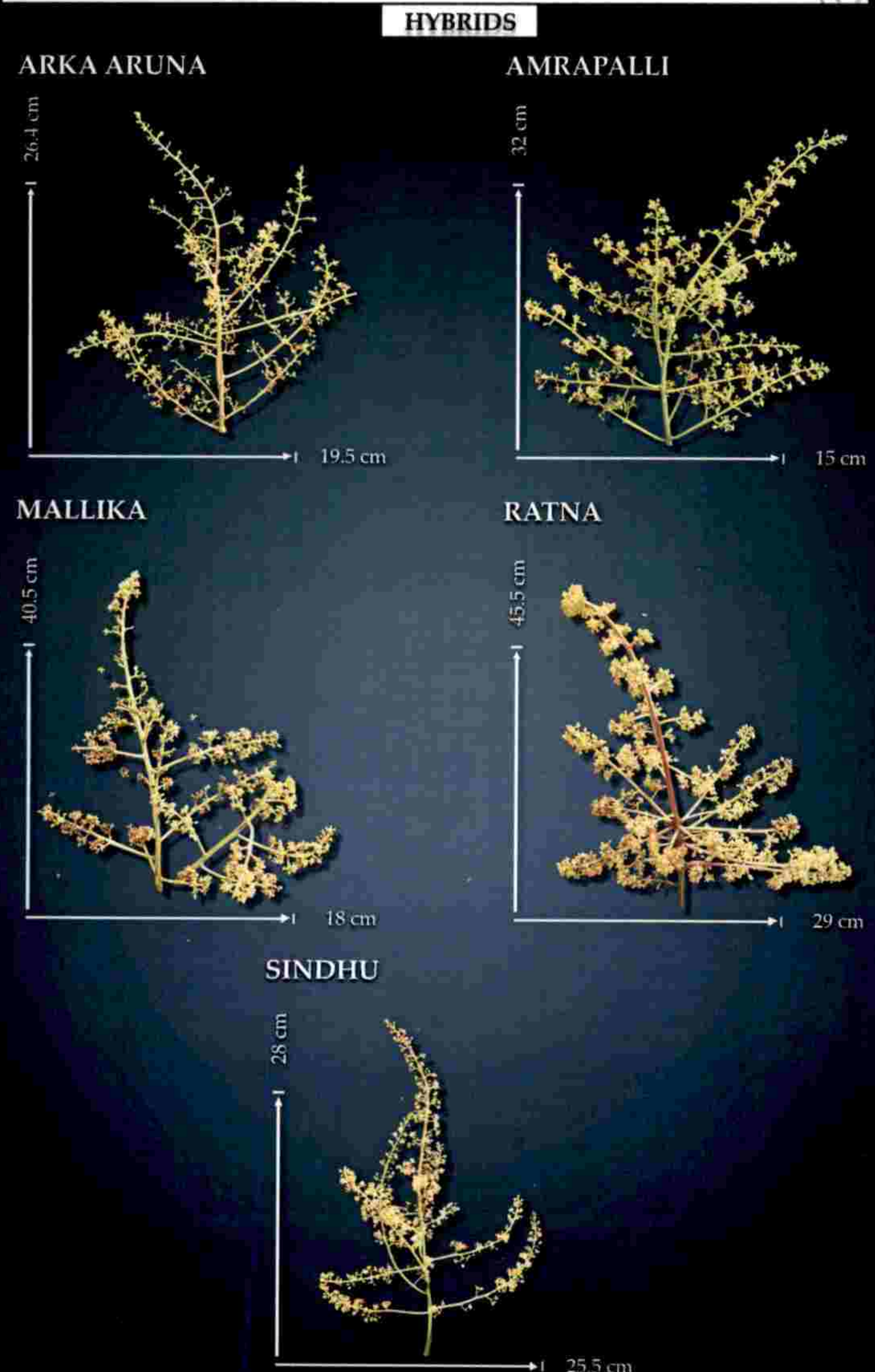


Plate 9. Variations in inflorescence characters of mango genotypes H45, H151, PKM1, PKM 2 and Neelgoa selected under normal planting system

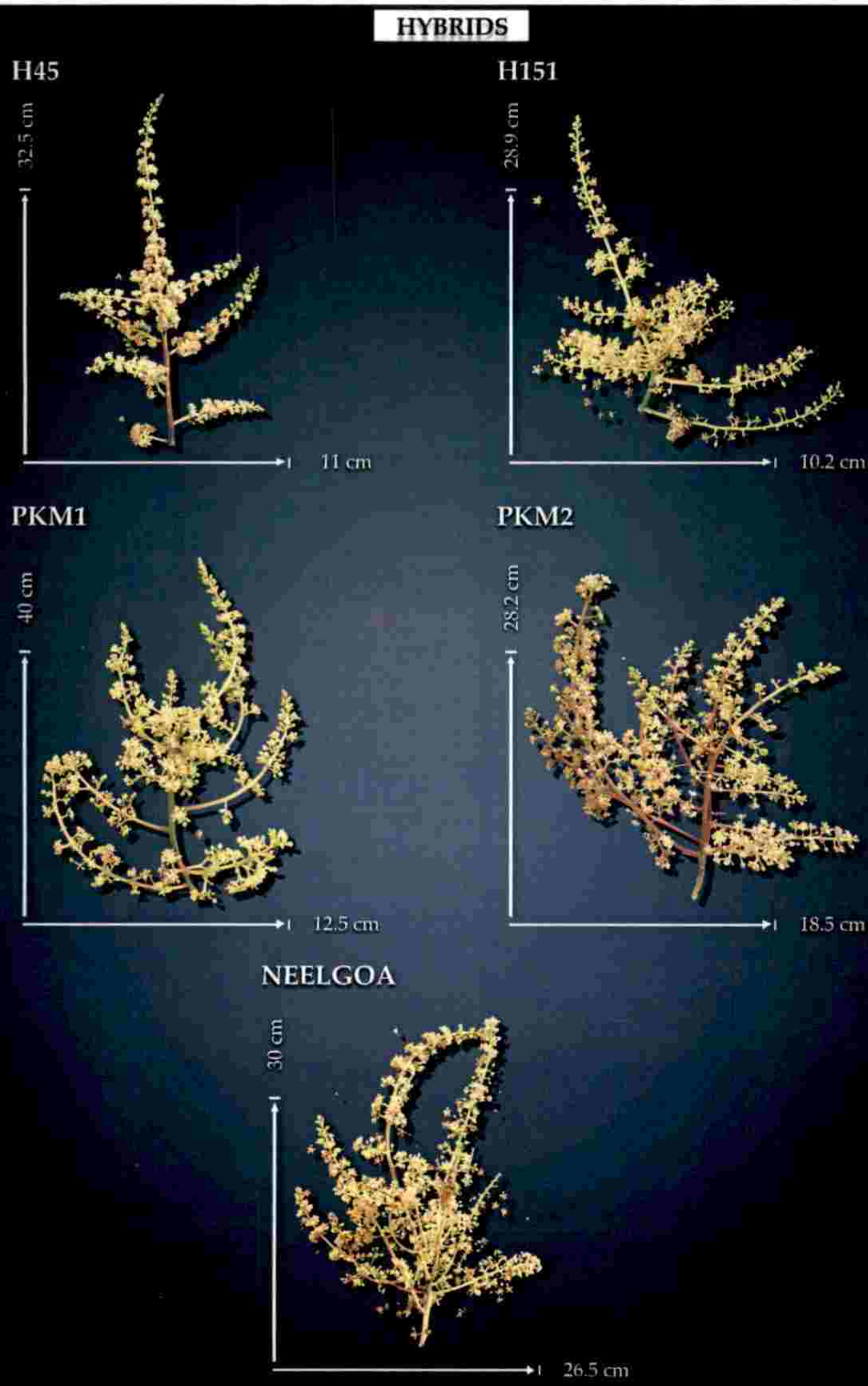


Plate 10. Variations in inflorescence characters of mango genotypes Banganapalli, Alphonso, Dashehari, Neelum and Himayuddin selected under normal planting system

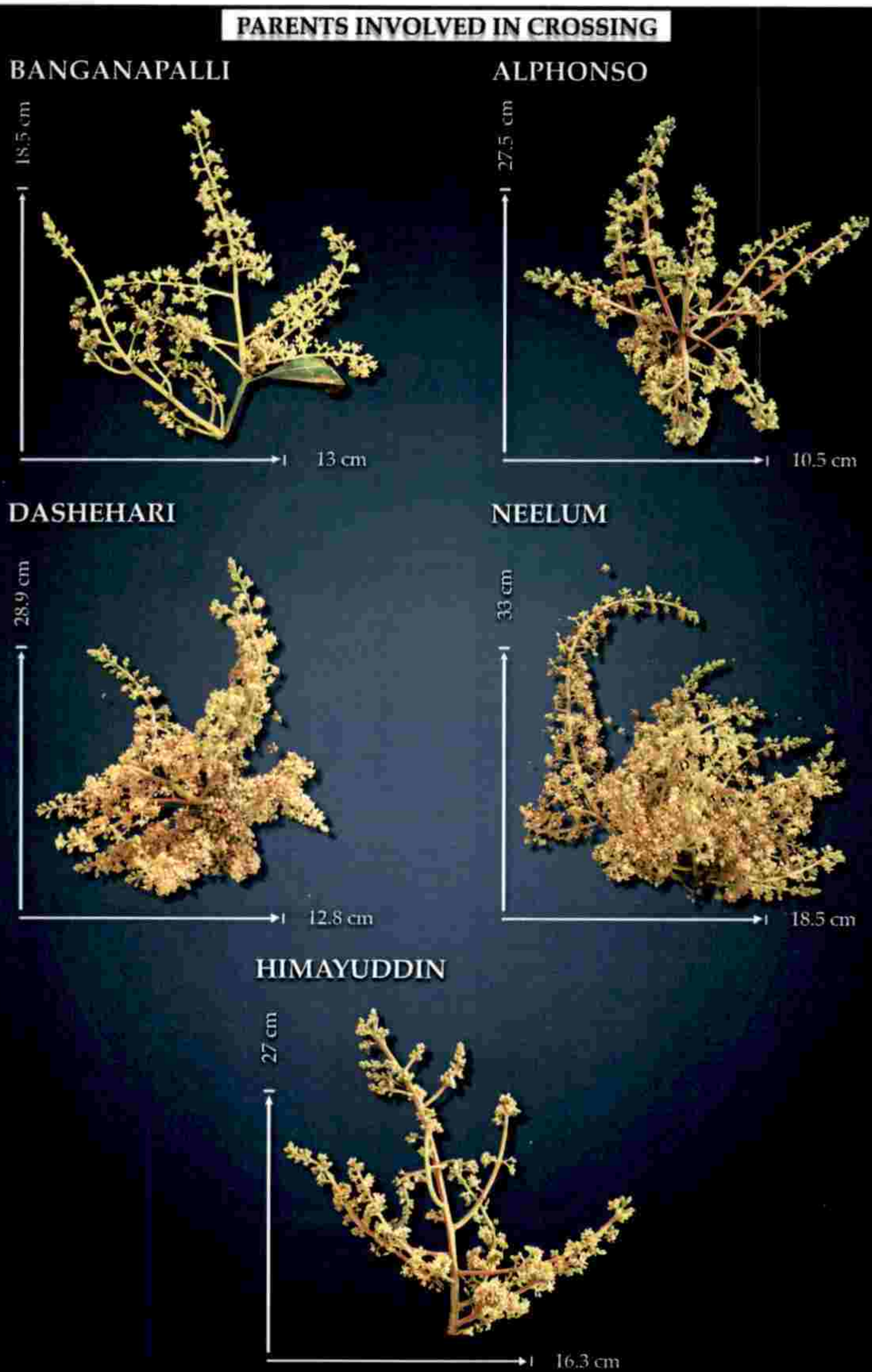


Plate 11. Variations in inflorescence characters of mango genotypes Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa selected under normal planting system

PARENTS INVOLVED IN CROSSING

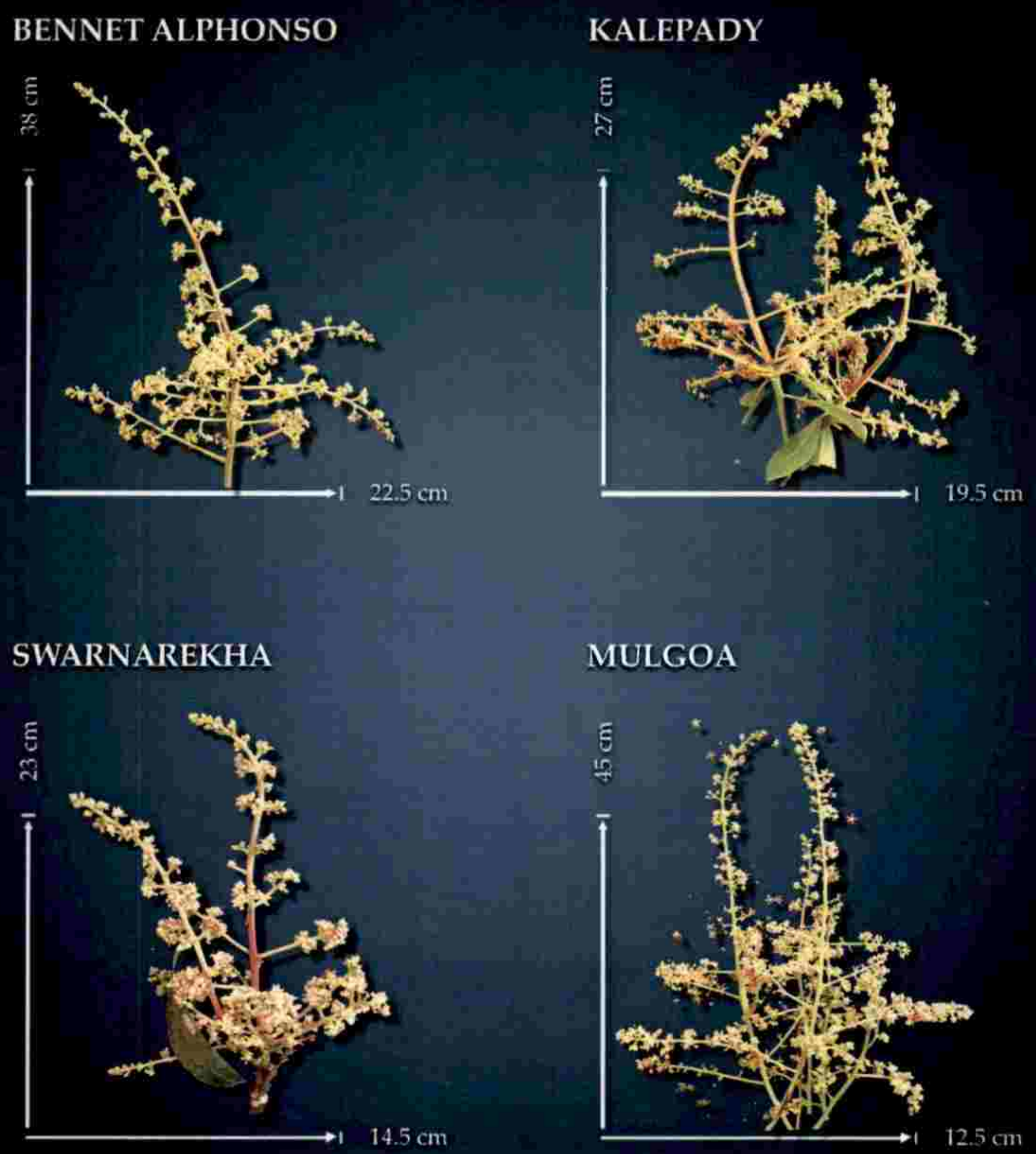
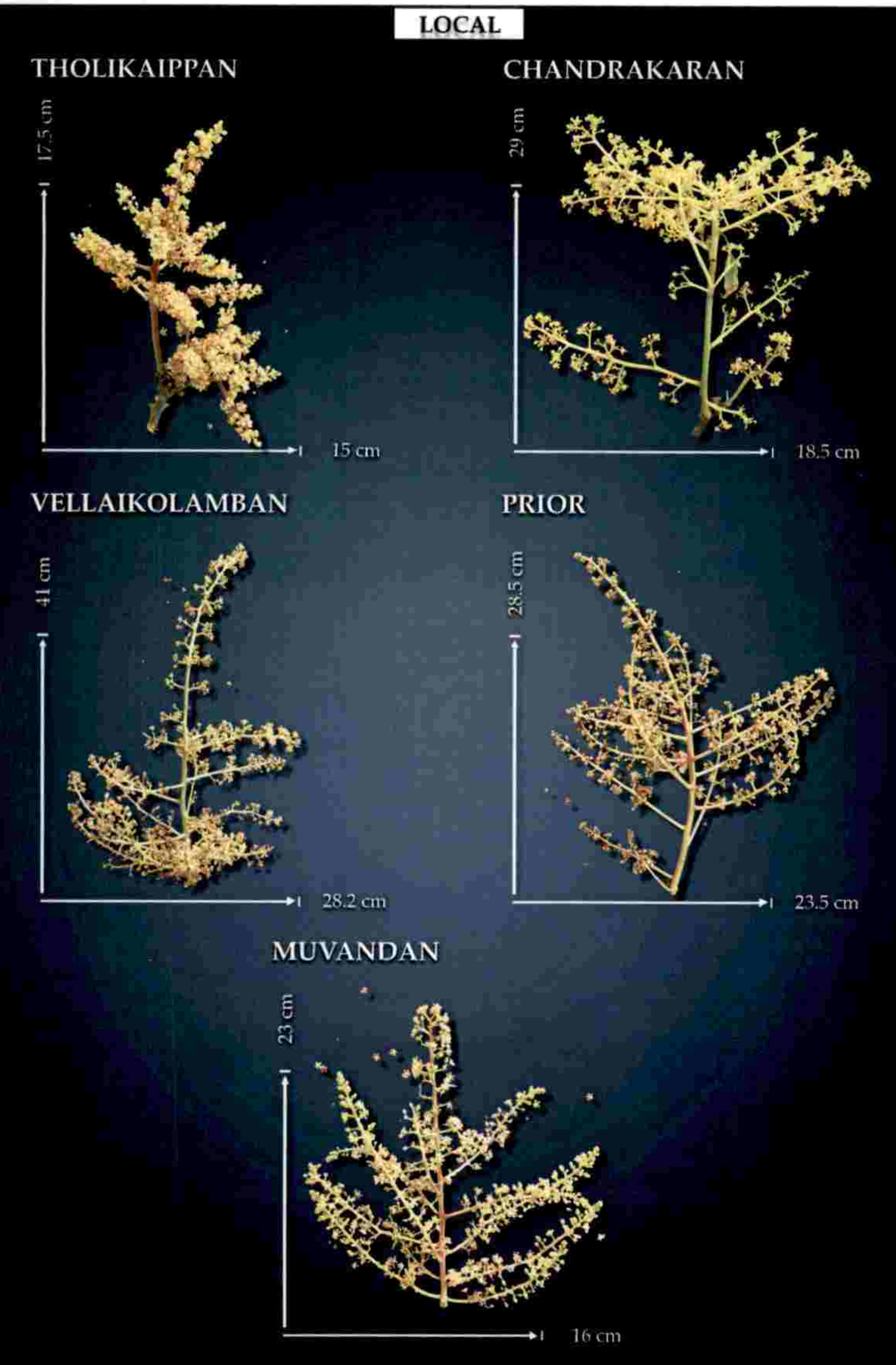


Plate 12. Variations in inflorescence characters of mango genotypes Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan selected under normal planting system



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4.1.3.10 Inflorescence length

The data presented in Table 29a shows the variation in inflorescence length of different genotypes during the two seasons. Sindhu (33.45 cm) recorded the highest inflorescence length followed by Mallika (30.18 cm), Ratna (29.63 cm), H 151 (28.90 cm), Amrapali (28.53 cm), Neelgoa (28.43 cm) and H 45 (28.30 cm) among the hybrids. PKM 2 (22.22) recorded the lowest inflorescence length which was on par with Arka Aruna (233.43 cm) and PKM 1 (24.58cm).

Bennet Alphonso (42.42 cm) recorded the highest inflorescence length followed by Mulgoa (34.20 cm) among the parents. Dashehari (12.58 cm) recorded the lowest inflorescence length which was on par with Banganapalli (14.55 cm).

Vellaikolumban (36.87 cm) recorded the highest inflorescence length followed by Chandrakaran (30.98 cm) among the local types. The lowest value was recorded by Tholikaippan (22.35 cm) which was on par with Muvandan (22.95 cm) and Prior (26.18 cm).

The data presented in Table 29b shows the variation in inflorescence length of different genotypes during the three seasons. H 151 recorded the highest inflorescence length followed by Ratna (26.76 cm) and H 45 (25.84 cm). PKM 2 (20.78 cm) recorded the lowest inflorescence length among the hybrids.

Mulgoa (34.71 cm) recorded the highest inflorescence length followed by Bennet Alphonso (34.13 cm) among the parents involved in breeding. Banganapalli (13.87 cm) recorded the lowest inflorescence length.

Chandrakaran (28.14 cm) recorded the highest inflorescence length among the local types and Prior (25.52 cm) recorded the lowest inflorescence length (25.52 cm).

4.1.3.11 Inflorescence width

The data presented in Table 30a shows the variation in inflorescence length of different genotypes during the two seasons. Ratna (25.33 cm) recorded the highest inflorescence width followed by Sindhu (24.80 cm) among the hybrids. Pkm 1 (12.92 cm) recorded the lowest inflorescence width followed by Pkm 2 (13.42 cm), Amrapali (14.03 cm) and H 151 (14.33 cm).

Bennet Alphonso (20.83 cm) recorded the highest inflorescence width followed by Swarnarekha (20.23 cm), Kalepady (18.03 cm) and Himayuddin (17.35 cm) among the parents involved in breeding. Dashehari (9.32 cm) recorded the lowest inflorescence length which was on par with Alphonso (9.83 cm).

Vellaikolumban (30.40 cm) recorded the highest inflorescence width which was significantly different from the rest of the local types. Chandrakaran (11.65 cm) recorded the lowest inflorescence width followed by Tholikaippan (13.30 cm) and Muvandan (15.22 cm) among the local types.

The data presented in Table 30b shows the variation in inflorescence width of different genotypes during the three seasons. Ratna (23.57 cm) recorded the highest inflorescence width which was significantly different from the other hybrids. Pkm 2 (13.40 cm) recorded the lowest inflorescence width among the hybrids.

Bennet Alphonso (20.56 cm) recorded the highest inflorescence width followed by Swarnarekha (19.34 cm) among the parents involved in breeding. Alphonso (10.12) recorded the lowest inflorescence width.

Prior (19.99 cm) recorded the highest inflorescence width and Chandrakaran (10.86 cm) recorded the lowest inflorescence width among the local types.

4.1.3.12 Hermaphrodite flowers in the inflorescence

The data presented in Table 31a shows the variation in inflorescence length of different genotypes during the two seasons. Among the hybrids, PKM 1 (66.67 %) recorded the highest hermaphrodite flowers in the inflorescence which is significantly different form the rest of the hybrids other than H 151 (37.00 %). H 151 (37.00 %) recorded the lowest hermaphrodite flowers in the inflorescence.

Neelam (67.83%) recorded the highest hermaphrodite flowers in the inflorescence followed by Bennet Alphonso (62.33%), Dashehari (58.83%) and Himayuddin (57.67%) among the parents involved in breeding. Mulgoa (14.00%) recorded the lowest hermaphrodite flowers in the inflorescence.

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Table 29a. Inflorescence length (cm) of different mango genotypes

Sl. No.	Genotypes	YEAR		Mean
		2016-17	2017-18	
1	Arka Aruna	21.97	24.90	23.43
2	Amrapali	29.83	27.23	28.53
3	Mallika	30.67	29.70	30.18
4	Ratna	35.50	23.77	29.63
5	Sindhu	32.00	34.90	33.45
6	H 45	33.00	23.60	28.30
7	H 151	25.70	32.10	28.90
8	PKM1	21.43	27.73	24.58
9	PKM 2	21.60	22.83	22.22
10	Neelgoa	25.17	31.70	28.43
11	Banganapalli	12.13	16.97	14.55
12	Alphonso	23.03	19.67	21.35
13	Dashehari	12.27	12.90	12.58
14	Neelum	17.47	31.67	24.57
15	Himayuddin	24.57	25.17	24.87
16	Bennet Alphonso	33.97	34.87	34.42
17	Kalepady	24.87	30.60	27.73
18	Swarnarekha	25.17	27.40	26.28
19	Mulgoa	36.33	32.07	34.20
20	Tholikaippan	19.67	25.03	22.35
21	Chandrakaran	32.97	29.00	30.98
22	Vellaikolumban	37.33	36.40	36.87
23	Prior	28.37	24.00	26.18
24	Muvandan	22.23	23.67	22.95
	Mean	26.14	26.99	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	5.46	2.75	1.94
	Year x Genotype	7.73	3.89	2.75

Table 29b. Inflorescence length (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	24.97	21.97	24.90	23.94
2	Ratna	21.00	35.50	23.77	26.76
3	H 45	20.93	33.00	23.60	25.84
4	H 151	26.63	25.70	32.10	28.14
5	PKM 2	17.90	21.60	22.83	20.78
6	Banganappalli	12.50	12.13	16.97	13.87
7	Alphonso	28.87	23.03	19.67	23.86
8	Himayuddin	23.77	24.57	25.17	24.50
9	Bennet Alphonso	33.57	33.97	34.87	34.13
10	Swarnarekha	22.37	25.17	27.40	24.98
11	Mulgoa	35.73	36.33	32.07	34.71
12	Chandrakaran	22.47	32.97	29.00	28.14
13	Prior	24.20	28.37	24.00	25.52
	Mean	24.22	27.25	25.87	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.56	1.79	1.26	
	Year x Genotype	6.17	3.09	2.19	

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Table 30a. Inflorescence width (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	18.43	17.00	17.72
2	Amrapali	11.00	17.07	14.03
3	Mallika	17.00	18.77	17.88
4	Ratna	26.17	24.50	25.33
5	Sindhu	20.67	28.93	24.80
6	H45	17.10	18.67	17.88
7	H 151	14.40	14.27	14.33
8	PKM1	12.50	13.33	12.92
9	PKM 2	11.83	15.00	13.42
10	Neelgoa	19.83	21.10	20.47
11	Banganapalli	11.67	16.40	14.03
12	Alphonso	8.83	10.83	9.83
13	Dashehari	9.27	9.37	9.32
14	Neelum	10.70	16.90	13.80
15	Himayuddin	16.77	17.93	17.35
16	Bennet Alphonso	20.80	20.87	20.83
17	Kalepady	17.57	18.50	18.03
18	Swarnarekha	17.97	22.50	20.23
19	Mulgoa	14.50	15.77	15.13
20	Tholikaippan	12.33	14.27	13.30
21	Chandrakaran	10.70	12.60	11.65
22	Vellaikolumban	27.93	32.87	30.40
23	Prior	21.93	19.43	20.68
24	Muvandan	15.07	15.37	15.22
	Mean	16.04	18.01	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	3.74	1.88	1.33
	Year x Genotype	NS	2.66	1.88

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Table 30b. Inflorescence width (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	17.13	18.43	17.00	17.52
2	Ratna	20.03	26.17	24.50	23.57
3	H 45	16.43	17.10	18.67	17.40
4	H 151	15.73	14.40	14.27	14.80
5	Pkm 2	13.37	11.83	15.00	13.40
6	Banganapalli	11.87	11.67	16.40	13.31
7	Alphonso	10.70	8.83	10.83	10.12
8	Himayuddin	16.47	16.77	17.93	17.06
9	Bennet Alphonso	20.00	20.80	20.87	20.56
10	Swarnarekha	17.57	17.97	22.50	19.34
11	Mulgoa	16.27	14.50	15.77	15.51
12	Chandrakaran	9.27	10.70	12.60	10.86
13	Prior	18.60	21.93	19.43	19.99
	Mean	15.65	16.24	17.37	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.78	1.40	0.99	
	Year x Genotype	NS	2.42	1.71	

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Table 31a. Hermaphrodite flowers in the inflorescence (%) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	61.67	55.67	58.67
2	Amrapali	34.00	63.33	48.67
3	Mallika	63.00	52.00	57.50
4	Ratna	29.67	73.33	51.50
5	Sindhu	59.33	69.00	64.17
6	H45	37.67	62.00	49.83
7	H 151	18.67	55.33	37.00
8	PKM1	70.00	63.33	66.67
9	PKM 2	41.67	54.33	48.00
10	Neelgoa	66.67	28.67	47.67
11	Banganapalli	49.00	37.00	43.00
12	Alphonso	30.00	59.00	44.50
13	Dashehari	47.67	70.00	58.83
14	Neelum	77.00	58.67	67.83
15	Himayuddin	46.33	57.00	51.67
16	Bennet Alphonso	72.67	52.00	62.33
17	Kalepady	50.00	38.67	44.33
18	Swarnarekha	37.33	46.00	41.67
19	Mulgoa	11.33	16.67	14.00
20	Tholikaippan	50.33	62.00	56.17
21	Chandrakaran	56.00	37.00	46.50
22	Vellaikolumban	59.33	48.00	53.67
23	Prior	67.33	66.67	67.00
24	Muvandan	12.67	29.00	20.83
	Mean	47.89	52.28	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	20.74	10.43	7.38
	Year x Genotype	29.33	14.75	10.43

Table 31b. Hermaphrodite flowers in the inflorescence (%) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	46.67	61.67	55.67	54.67
2	Ratna	20.67	29.67	73.33	41.22
3	H 45	66.33	37.67	62.00	55.33
4	H 151	29.67	18.67	55.33	34.56
5	PKM 2	47.67	41.67	54.33	47.89
6	Banganapalli	38.67	49.00	37.00	41.56
7	Alphonso	42.00	30.00	59.00	43.67
8	Himayuddin	29.33	46.33	57.00	44.22
9	Bennet Alphonso	73.00	72.67	52.00	65.89
10	Swarnarekha	29.67	37.33	46.00	37.67
11	Mulgoa	9.33	11.33	16.67	12.44
12	Chandrakaran	61.67	56.00	37.00	51.56
13	Prior	52.67	67.33	66.67	62.22
	Mean	42.10	43.03	51.69	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	15.02	7.53	5.33	
	Year x Genotype	26.02	13.04	9.22	

Prior (67.00%) recorded the highest hermaphrodite flowers in the inflorescence followed by the rest of the hybrids except Muvandan (20.83%) among the local types. Muvandan (20.83%) recorded the lowest hermaphrodite flowers in the inflorescence.

The data presented in Table 31b shows the variation in inflorescence width of different genotypes during the three seasons. Among the hybrids, H 45 (55.33%) recorded the highest hermaphrodite flowers in the inflorescence followed by the rest of the hybrids. H 151 (34.56%) recorded the lowest hermaphrodite flowers in the inflorescence.

Bennet Alphonso (65.89%) recorded the highest number of hermaphrodite flowers in the inflorescence which is significantly different from the rest of the parents involved in breeding. Mulgoa (12.44%) recorded the lowest hermaphrodite flowers in the inflorescence.

Prior (62.22%) recorded the highest hermaphrodite flowers in the inflorescence which was significantly different from the rest of the local types, Chandrakaran (51.56%) recorded the lowest hermaphrodite flowers in the inflorescence.

4.1.3.13 Number of stamens per flower

The data presented in Table 32 shows the variation in number of stamens per flower. All the hybrids had 5 number of stamens of which 1 or 2 may be fertile whereas Ratna, H 45 and H 151 recorded 4 number of stamens per flower. All the parents involved in breeding had 5 number of stamens per flower except Himayuddin with 4 number of stamens per flower. All the local types had 5 number of stamens per flower. There was no seasonal effect on the number of stamens per flower.

4.1.4 Fruit characters

4.1.4.1 Fruiting duration

Different fruiting durations like April-May, March – May and May- June were noticed among the varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I and II included trees that had fruiting duration from April – May. Cluster II and III included tress with fruiting duration from March - May (Table 34 and Table 35).

Table 32. Number of stamens per flower of different mango genotypes

Sl. No.	Genotypes	Year
		2015-16
1	Arka Aruna	5
2	Amrapali	5
3	Mallika	5
4	Ratna	4
5	Sindhu	5
6	H45	4
7	H 151	4
8	PKM1	5
9	PKM 2	5
10	Neelgoa	5
11	Banganapalli	5
12	Alphonso	5
13	Dashehari	5
14	Neelum	5
15	Himayuddin	4
16	Bennet Alphonso	5
17	Kalepady	5
18	Swarnarekha	5
19	Mulgoa	5
20	Tholikaippan	5
21	Chandrakaran	5
22	Vellaikolumban	5
23	Prior	5
24	Muvandan	5

Grouping the parents involved in breeding, cluster I included trees that had fruiting duration from April - May, May – June and March – May. Cluster II had trees with fruiting duration from March – May. Cluster III included trees with fruiting duration from April-May (Table 36 and Table 37).

Grouping the local types, Cluster I, II and III included trees with fruiting duration from April-May (Table 38 and Table 39).

4.1.4.2 Fruit bearing intensity

Low, medium and high fruit bearing intensity was observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I and II included trees with medium fruit bearing intensity. Cluster II and III included trees with high fruit bearing intensity (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I included trees with low, medium and high fruit bearing intensity. Cluster II and III included trees with medium fruit bearing intensity (Table 36 and Table 37).

Grouping the local types, Cluster I and III included trees with medium fruit bearing intensity. Cluster II included trees with high fruit bearing intensity (Table 38 and Table 39).

4.1.4.3 Fruit shape

Oblong, elliptic and roundish fruit shapes were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I and II included trees with oblong fruit shape. Cluster II included trees with oblong fruit shape and cluster III included trees with roundish fruit shape (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I had trees with elliptic and roundish fruti shape. Cluster II had trees with oblong fruit shapes and cluster III had fruits with roundish fruit shapes (Table 36 and Table 37).

Grouping the local types, Cluster I included trees with elliptic, obovoid and oblong fruit shapes. Cluster II and III included trees with roundish fruit shapes (Table 38 and Table 39).

4.1.4.4 Shape of fruit apex

Round, acute and obtuse fruit apex shapes were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I had trees with obtuse and acute fruit apex. Cluster II had trees with round and acute fruit apex and cluster III had trees with obtuse fruit apex (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I had trees with acute fruit apex. Cluster II and three had trees with round fruit apex (Table 36 and Table 37).

Grouping the local types, Cluster I, II and III included trees with acute fruit apex (Table 38 and Table 39).

4.1.4.5 Fruit attractiveness

Excellent, good and average fruit attractiveness were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I had trees with excellent, good and average fruit attractiveness. Cluster II had trees with average fruit attractiveness and cluster III included trees with good fruit attractiveness (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I had trees with good, average and excellent fruit attractiveness. Cluster II and III had trees with good fruit attractiveness (Table 36 and Table 37).

Grouping the local types, Cluster I and II included trees with average fruit attractiveness. Cluster III included trees with excellent fruit attractiveness (Table 38 and Table 39).

4.1.4.6 Skin colour of unripe fruit

All the varieties/ cultivars had trees with green skin colour for unripe fruits (Table 33 a and b).

4.1.4.7 Skin colour of ripe fruit

Yellow, orange and shallow yellow with blush skin colours were observed for ripe fruits among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I had trees with yellow and shallow yellow with blush skin colour for ripe fruits. Cluster II had trees with yellow skin colour for ripe fruits. Cluster III had fruits with orange skin colour for ripe fruits (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I and II had trees with greenish yellow skin colour for ripe fruits. Cluster I also included trees with yellow skin colour for ripe fruits. Cluster II included trees with yellow skin colour for ripe fruits (Table 36 and Table 37).

Grouping the local types, Cluster I, II and III included trees with green skin colour for ripe fruits (Table 38 and Table 39).

4.1.4.8 Depth of fruit stalk cavity

Shallow, medium and no depth for fruit stalk cavity were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I had trees with shallow, medium and no depth for fruit stalk cavity. Cluster II included tress with no depth for fruit stalk cavity and cluster III included tress with medium depth for fruit stalk cavity (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I included trees with shallow, deep and no depth for fruit stalk cavity. Cluster II included trees with medium depth for fruit stalk cavity and cluster III included trees with shallow depth for fruit stalk cavity (Table 36 and Table 37).

Grouping the local types, Cluster I included trees with shallow and no depth for fruit stalk cavity. Cluster II included trees with shallow depth for fruit stalk cavity. And cluster III included trees with no depth for fruit stalk cavity (Table 38 and Table 39).

4.1.4.9 Fruit neck prominence

Slightly prominent and no fruit neck were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I, II and III included trees with slightly prominent fruit neck. Cluster I and II also included trees with no fruit neck (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I included trees with slightly prominent and no fruit neck prominence. Cluster II and III included trees with no fruit neck prominence (Table 36 and Table 37).

Grouping the local types, Cluster I included trees with slightly prominent and no fruit neck prominence. Cluster II and III had trees with no fruit neck prominence (Table 38 and Table 39).

4.1.4.10 Fruit beak type

Prominent, perceptible, pointed and mammiform fruit beaks were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I and III included trees with perceptible fruit beak, Cluster II included trees with pointed and mammiform fruit beaks. Cluster I also included trees with prominent fruit beak types (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I included tress with pointed, prominent and perceptible fruit beak types. Cluster II included trees with perceptible and pointed fruit beak types. Cluster III included trees with perceptible fruit beak types (Table 36 and Table 37).

Grouping the local types, Cluster I had trees with pointed and perceptible fruit beak types. Cluster II had trees with pointed fruit beak types. Cluster III had trees with perceptible fruit beak types (Table 38 and Table 39).

4.1.4.11 Pulp colour of ripe fruit

Golden yellow, light yellow, yellow and yellow orange pulp colour of ripe fruits were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I included trees with golden yellow, light yellow and yellow orange pulp colour of ripe fruits. Cluster II included trees with yellow and yellow orange pulp colour. Cluster III included trees with yellow orange pulp colour of ripe fruits (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I included trees with yellow pulp colour for ripe fruits. Cluster II included trees with orange and yellow orange pulp colour for ripe fruits. Cluster III included trees with orange pulp colour for ripe fruits (Table 36 and Table 37).

Grouping the local types, Cluster I had trees with light yellow pulp colour for ripe fruits. Cluster II had trees with yellow orange pulp colour for ripe fruits. And cluster III had trees with golden yellow pulp colour for ripe fruits (Table 38 and Table 39).

4.1.4.12 Aroma of ripe fruit

Mild, intermediate and strong aroma of ripe fruits were observed among the different varieties/cultivars (Table 33 a and b).

Grouping the hybrids, cluster I, II and III included trees with mild aroma for ripe fruits. Cluster I and II included trees with intermediate aroma for ripe fruits. And Cluster I also included trees with strong aroma for ripe fruits (Table 34 and Table 35).

Grouping the parents involved in breeding, cluster I and II included trees with mild and intermediate aroma for ripe fruits. Cluster III included trees with intermediate aroma for ripe fruits (Table 36 and Table 37).

Table 33a. Fruiting duration, fruit bearing intensity, fruit shape, shape of fruit apex, fruit attractiveness, skin colour of unripe fruit, skin colour of ripe fruit, depth of fruit stalk cavity, fruit neck prominence, fruit beak type, pulp colour of ripe fruit and aroma of ripe fruit of different mango genotypes

Sl. No.	Genotypes	Fruiting duration	Fruit bearing intensity	Fruit shape	Shape of fruit apex	Fruit attractiveness	Skin colour of unripe fruit	Skin colour of ripe fruit	Depth of fruit stalk cavity	Fruit neck prominence	Fruit beak type	Pulp colour of ripe fruit	Aroma of ripe fruit
1	Arka Aruna	April - May	Medium	Oblong	Obtuse	Excellent	Green	Yellow	Medium	Absent	Prominent	Golden yellow	Strong
2	Amrapali	April - May	Medium	Oblong	Acute	Good	Green	Yellow	Shallow	Absent	Perceptible	Yellow orange	Strong
3	Mallika	April - May	Medium	Oblong	Obtuse	Good	Green	Yellow	Absent	Slightly prominent	Prominent	Golden yellow	Intermediate
4	Ratna	April - May	Medium	Oblong	Round	Average	Green	Yellow	Absent	Absent	Pointed	Yellow orange	Intermediate
5	Sindhu	April - May	Medium	Elliptic	Acute	Good	Red	Shallow yellow with blush	Shallow	Slightly prominent	Perceptible	Golden Yellow	Intermediate
6	H45	March - May	High	Roundish	Obtuse	Good	Green	Orange	Medium	Slightly prominent	Percepible	Yellow Orange	Mild
7	H 151	March - May	High	Oblong	Round	Average	Green	Yellow	Absent	Slightly prominent	Mammiform	Yellow	Intermediate
8	PKM1	March - May	Medium	Oblong	Acute	Average	Green	Yellow	Absent	Absent	Mammiform	Yellow	Mild
9	PKM 2	April - May	Medium	Oblong	Obtuse	Average	Green	Yellow	Shallow	Slightly prominent	prominent	Light yellow	Mild
10	Neelgoa	April - May	Medium	Elliptic	Obtuse	Average	Green	Yellow	Absent	Absent	Perceptible	Light yellow	Mild
11	Banganapalli	April - May	Medium	Elliptic	Acute	Good	Green	Greenish yellow	Shallow	Slightly prominent	Pointed	Yellow	Mild
12	Alphonso	March - May	Medium	Oblong	Round	Good	Green	Yellow	Medium	Absent	Perceptible	Orange	Intermediate

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Table 33b. Fruiting duration, fruit bearing intensity, fruit shape, shape of fruit apex, fruit attractiveness, skin colour of unripe fruit, skin colour of ripe fruit, depth of fruit stalk cavity, fruit neck prominence, fruit beak type, pulp colour of ripe fruit and aroma of ripe fruit of different mango genotypes

Sl. No.	Genotypes	Fruiting duration	Fruit bearing intensity	Fruit shape	Shape of fruit apex	Fruit attractiveness	Skin colour of unripe fruit	Skin colour of ripe fruit	Depth of fruit stalk cavity	Fruit neck prominence	Fruit beak type	Pulp colour of ripe fruit	Aroma of ripe fruit
13	Dashehari	May - June	Medium	Elliptic	Acute	Excellent	Green	Yellow	Absent	Absent	Perceptible	Yellow	Intermediate
14	Neelum	May - June	Medium	Roundish	Acute	Average	Green	Yellow	Absent	Absent	Perceptible	Yellow	Intermediate
15	Himayuddin	April - May	Medium	Roundish	Acute	Good	Green	Yellow	Deep	Absent	Prominent	Yellow	Intermediate
16	Bennet Alphonso	April - May	Medium	Roundish	Round	Good	Green	Greenish yellow	Shallow	Absent	Perceptible	Orange	Intermediate
17	Kalepady	March - May	High	Elliptic	Acute	Excellent	Green	Yellow	Absent	Slightly prominent	Perceptible	Yellow	Intermediate
18	Swarnarekha	March - May	Medium	Oblong	Round	Good	Green	Yellow	Medium	Absent	Pointed	Yellow orange	Mild
19	Mulgoa	May - June	Low	Roundish	Acute	Excellent	Green	Yellow	Absent	Slightly prominent	Perceptible	Yellow	Intermediate
20	Tholikaippan	April - May	Medium	Elliptic	Acute	Average	Green	Green	Shallow	Absent	Perceptible	Light yellow	Strong
21	Chandrakaran	April - May	High	Roundish	Acute	Average	Green	Green	Shallow	Absent	Pointed	Yellow orange	Strong
22	Vellaikolumban	April - May	Medium	Oblong	Acute	Average	Green	Green	Absent	Present	Pointed	Light yellow	Intermediate
23	Prior	April - May	Medium	Roundish	Acute	Excellent	Green	Green	Absent	Absent	Perceptible	Golden yellow	Mild
24	Muvandan	April - May	Medium	Obovoid	Acute	Average	Green	Green	Absent	Slightly prominent	Perceptible	Light yellow	Strong

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Table 34. Cluster wise listing of hybrids according to fruit characters

Clusters		
I	II	III
Arka Aruna	Ratna	H 45
Mallika	H 151	
PKM 2	PKM 1	
Neelgoa		
Amrapali		
Sindhu		

Table 35. Cluster wise summary statistics of hybrids according to fruit characters

Characters	Clusters		
	I	II	III
Fruiting duration	April - May	April - May, March - May	March - May
Fruit bearing intensity	Medium	Medium, High	High
Fruit shape	Oblong, Elliptic	Oblong	Roundish
Shape of fruit apex	Obtuse, Acute	Round, Acute	Obtuse
Fruit Attractiveness	Excellent, Good, Average	Average	Good
Skin colour of unripe fruit	Green, Red	Green	Green
Skin colour of ripe fruit	Yellow, Shallow yellow with blush	Yellow	Orange
Depth of fruit stalk cavity	Medium, Absent, Shallow	Absent	Medium
Fruit neck prominence	Absent, Slightly prominent	Absent, Slightly prominent	Slightly prominent
Fruit beak type	Prominent, Perceptible	Pointed, Mammiform	Perceptible
Pulp colour of ripe fruit	Golden yellow, Light yellow, Yellow orange	Yellow orange, Yellow	Yellow Orange
Aroma of ripe fruit	Strong, Intermediate, Mild	Intermediate, Mild	Mild

Table 36. Cluster wise listing of parents according to fruit characters

Clusters		
I	II	III
Banganapalli	Alphonso	Bennet Alphonso
Himayuddin	Swarnarekha	
Dashehari		
Neelum		
Mulgoa		
Kalepady		

Table 37. Cluster wise summary statistics of parents according to fruit characters

Characters	Clusters		
	I	II	III
Fruiting duration	April - May, May - June, March - May	March - May	April - May
Fruit bearing intensity	Medium, Low, High	Medium	Medium
Fruit shape	Elliptic, Roundish	Oblong	Roundish
Shape of fruit apex	Acute	Round	Round
Fruit attractiveness	Good, Excellent, Average	Good	Good
Skin colour of unripe fruit	Green	Green	Green
Skin colour of ripe fruit	Greenish yellow, Yellow	Yellow	Greenish yellow
Depth of fruit stalk cavity	Shallow, Deep, Absent	Medium	Shallow
Fruit neck prominence	Slightly prominent, Absent	Absent	Absent
Fruit beak type	Pointed, Prominent, Perceptible	Perceptible, Pointed	Perceptible
Pulp colour of ripe fruit	Yellow	Orange, Yellow orange	Orange
Aroma of ripe fruit	Mild, Intermediate	Intermediate, Mild	Intermediate

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Table 38. Cluster wise listing of local types according to fruit characters

Clusters		
I	II	III
Tholikaippan	Chandrakaran	Prior
Muvandan		
Vellaikolumban		

Table 39. Cluster wise summary statistics of local types according to fruit characters

Characters	Clusters		
	I	II	III
Fruiting duration	April - May	April - May	April - May
Fruit bearing intensity	Medium	High	Medium
Fruit shape	Elliptic, Obovoid, Oblong	Roundish	Roundish
Shape of fruit apex	Acute	Acute	Acute
Fruit attractiveness	Average	Average	Excellent
Skin colour of unripe fruit	Green	Green	Green
Skin colour of ripe fruit	Green	Green	Green
Depth of fruit stalk cavity	Shallow, Absent	Shallow	Absent
Fruit neck prominence	Absent, Slightly prominent, Present	Absent	Absent
Fruit beak type	Perceptible, Pointed	Pointed	Perceptible
Pulp colour of ripe fruit	Light yellow	Yellow orange	Golden yellow
Aroma of ripe fruit	Strong, Intermediate	Strong	Mild

Plate 13. Variations in fruit characters of mango genotypes Arka Aruna selected under normal planting system

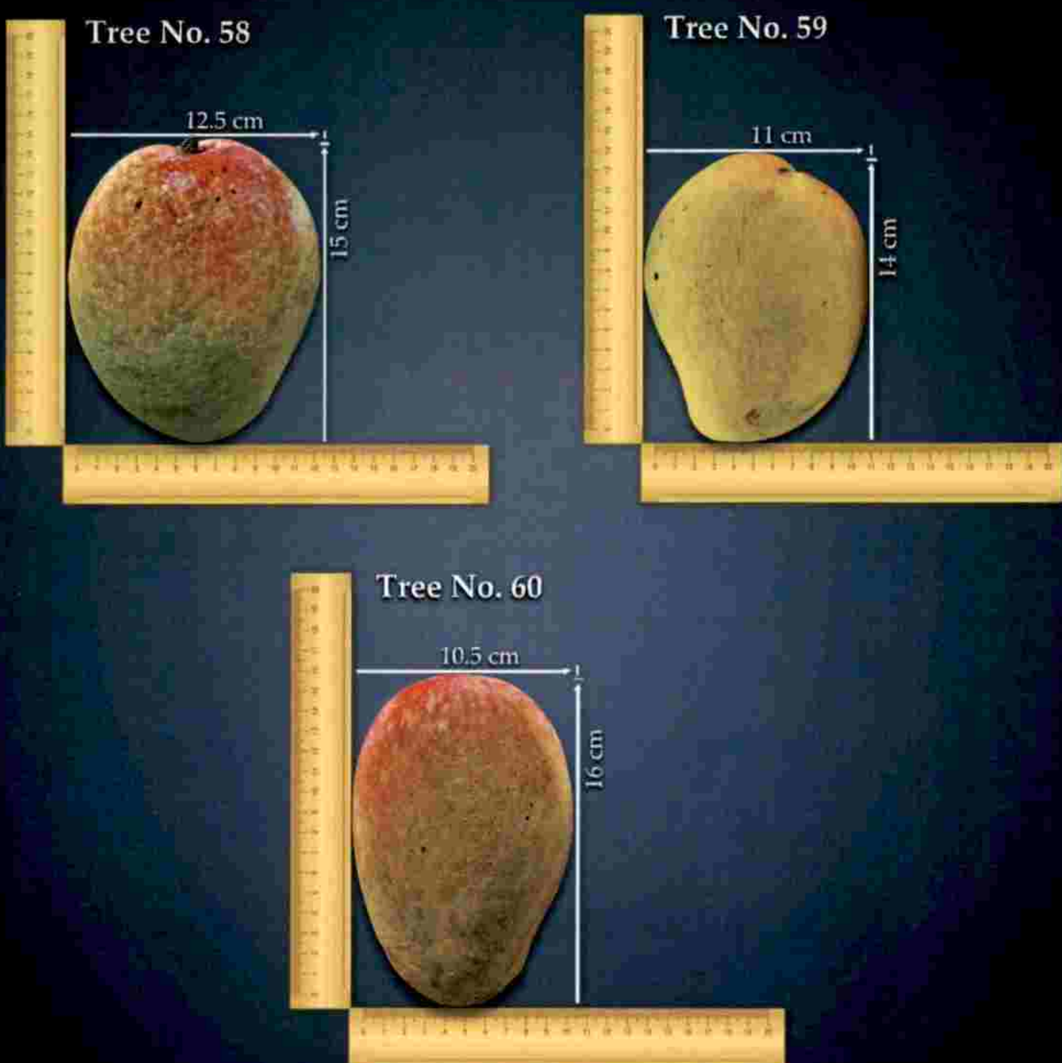

Plate 14. Variations in fruit characters of mango genotypes Amrapali selected under normal planting system

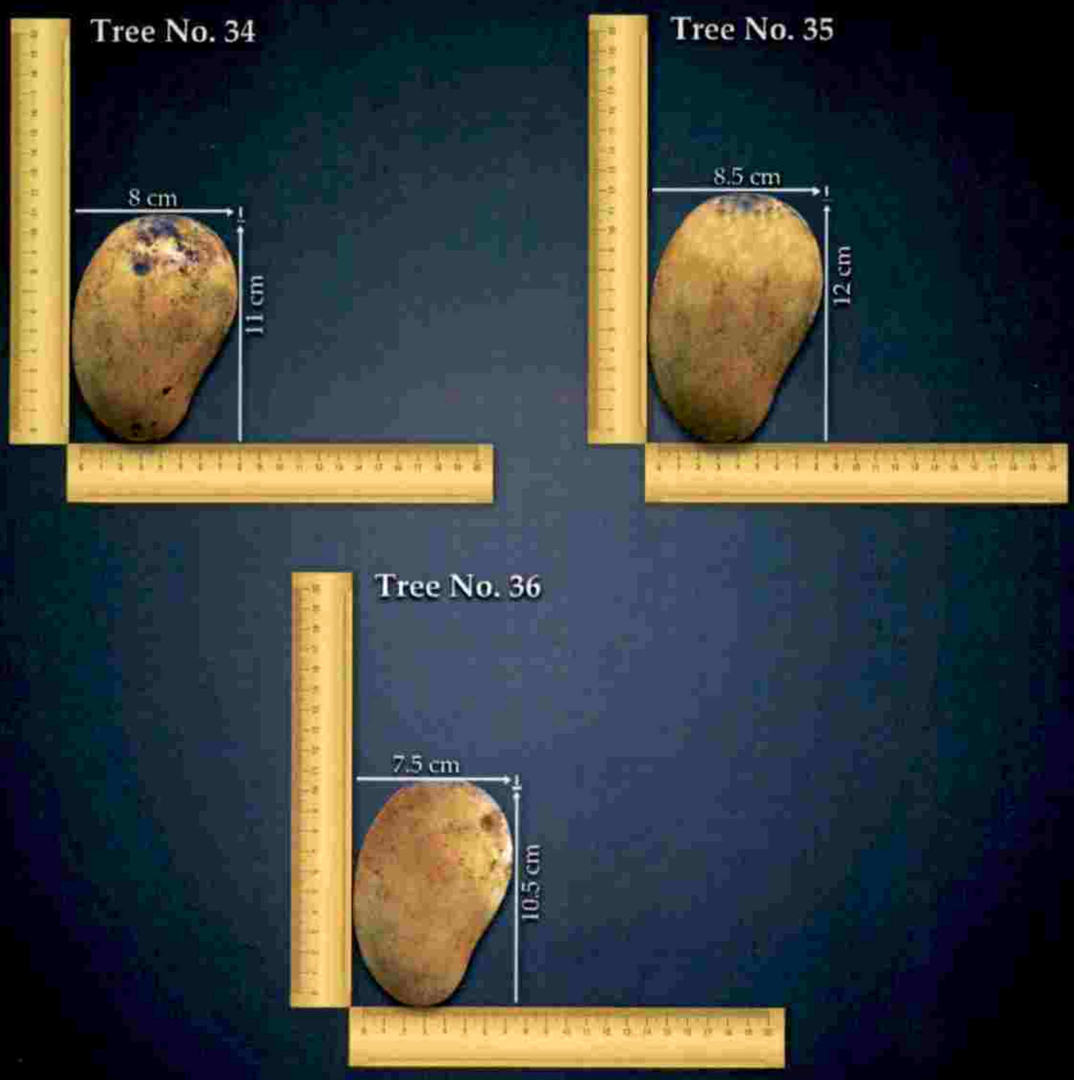

Plate 15. Variations in fruit characters of mango genotype Mallika selected under normal planting system

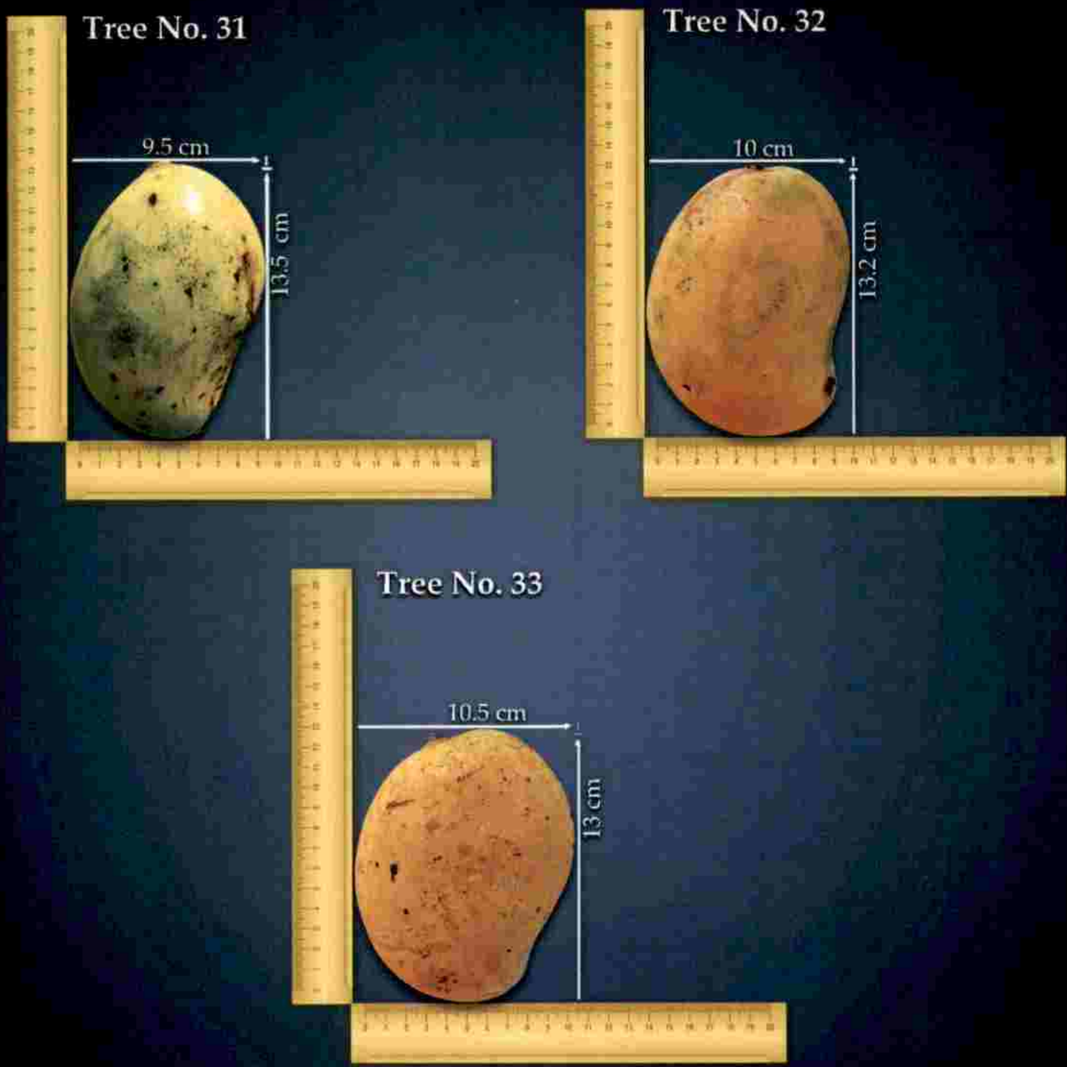

Plate 16. Variations in fruit characters of mango genotype Ratna selected under normal planting system

Plate 17. Variations in fruit characters of mango genotype Sindhu selected under normal planting system

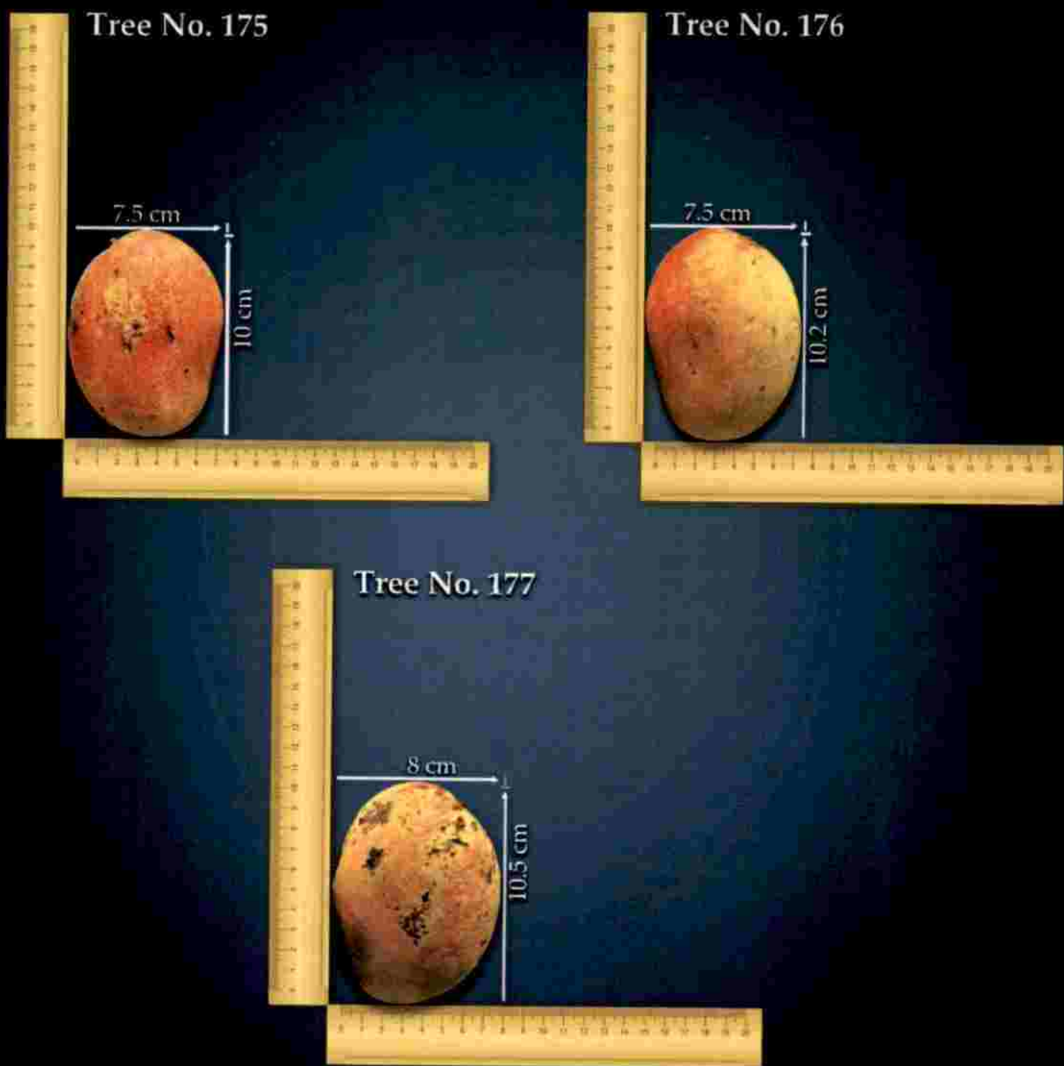

Plate 18. Variations in fruit characters of mango genotype H45 selected under normal planting system

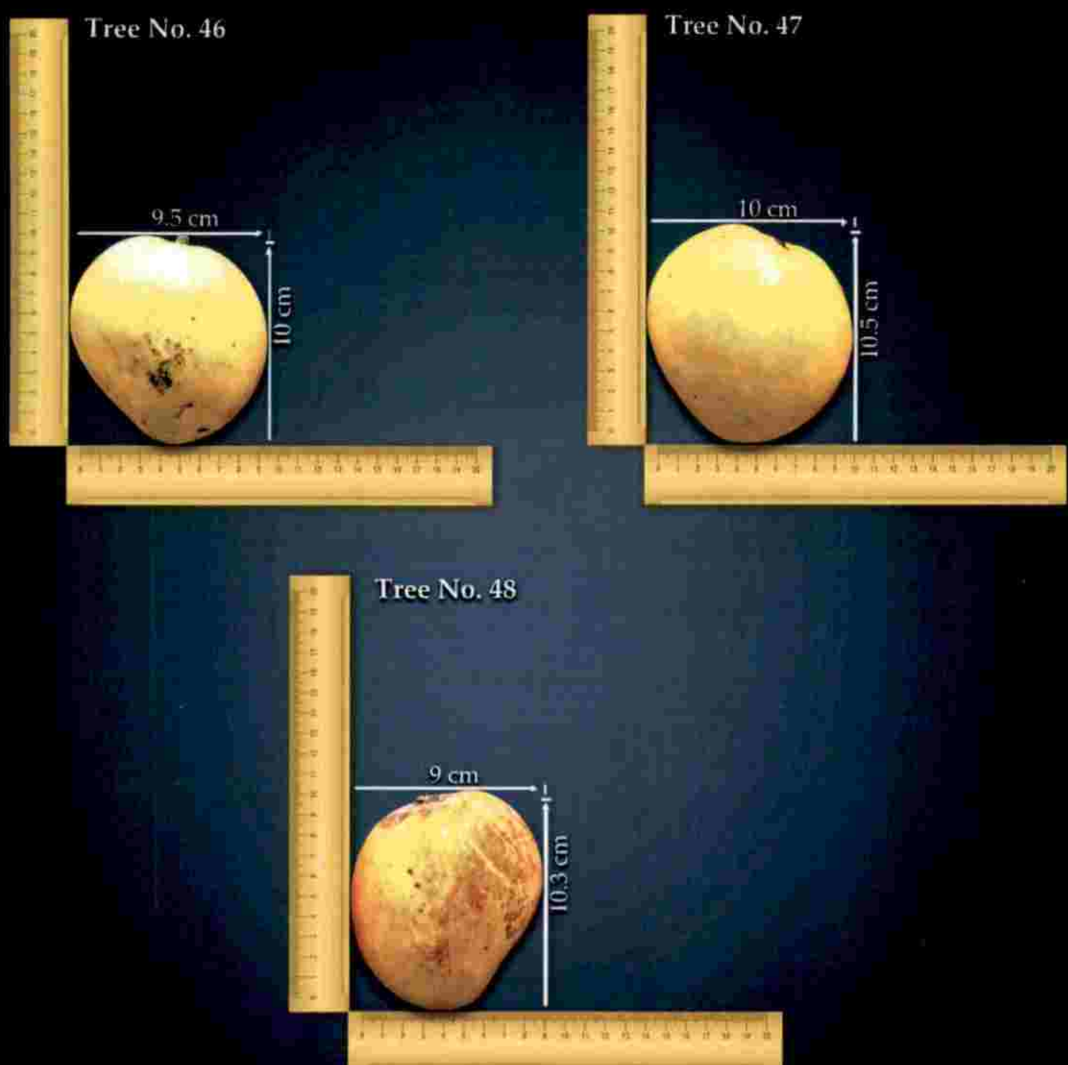

Plate 19. Variations in fruit characters of mango genotype H151 selected under normal planting system

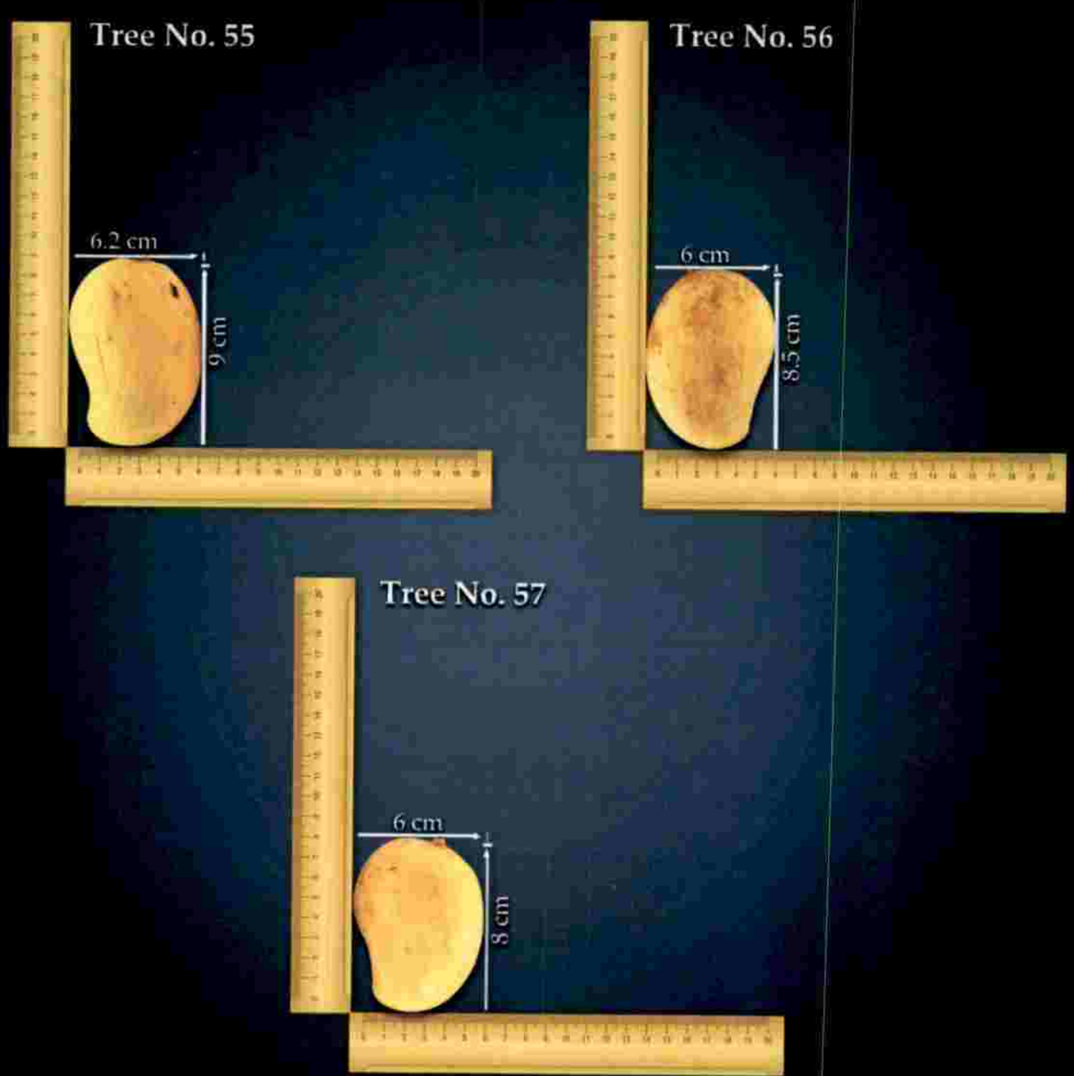

Plate 20. Variations in fruit characters of mango genotype PKM1
selected under normal planting system

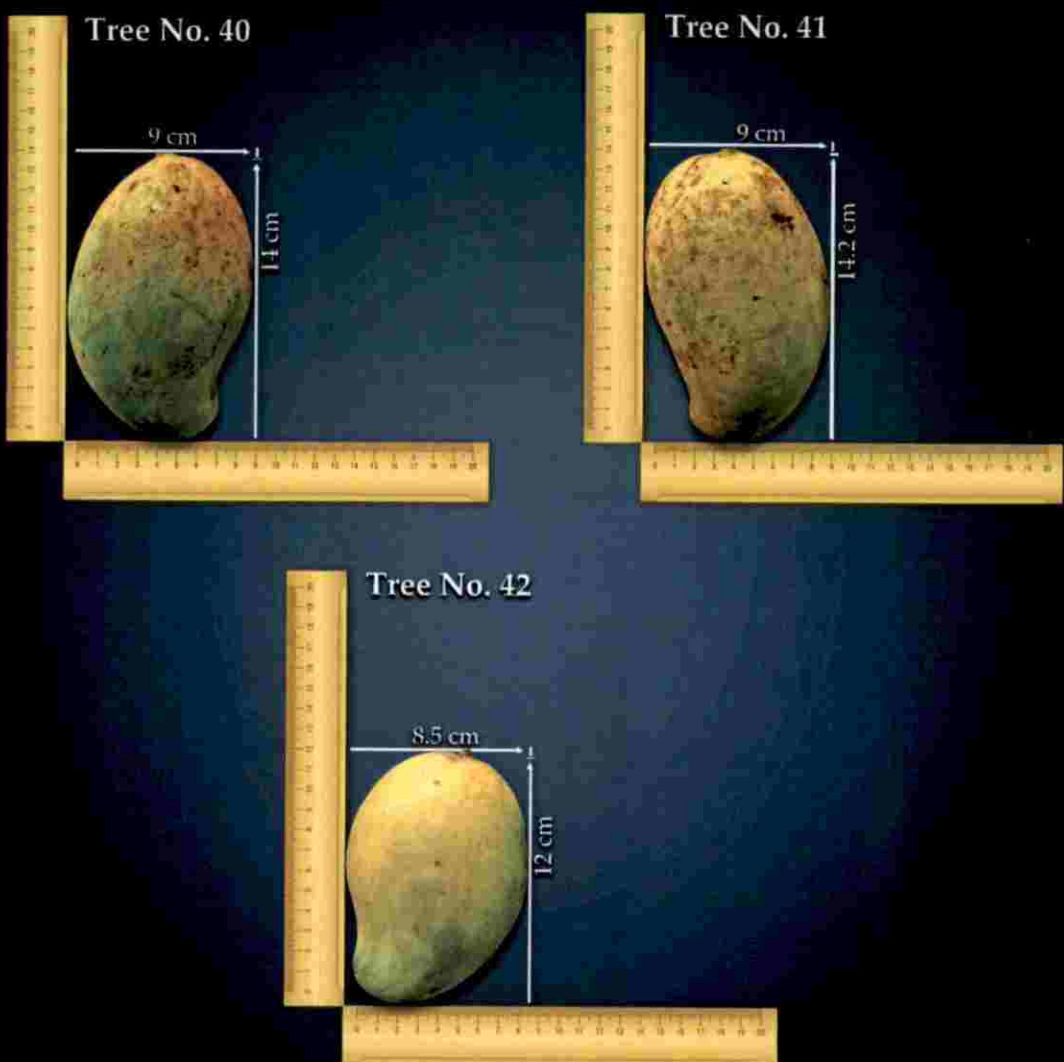

Plate 21. Variations in fruit characters of mango genotype PKM 2 selected under normal planting system

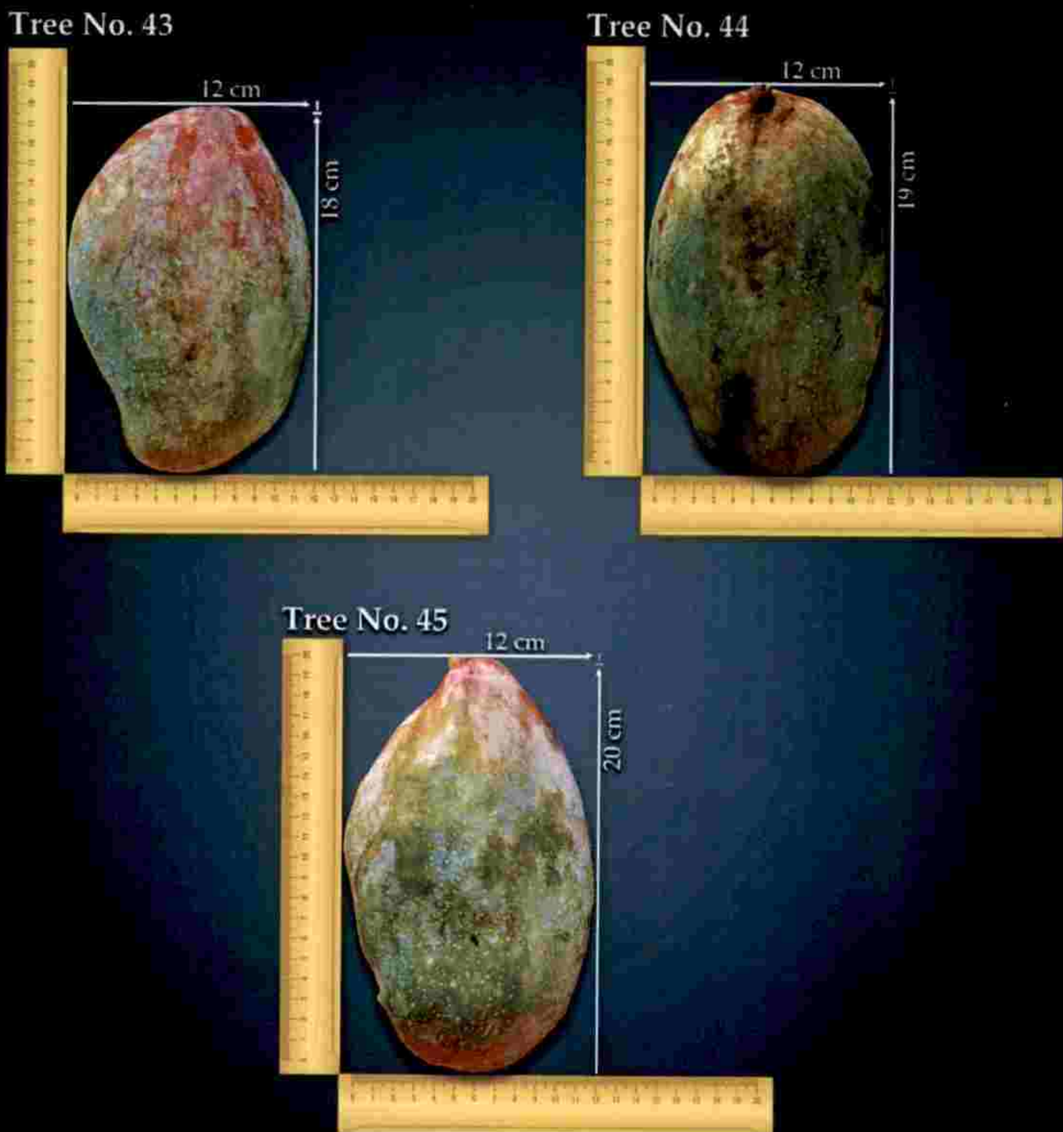

Plate 22. Variations in fruit characters of mango genotype Neelgoa selected under normal planting system

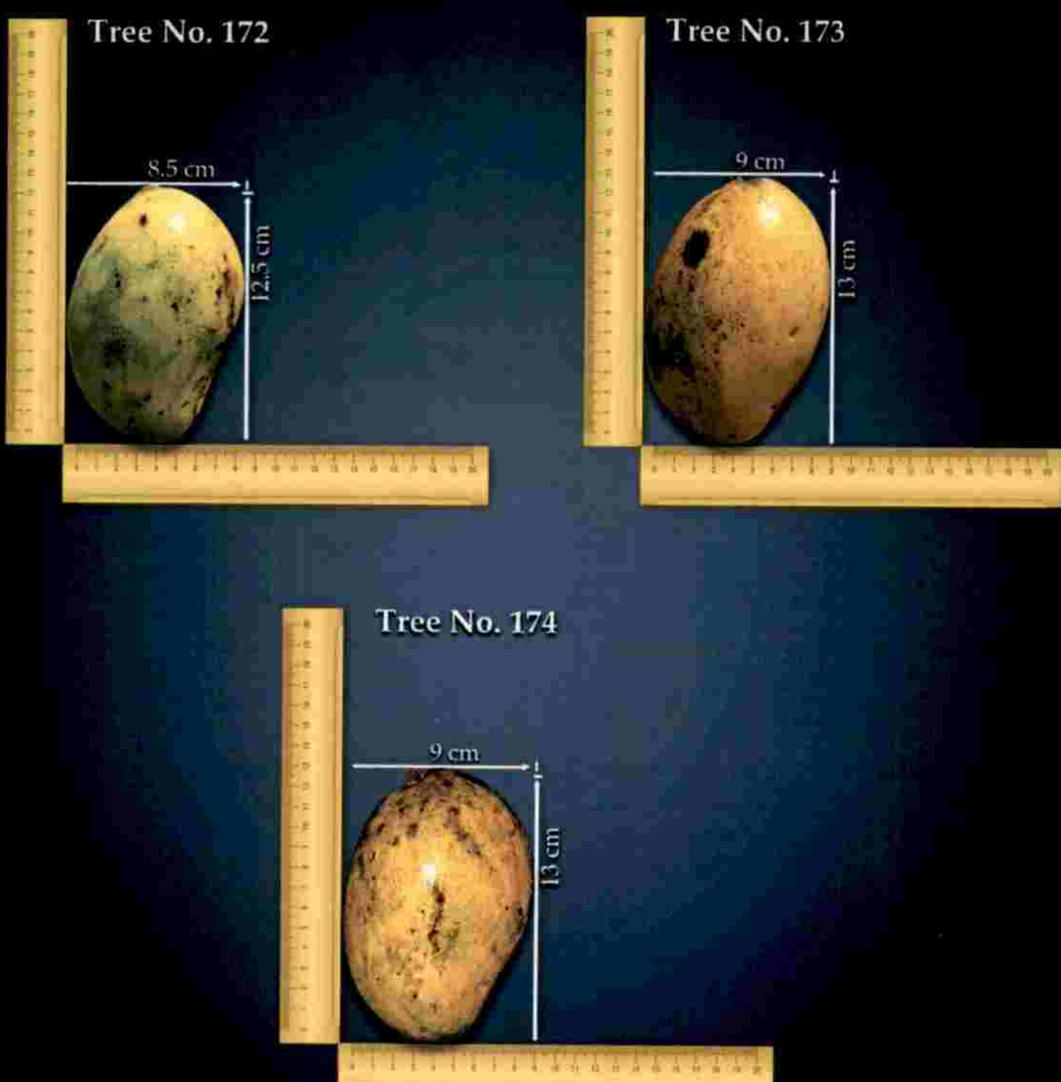

Plate 23. Variations in fruit characters of mango genotype Banganapalli selected under normal planting system

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Plate 24. Variations in fruit characters of mango genotype Alphonso selected under normal planting system

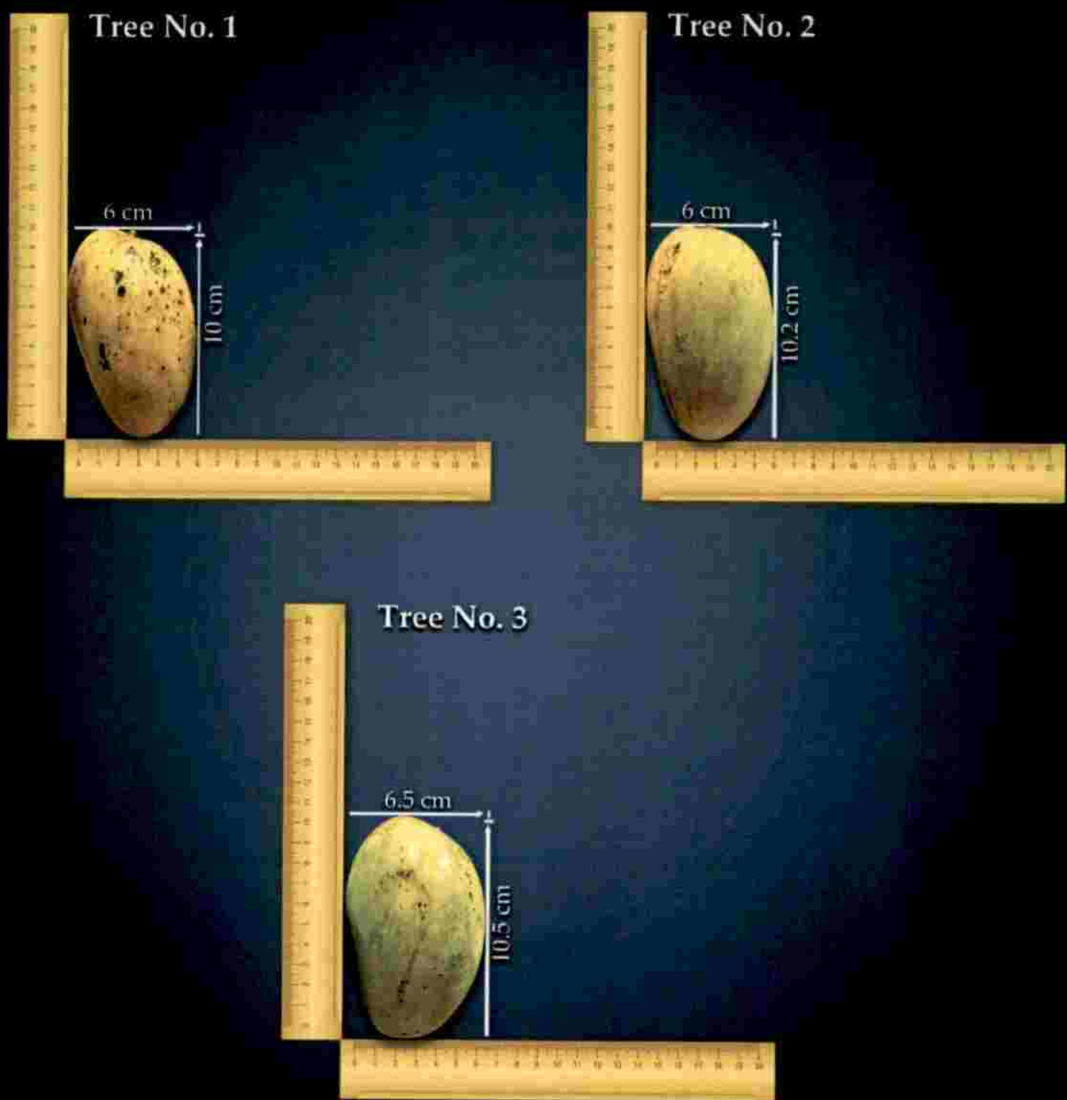

Plate 25. Variations in fruit characters of mango genotype Dashehari selected under normal planting system

Plate 26. Variations in fruit characters of mango genotype Neelum selected under normal planting system

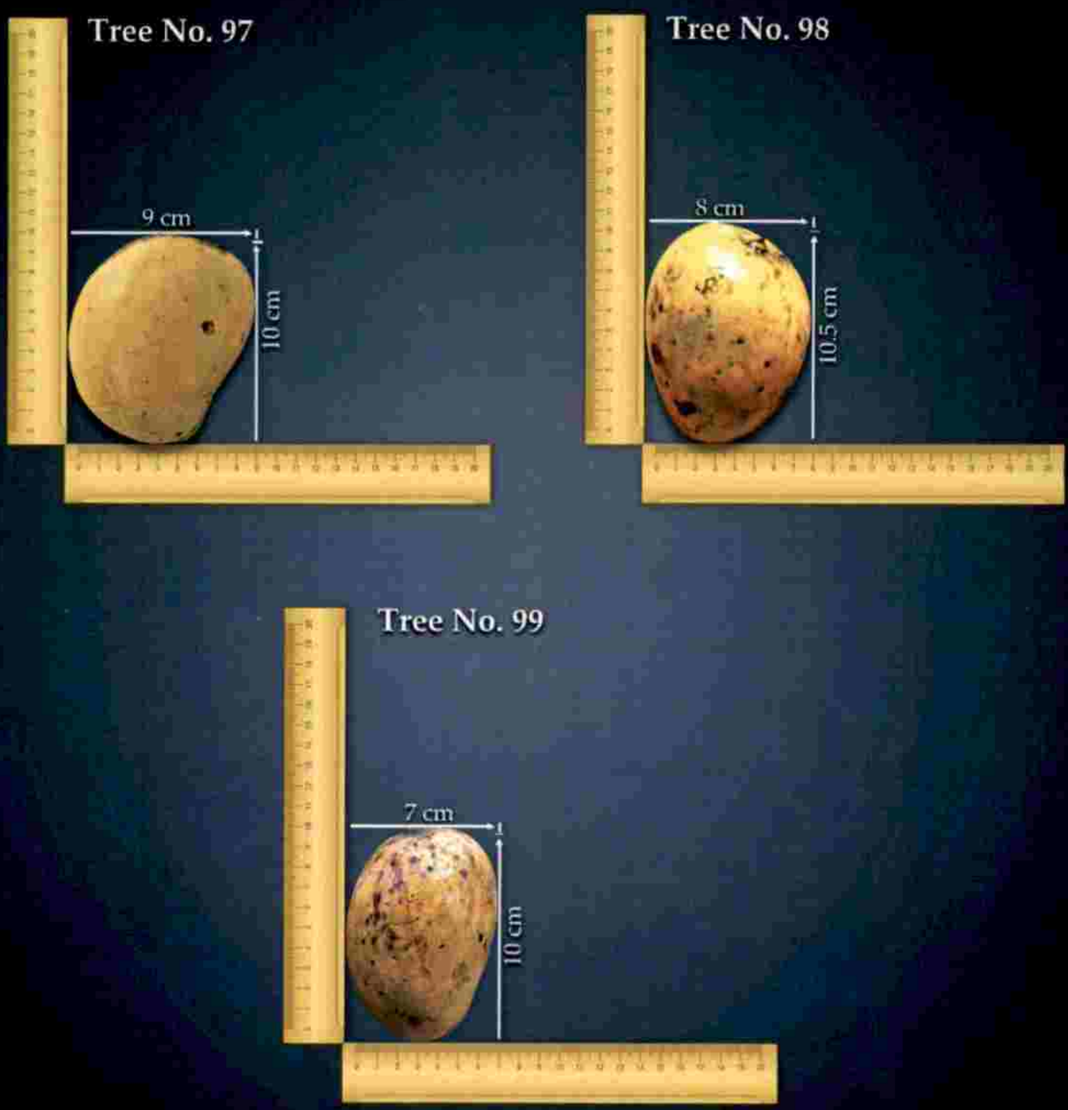

Plate 27. Variations in fruit characters of mango genotype Himayuddin selected under normal planting system

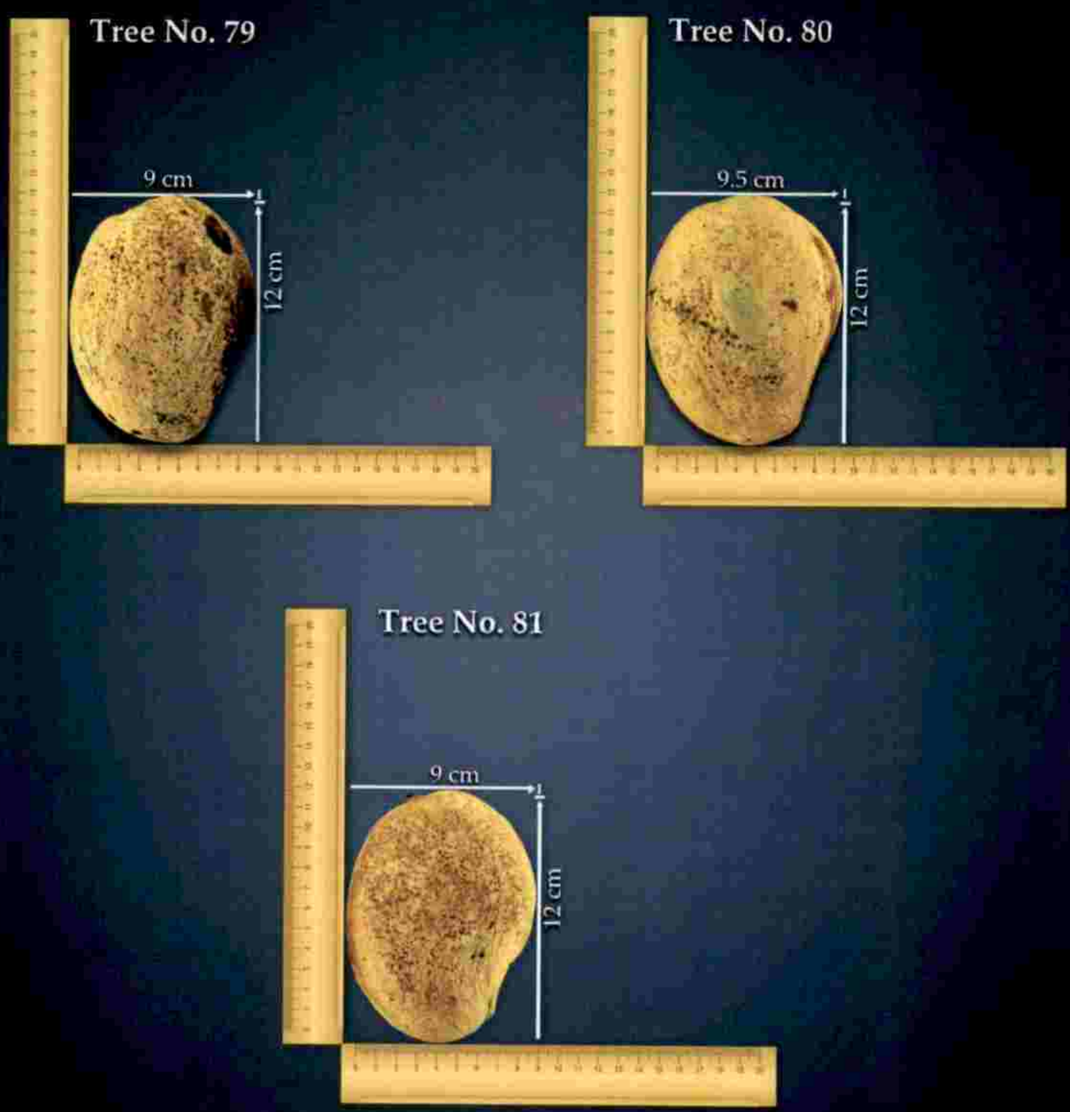

Plate 28. Variations in fruit characters of mango genotype Bennet Alphonso selected under normal planting system

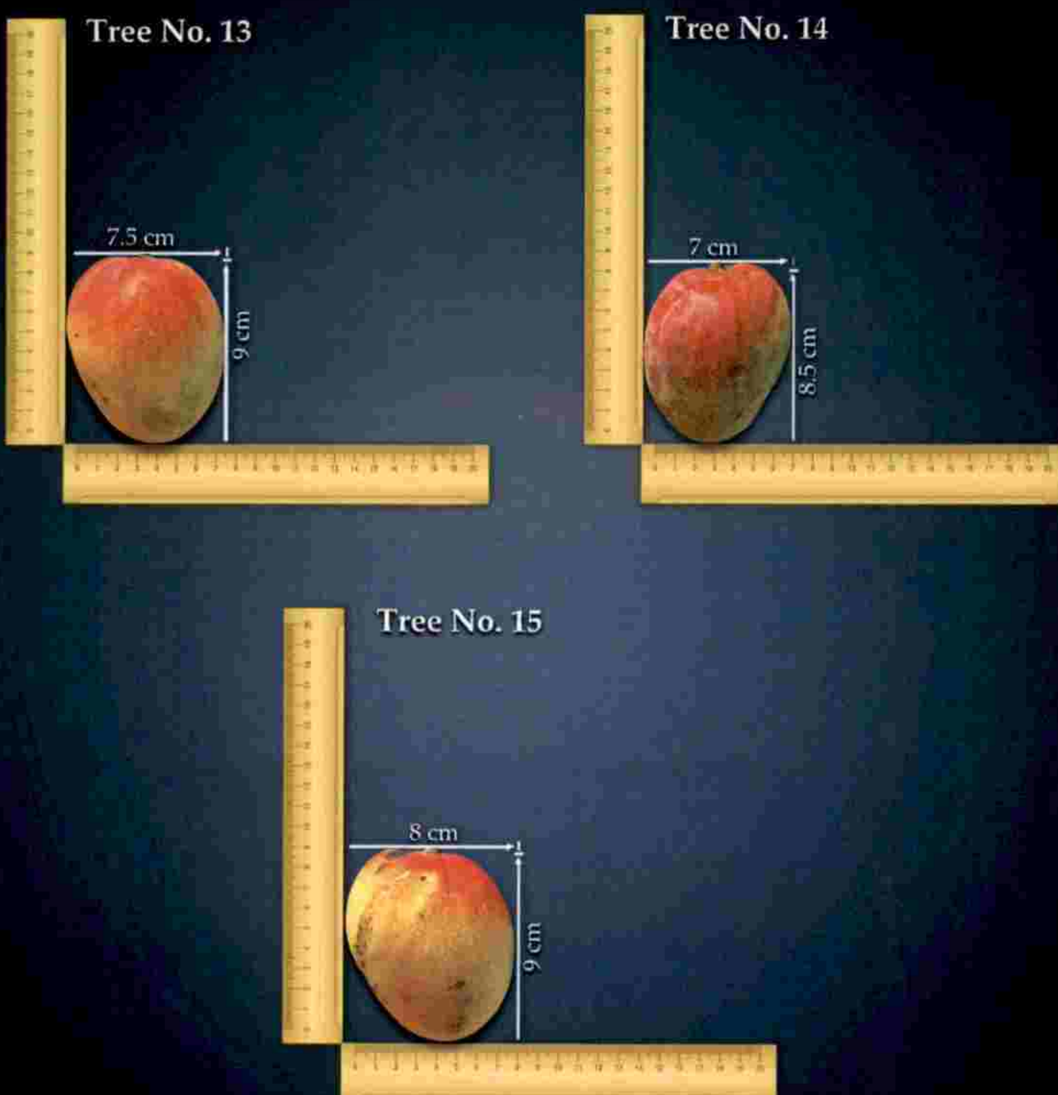

Plate 29. Variations in fruit characters of mango genotype Kalepady selected under normal planting system

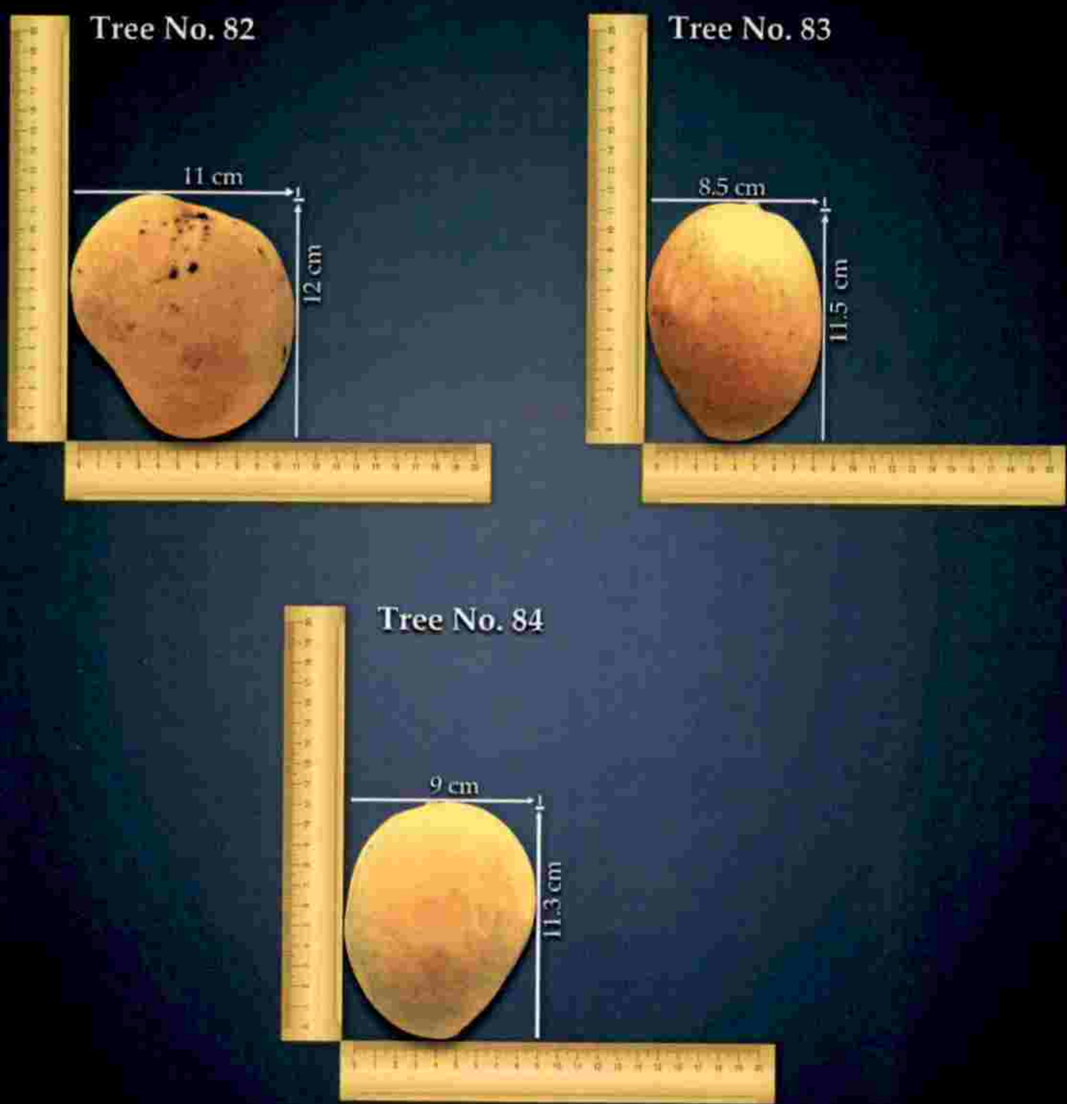

Plate 30. Variations in fruit characters of mango genotype Swarnarekha selected under normal planting system

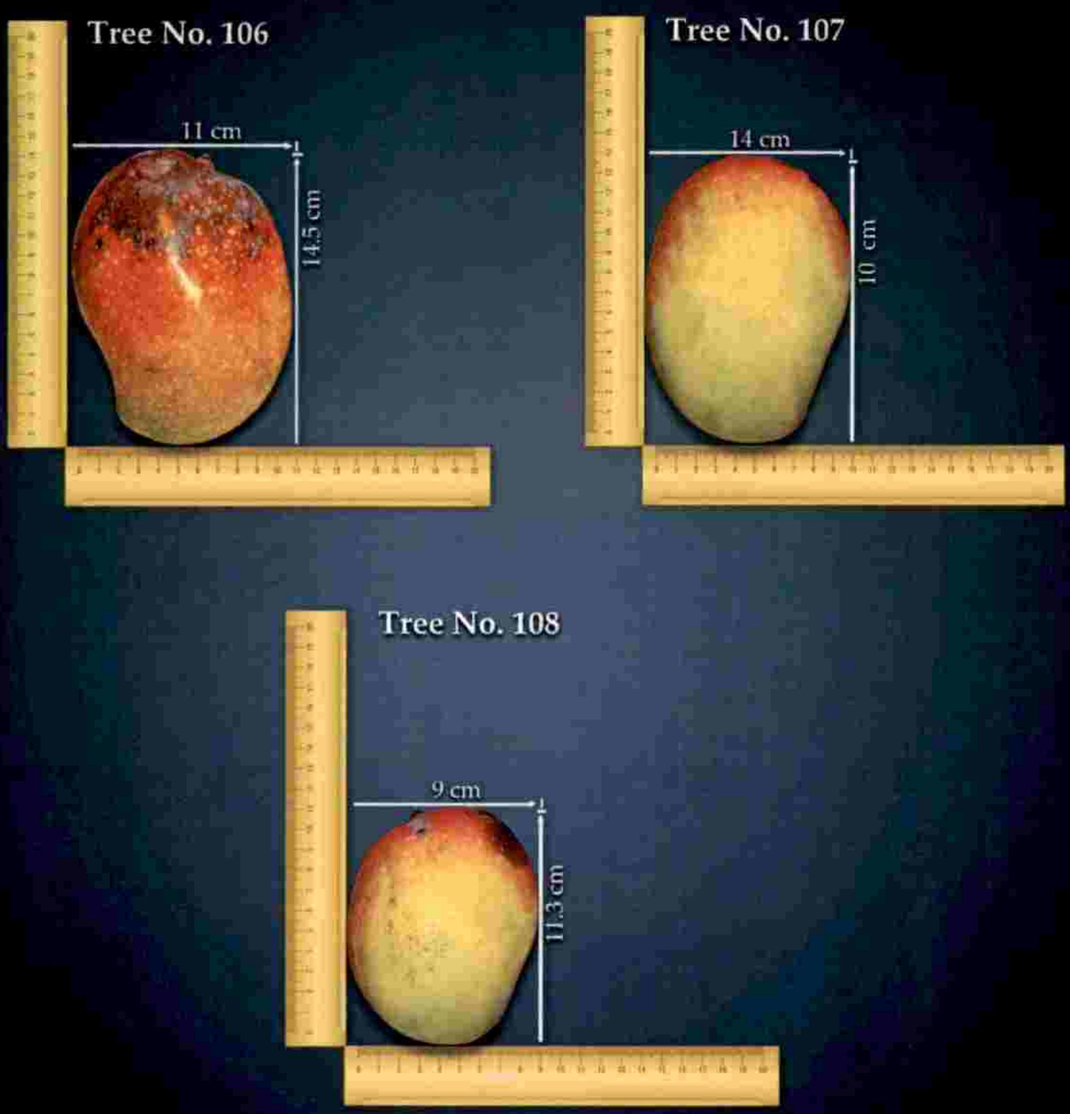

Plate 31. Variations in fruit characters of mango genotype Mulgoa selected under normal planting system

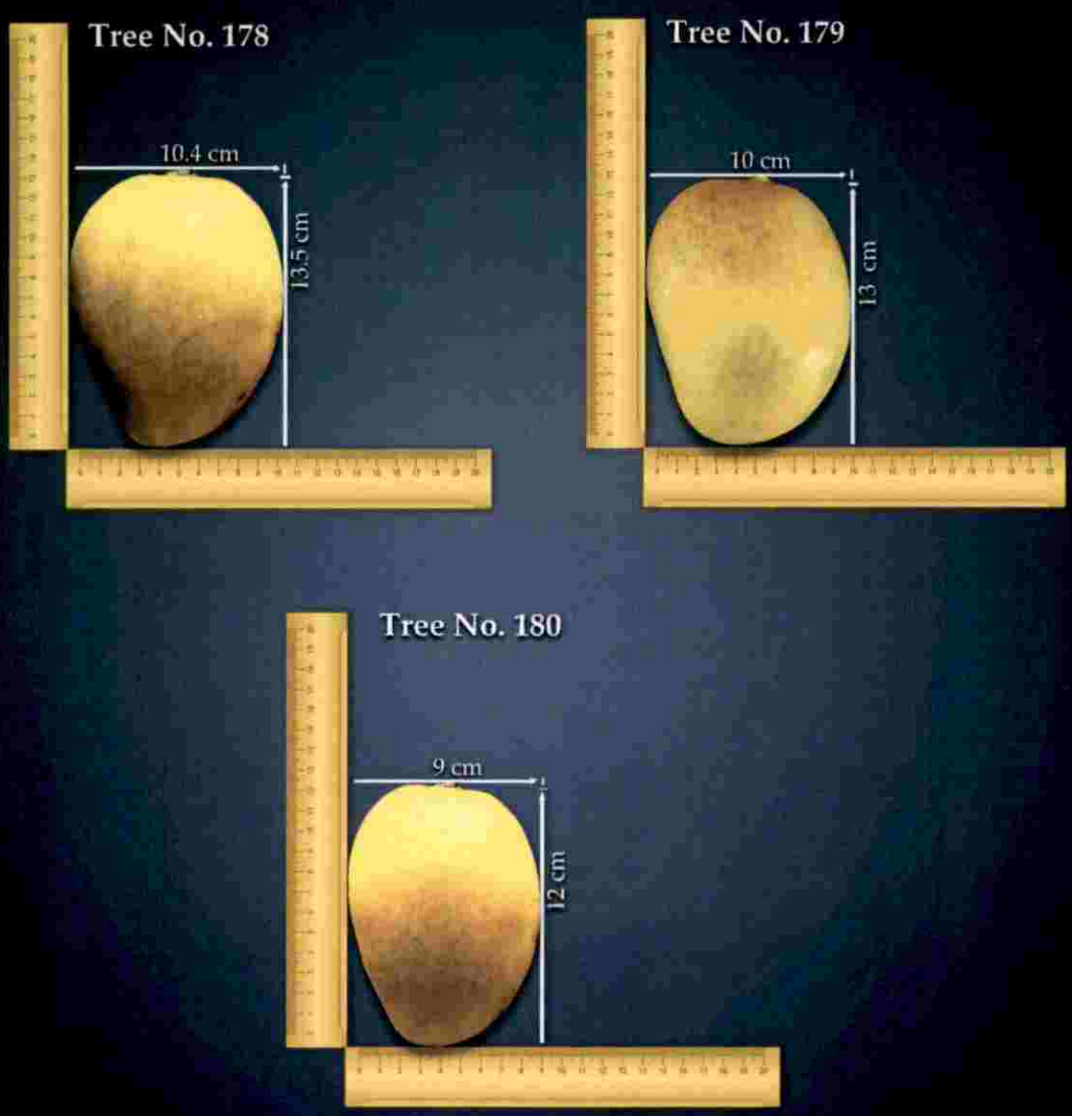

Plate 32. Variations in fruit characters of mango genotype Tholikaippan selected under normal planting system

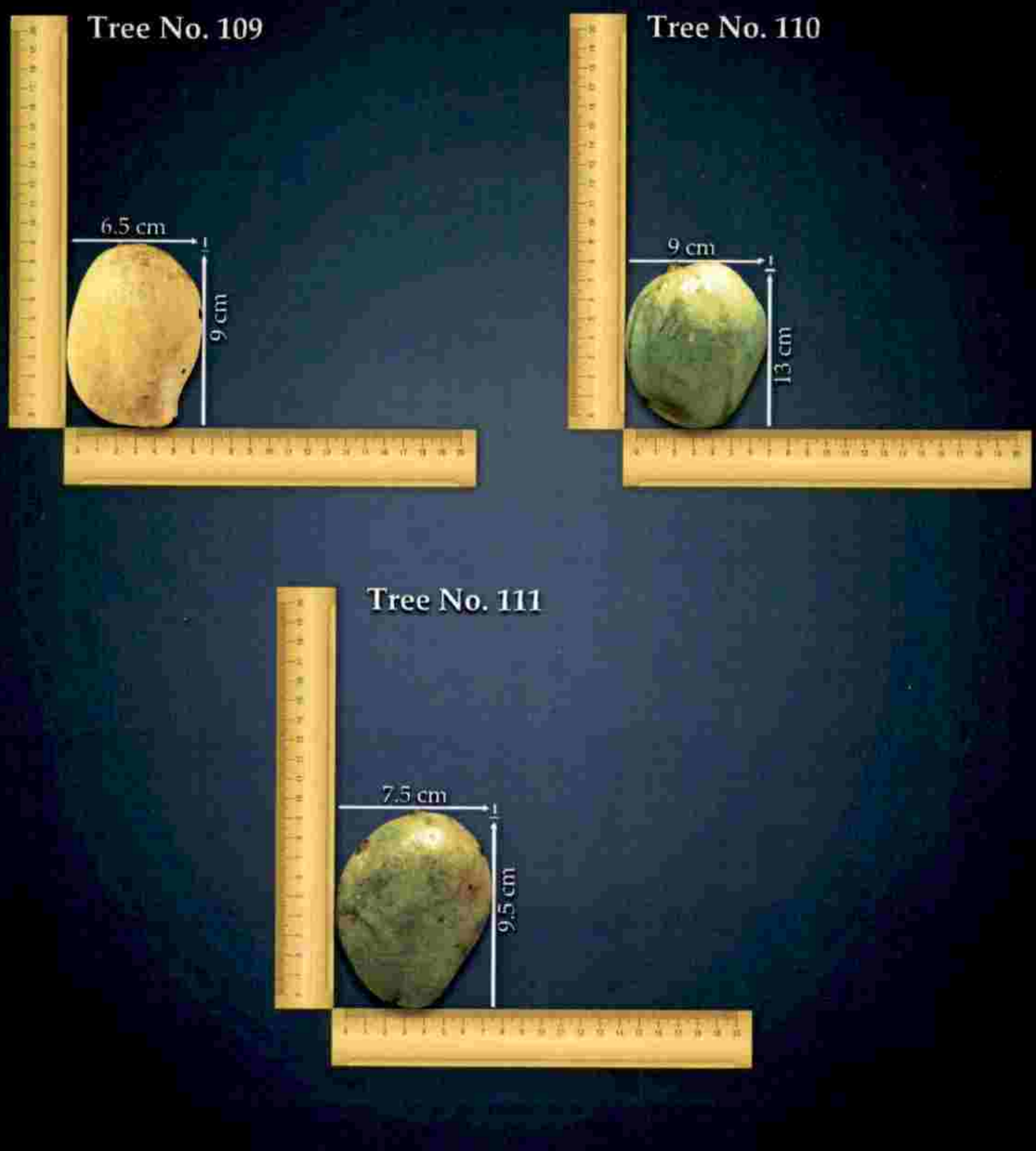

Plate 33. Variations in fruit characters of mango genotype Chandrakaran selected under normal planting system

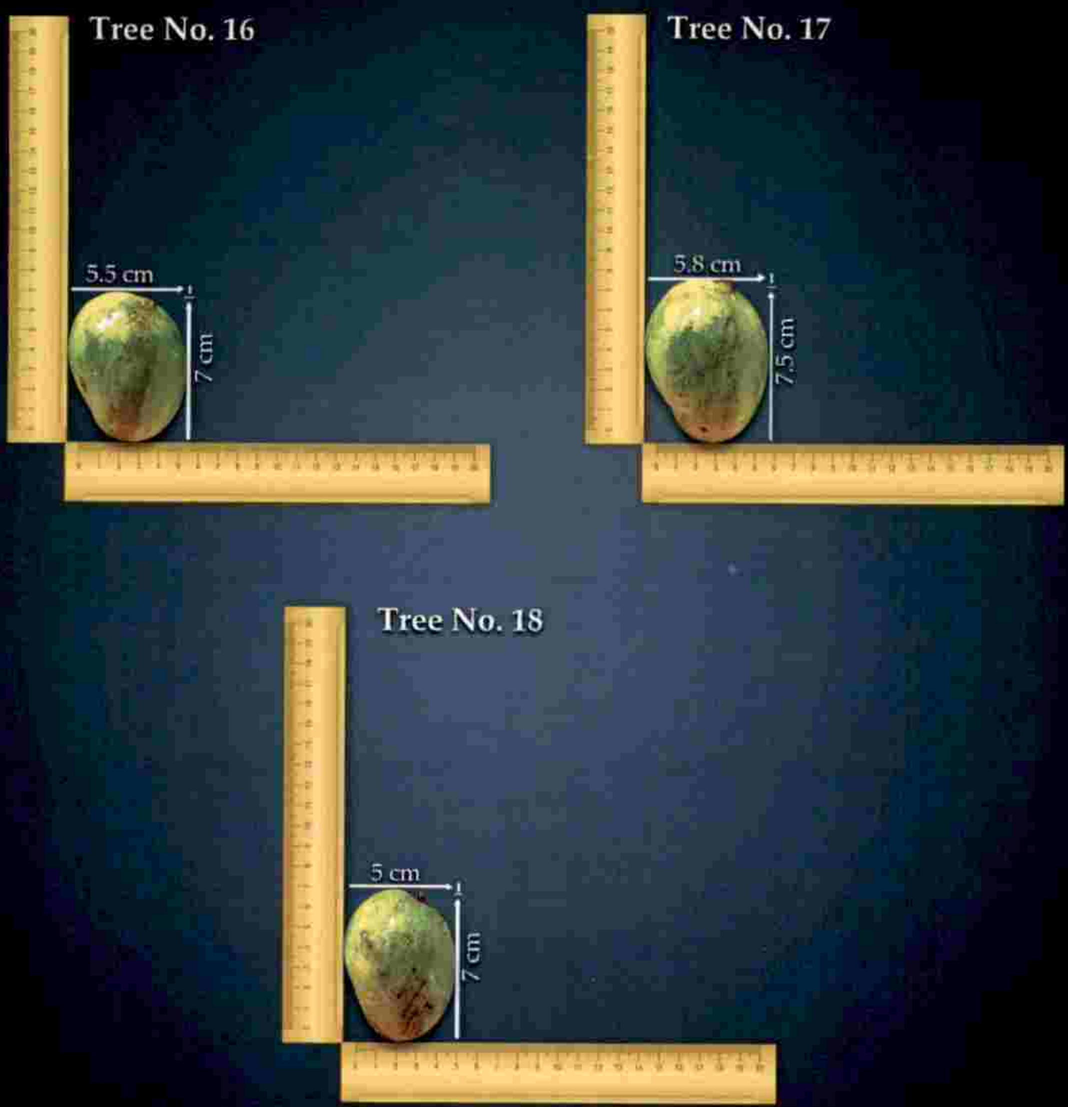

Plate 34. Variations in fruit characters of mango genotype Vellaikolumban selected under normal planting system

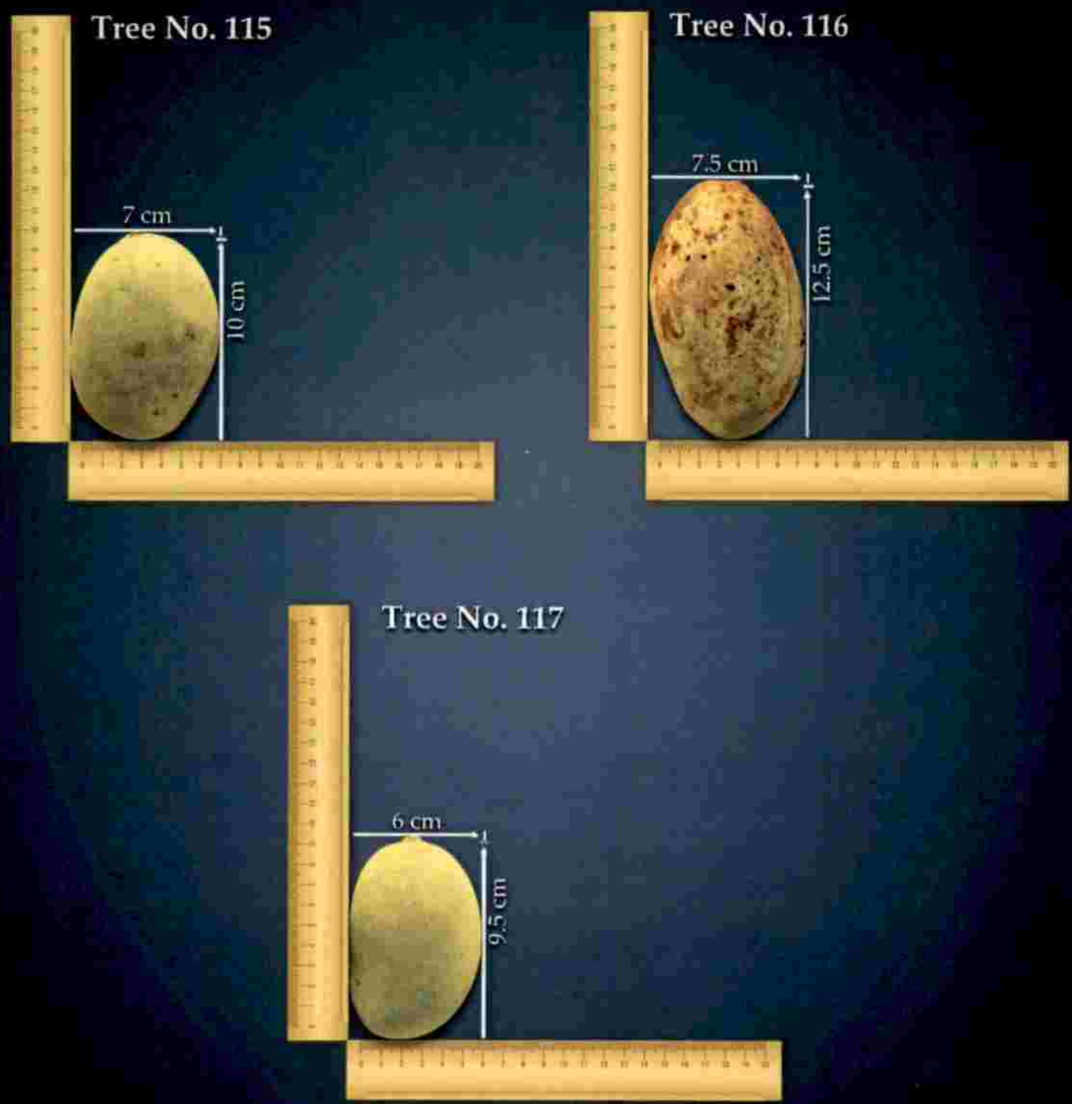

Plate 35. Variations in fruit characters of mango genotype Prior selected under normal planting system

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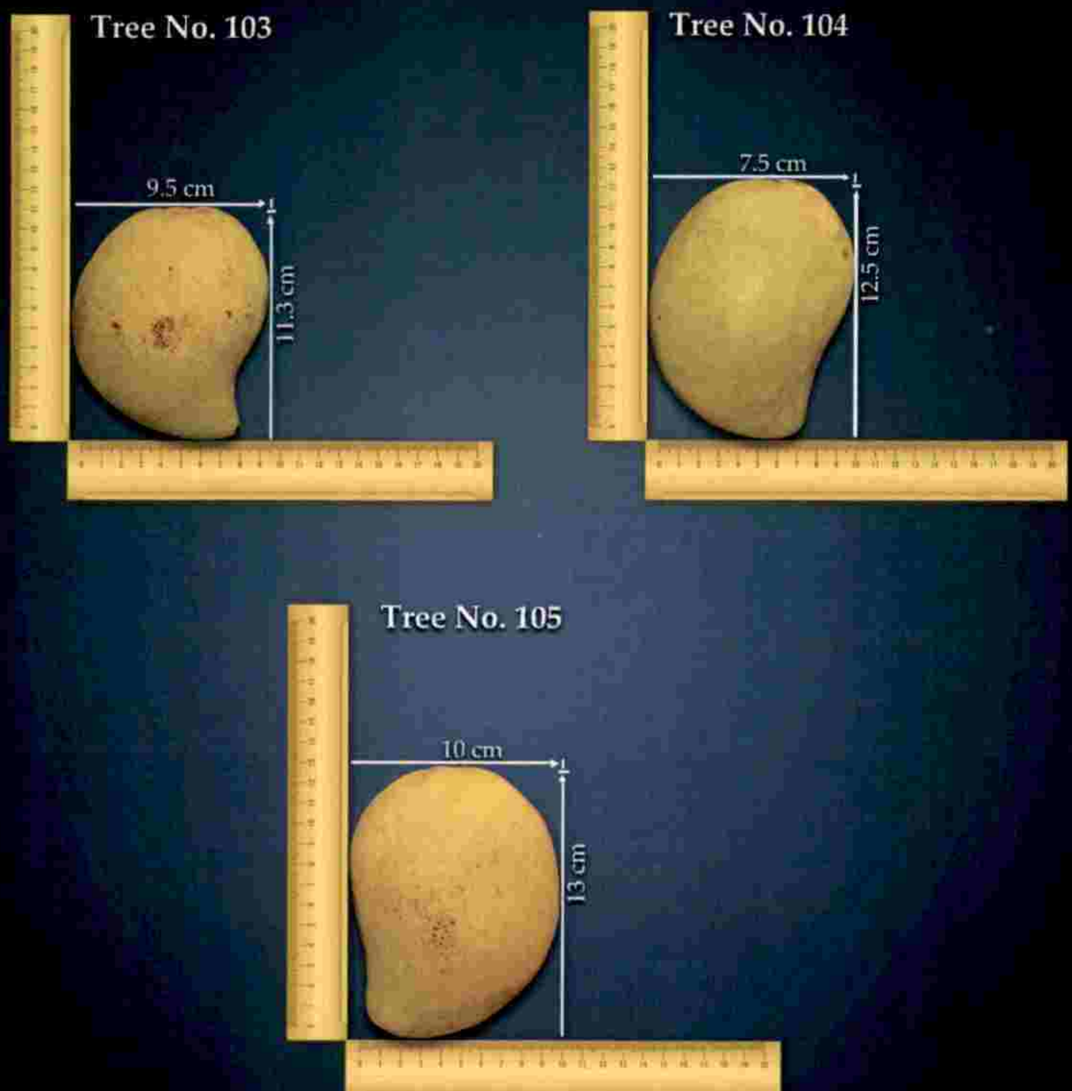
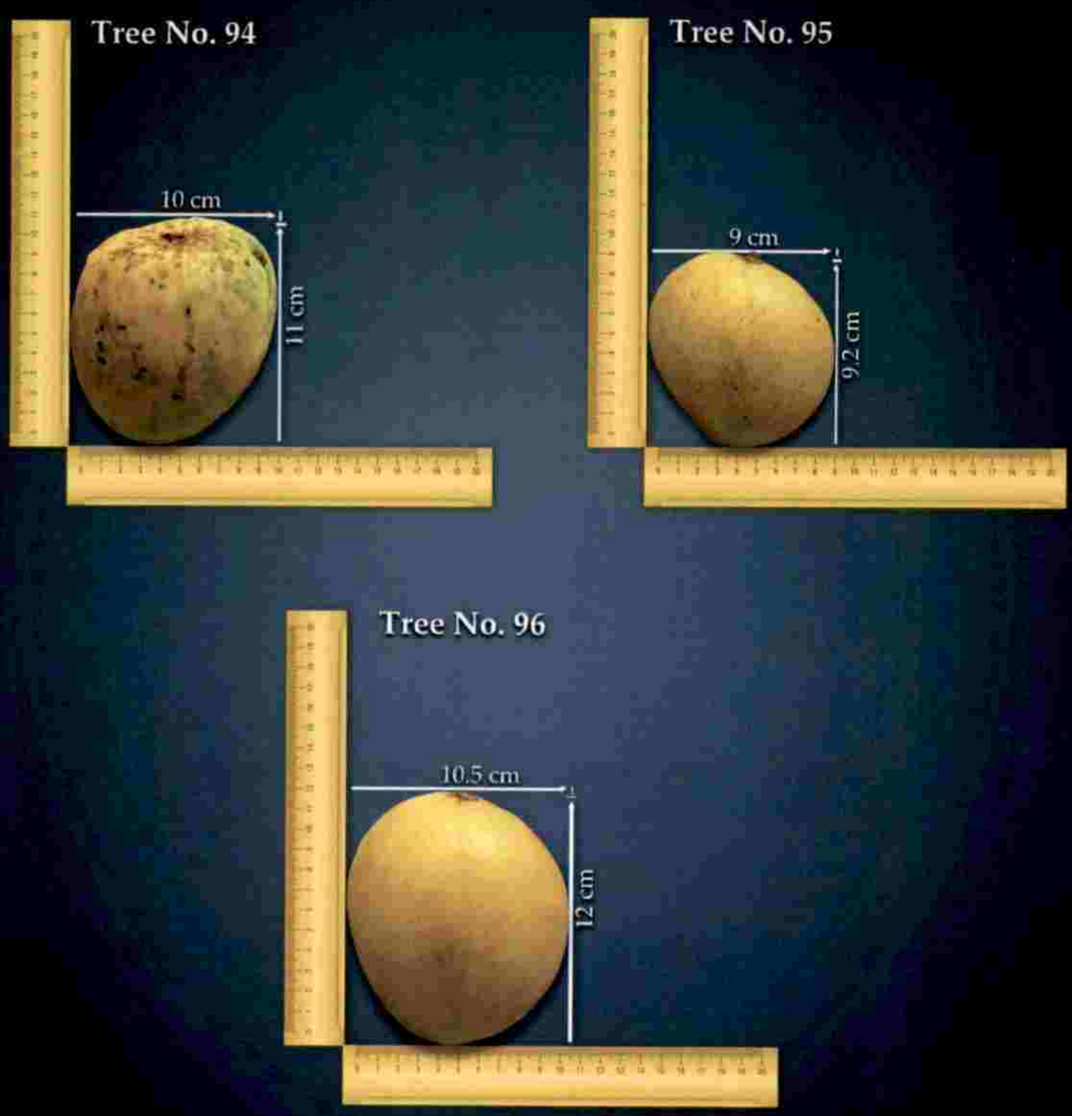


Plate 36. Variations in fruit characters of mango genotype Muvandan selected under normal planting system



Grouping the local types, Cluster I had trees with strong and intermediate aroma for ripe fruits. Cluster II had trees with strong aroma for ripe fruits. Cluster III had tress with mild aroma for ripe fruits (Table 38 and Table 39).

4.1.4.13 Fruit length

The data presented in Table 40a shows the variation in fruit length of different genotypes during the two seasons. Among the hybrids, Mallika (17.97 cm) recorded the highest fruit length followed by PKM 1 (17.82 cm). H 151 (10.27 cm) recorded the lowest fruit length.

Mulgoa (20.08 cm) recorded the highest fruit length which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (10.47 cm) recorded the lowest fruit length which was on par with Neelum (10. 48 cm) and Alphonso (10.65 cm).

Prior (13.77 cm) recorded the highest fruit length followed by Vellaikolumban (13.52 cm) among the local types. Chandrakaran (7.60 cm) recorded the lowest fruit length.

The data presented in Table 40b shows the variation in fruit length of different genotypes during the three seasons. Among the hybrids Arka Aruna (16.56 cm) recorded the highest fruit length which followed by PKM 2 (16.47 cm). H 151 (9.11 cm) recorded the lowest fruit length.

Mulgoa (19.99 cm) recorded the highest fruit length which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (10.47 cm) recorded the lowest fruit length which was on par with Alphonso (10.54 cm).

Prior (13.67 cm) recorded the highest fruit length whereas Chandrakaran (7.47 cm) recorded the lowest fruit length among the local types.

4.1.4.14 Fruit diameter

The data presented in Table 41a shows the variation in fruit diameter of different genotypes during the two seasons. Among the hybrids Arka Aruna (32.50 cm) recorded the highest fruit diameter which was significantly different from the rest of the hybrids. H 151 (17.05 cm) recorded the lowest fruit diameter.

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Table 40a. Fruit length (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	16.53	16.33	16.43
2	Amrapali	13.73	12.67	13.20
3	Mallika	17.90	18.03	17.97
4	Ratna	13.33	14.30	13.82
5	Sindhu	14.13	13.73	13.93
6	H45	12.27	12.07	12.17
7	H 151	9.93	10.60	10.27
8	PKM1	17.60	18.03	17.82
9	PKM 2	16.23	15.87	16.05
10	Neelgoa	12.53	13.40	12.97
11	Banganapalli	15.23	14.13	14.68
12	Alphonso	10.80	10.50	10.65
13	Dashehari	14.67	14.03	14.35
14	Neelum	10.60	10.37	10.48
15	Himayuddin	14.27	16.77	15.52
16	Bennet Alphonso	10.33	10.60	10.47
17	Kalepady	13.40	14.23	13.82
18	Swarnarekha	14.93	14.03	14.48
19	Mulgoa	20.27	19.90	20.08
20	Tholikaippan	9.83	9.67	9.75
21	Chandrakaran	7.50	7.70	7.60
22	Vellaikolumban	14.07	12.97	13.52
23	Prior	13.50	14.03	13.77
24	Muvandan	12.23	11.00	11.62
	Mean	13.58	13.54	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.89	0.45	0.32
	Year x Genotype	1.25	0.63	0.45

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Table 40b. Fruit length (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	16.80	16.53	16.33	16.56
2	Ratna	14.15	13.33	14.30	13.93
3	H 45	14.17	12.27	12.07	12.83
4	H 151	6.79	9.93	10.60	9.11
5	PKM 2	17.32	16.23	15.87	16.47
6	Banganapalli	14.51	15.23	14.13	14.63
7	Alphonso	10.32	10.80	10.50	10.54
8	Himayuddin	15.76	14.27	16.77	15.60
9	Bennet Alphonso	10.49	10.33	10.60	10.47
10	Swarnarekha	13.42	14.93	14.03	14.13
11	Mulgoa	19.80	20.27	19.90	19.99
12	Chandrakaran	7.20	7.50	7.70	7.47
13	Prior	13.47	13.50	14.03	13.67
	Mean				
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.18	0.59	0.42	
	Year x Genotype	NS	1.03	0.73	

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Table 41a. Fruit diameter (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	31.20	33.80	32.50
2	Amrapali	23.73	23.63	23.68
3	Mallika	24.97	24.63	24.80
4	Ratna	23.83	28.17	26.00
5	Sindhu	19.33	19.57	19.45
6	H45	24.87	24.00	24.43
7	H 151	17.43	16.67	17.05
8	PKM1	27.03	26.87	26.95
9	PKM 2	26.23	25.47	25.85
10	Neelgoa	24.00	23.60	23.80
11	Banganapalli	23.90	24.13	24.02
12	Alphonso	19.37	19.40	19.38
13	Dashehari	21.77	21.53	21.65
14	Neelum	18.90	18.67	18.78
15	Himayuddin	26.03	27.03	26.53
16	Bennet Alphonso	19.40	18.53	18.97
17	Kalepady	21.27	21.07	21.17
18	Swarnarekha	24.60	25.33	24.97
19	Mulgoa	27.63	28.40	28.02
20	Tholikaippan	17.87	17.60	17.73
21	Chandrakaran	17.07	17.20	17.13
22	Vellaikolumban	21.43	25.60	23.52
23	Prior	26.93	26.73	26.83
24	Muvandan	21.37	22.83	22.10
	Mean	22.92	23.35	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	1.66	0.83	0.59
	Year x Genotype	NS	1.18	0.83

Table 41.b Fruit diameter (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	33.60	31.20	33.80	32.87
2	Ratna	27.23	23.83	28.17	26.41
3	H 45	30.61	24.87	24.00	26.49
4	H 151	20.68	17.43	16.67	18.26
5	PKM 2	31.69	26.23	25.47	27.80
6	Banganapalli	24.07	23.90	24.13	24.04
7	Alphonso	19.30	19.37	19.40	19.36
8	Himayuddin	23.50	26.03	27.03	25.52
9	Bennet Alphonso	19.27	19.40	18.53	19.07
10	Swarnarekha	23.87	24.60	25.33	24.60
11	Mulgoa	25.20	27.63	28.40	27.08
12	Chandrakaran	16.63	17.07	17.20	16.96
13	Prior	26.03	26.93	26.73	26.57
	Mean	24.74	23.73	24.22	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.46	0.73	0.52	
	Year x Genotype	2.52	1.27	0.89	

Mulgoa (28.02 cm) recorded the highest fruit diameter followed by Himayuddin (26.53 cm) among the parents involved in breeding. Neelum (18.78 cm) recorded the lowest fruit diameter which was on par with Bennet Alphonso (18.97 cm) and Alphonso (19.38 cm).

Prior (26.83 cm) recorded the highest fruit diameter which was significantly different from the rest of the local types. Chandrakaran (17.13 cm) recorded the lowest fruit diameter which was on par with Tholikaippan (17.73 cm).

The data presented in Table 41b shows the variation in fruit diameter of different genotypes during the three seasons. Among the hybrids Arka Aruna (32.87 cm) recorded the highest diameter which was significantly different from the rest of the hybrids. H 151 (18.26 cm) recorded the lowest fruit diameter.

Mulgoa (27.08 cm) recorded the highest fruit diameter which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (19.07 cm) recorded the lowest fruit diameter which was on par with Alphonso (19.36 cm).

Prior (26.57 cm) recorded the highest fruit diameter and Chandrakaran (16.96 cm) recorded the lowest fruit diameter among the local types.

4.1.4.15 Fruit weight

The data presented in Table 42a shows the variation in fruit weight of different genotypes during the two seasons. Among the hybrids Arka Aruna (631.40 g) recorded the highest fruit weight which was significantly different from the rest of the hybrids. H 151 (131.25 g) recorded the lowest fruit weight.

Mulgoa (738.97 g) recorded the highest fruit weight which was significantly different from the other parents involved in breeding. Alphonso (145.83 g) recorded the lowest fruit weight which was on par with Bennet Alphonso (168.13 g).

Prior recorded the highest fruit weight which was significantly different from the rest of the local types. Chandrakaran (123.10 g) recorded the lowest fruit weight which was on par with Tholikaippan (142.87 g).

The data presented in Table 42b shows the variation in fruit weight of different genotypes during the three seasons. Among the hybrids Arka Aruna (660.01 g)

Table 42a. Fruit weight (g) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	611.60	651.20	631.40
2	Amrapali	330.70	312.90	321.80
3	Mallika	453.43	457.73	455.58
4	Ratna	290.27	304.47	297.37
5	Sindhu	175.33	177.43	176.38
6	H45	319.90	287.00	303.45
7	H 151	128.83	133.67	131.25
8	PKM1	484.37	432.87	458.62
9	PKM 2	507.60	522.50	515.05
10	Neelgoa	257.23	254.23	255.73
11	Banganapalli	405.97	340.00	372.98
12	Alphonso	153.60	138.07	145.83
13	Dashehari	249.03	237.10	243.07
14	Neelum	196.27	193.23	194.75
15	Himayuddin	343.23	400.10	371.67
16	Bennet Alphonso	165.77	170.50	168.13
17	Kalepady	242.03	245.90	243.97
18	Swarnarekha	428.87	425.30	427.08
19	Mulgoa	714.73	763.20	738.97
20	Tholikaippan	140.67	145.07	142.87
21	Chandrakaran	121.33	124.87	123.10
22	Vellaikolumban	179.50	173.13	176.32
23	Prior	330.47	379.40	354.93
24	Muvandan	256.73	263.37	260.05
	Mean	311.98	313.89	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	30.51	15.34	10.85
	Year x Genotype	43.14	21.70	15.34

Table 42.b Fruit weight (g) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	717.24	611.60	651.20	660.01
2	Ratna	459.74	290.27	304.47	351.49
3	H 45	701.23	319.90	287.00	436.04
4	H 151	175.48	128.83	133.67	145.99
5	PKM 2	795.43	507.60	522.50	608.51
6	Banganapalli	431.98	405.97	340.00	392.65
7	Alphonso	151.62	153.60	138.07	147.76
8	Himayuddin	382.07	343.23	400.10	375.13
9	Bennet Alphonso	165.19	165.77	170.50	167.15
10	Swarnarekha	313.85	428.87	425.30	389.34
11	Mulgoa	645.13	714.73	763.20	707.69
12	Chandrakaran	115.27	121.33	124.87	120.49
13	Prior	342.20	330.47	379.40	350.69
	Mean	415.11	347.86	356.94	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	54.32	27.23	19.26	
	Year x Genotype	94.09	47.17	33.35	

recorded the highest fruit weight followed by PKM 2 (608.51 g). H 151 (145.99 g) recorded the lowest fruit weight.

Mulgoa (707.69 g) recorded the highest fruit weight which was significantly different from the rest of the parents involved in breeding. Alphonso (147.76 g) recorded the lowest fruit weight which was on par with Bennet Alphonso (167.15 g).

Prior (350.69 g) recorded the highest fruit weight and Chandrakaran (120.49 g) recorded the lowest fruit weight among the local types.

4.1.4.16 Fruit yield

The data presented in Table 43a shows the variation in fruit yield of different genotypes during the two seasons. Among the hybrids H45 (46.92 kg/Tree) recorded the highest yield followed by Mallika (47.17 kg/Tree). Arka Aruna (9.75 kg/Tree) recorded the lowest yield which was on par with H 151 (11.57 kg/Tree) and PKM 2 (13.33 kg/Tree).

Dashehari (48.00 kg/Tree) recorded the highest fruit yield which was significantly different from the rest of the parents involved in breeding. Mulgoa (11.42 kg/Tree) recorded the lowest fruit yield which was on par with Banganapalli (12.13 kg/Tree) and Swarnarekha (12.80 kg/Tree).

Muvandan (52.13 kg/Tree) recorded the highest fruit yield followed by Tholikaippan (50.33 kg/Tree) and Prior (48.84 kg/Tree). Chandrakaran (12.87 kg/Tree) recorded the lowest fruit yield among the local types

The data presented in Table 43b shows the variation in fruit yield of different genotypes during the three seasons. Among the hybrids H 45 (38.61 kg/tree) recorded the highest fruit yield which was significantly different from the rest of the hybrids. Arka Aruna (8.67 kg/tree) recorded the lowest fruit yield which was on par with H 151 (9.93 kg/tree) and PKM 2 (11.94 kg/tree).

Bennet Alphonso (29.14 kg/tree) recorded the highest fruit yield which was significantly different from the rest of the parents involved in breeding. Mulgoa (9.67 kg/tree) recorded the lowest fruit yield which was on par with Banganapalli (11.26 kg/tree) and Swarnarekha (12.03 kg/tree).

Table 43a. Yield per tree (kg year $^{-1}$) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	11.17	8.33	9.75
2	Amrapali	36.63	31.67	34.15
3	Mallika	49.33	43.00	46.17
4	Ratna	33.43	29.00	31.22
5	Sindhu	44.83	40.83	42.83
6	H45	50.17	43.67	46.92
7	H 151	14.80	8.33	11.57
8	PKM1	20.33	14.80	17.57
9	PKM 2	18.33	8.33	13.33
10	Neelgoa	24.17	17.00	20.58
11	Banganapalli	14.27	10.00	12.13
12	Alphonso	21.50	14.73	18.12
13	Dashehari	51.67	44.33	48.00
14	Neelum	20.50	13.83	17.17
15	Himayuddin	20.63	15.00	17.82
16	Bennet Alphonso	36.60	31.50	34.05
17	Kalepady	48.50	37.83	43.17
18	Swarnarekha	16.93	8.67	12.80
19	Mulgoa	13.17	9.67	11.42
20	Tholikaippan	54.33	46.33	50.33
21	Chandrakaran	15.57	10.17	12.87
22	Vellaikolumban	47.90	32.67	40.28
23	Prior	51.77	45.91	48.84
24	Muvandan	54.77	49.50	52.13
	Mean	32.14	25.63	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	4.07	2.05	1.45
	Year x Genotype	NS	2.90	2.05

Table 43b. Yield per tree (kg year $^{-1}$) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	6.50	11.17	8.33	8.67
2	Ratna	20.67	33.43	29.00	27.70
3	H 45	22.00	50.17	43.67	38.61
4	H 151	6.67	14.80	8.33	9.93
5	PKM 2	9.17	18.33	8.33	11.94
6	Banganapalli	9.50	14.27	10.00	11.26
7	Alphonso	11.00	21.50	14.73	15.74
8	Himayuddin	11.67	20.63	15.00	15.77
9	Bennet Alphonso	19.33	36.60	31.50	29.14
10	Swarnarekha	10.50	16.93	8.67	12.03
11	Mulgoa	6.17	13.17	9.67	9.67
12	Chandrakaran	10.50	15.57	10.17	12.08
13	Prior	32.70	51.77	45.91	43.46
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.42	1.71	1.21	
	Year x Genotype	5.92	2.97	2.10	

Prior (43.46 kg/tree) recorded the highest fruit yield and Chandrakaran (12.08 kg/tree) recorded the lowest fruit yield among the local types.

4.1.4.17 Shelf Life

The data presented in Table 44a shows the variation in shelf life of different genotypes during the two seasons. Among the hybrids H 151 (7.00 Days) recorded the highest shelf life followed by Ratna (6.67 Days). PKM 1 (3.83 Days) recorded the lowest shelf life which was on par with PKM 2 (4.00 Days).

Dashehari (6.67 Days) recorded the highest shelf life which was significantly different from the rest of the parents involved in breeding. Himayuddin (4.00 Days) recorded the lowest shelf life.

Chandrakaran (4.17 Days) recorded the highest shelf life which followed by the rest of the local types. Tholikaippan (4.00 Days) recorded the lowest shelf life.

The data presented in Table 44b shows the variation in shelf life of different genotypes during the three seasons. Among the hybrids H 151 (7.00 Days) recorded the highest shelf life followed by Ratna (6.78 Days). Pkm 2 (4 Days) recorded the lowest shelf life.

Alphonso (6.00 Days) recorded the highest shelf life followed by Swarnarekha (5.89 Days), Bennet Alphonso (5.89 Days) and Banganapalli (5.78 Days) among the parents involved in breeding. Himayuddin (4 Days) recorded the lowest shelf life.

Chandrakaran (4.11 Days) and Prior (4.11 Days) recorded the same shelf life among the local types both.

4.1.5 Stone characters

4.1.5.1 Stone length

The data presented in Table 45a shows the variation in stone length of different genotypes during the two seasons. Among the hybrids, PKM 2 (11.83 cm) recorded the highest fruit stone length followed by Ratna (11.68 cm) and Mallika (11.53 cm). Sindhu (6.53 cm) recorded the lowest stone length.

Table 44a. Shelf life (days) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	5.00	5.00	5.00
2	Amrapali	5.67	6.00	5.83
3	Mallika	6.00	6.00	6.00
4	Ratna	6.33	7.00	6.67
5	Sindhu	6.00	6.00	6.00
6	H45	5.33	6.00	5.67
7	H 151	7.00	7.00	7.00
8	PKM1	3.67	4.00	3.83
9	PKM 2	4.00	4.00	4.00
10	Neelgoa	4.67	6.00	5.33
11	Banganapalli	5.33	6.00	5.67
12	Alphonso	6.00	6.00	6.00
13	Dashehari	6.33	7.00	6.67
14	Neelum	6.00	6.00	6.00
15	Himayuddin	4.00	4.00	4.00
16	Bennet Alphonso	5.67	6.00	5.83
17	Kalepady	5.67	6.00	5.83
18	Swarnarekha	5.67	6.00	5.83
19	Mulgoa	5.67	6.00	5.83
20	Tholikaippan	4.00	4.00	4.00
21	Chandrakaran	4.33	4.00	4.17
22	Vellaikolumban	4.33	4.00	4.17
23	Prior	4.33	4.00	4.17
24	Muvandan	4.33	4.00	4.17
	Mean	5.22	5.42	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.52	0.26	0.19
	Year x Genotype	NS	0.37	0.26

Table 44b. Shelf life (days) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	5.00	5.00	5.00	5.00
2	Ratna	7.00	6.33	7.00	6.78
3	H 45	6.00	5.33	6.00	5.78
4	H 151	7.00	7.00	7.00	7.00
5	Pkm 2	4.00	4.00	4.00	4.00
6	Banganapalli	6.00	5.33	6.00	5.78
7	Alphonso	6.00	6.00	6.00	6.00
8	Himayuddin	4.00	4.00	4.00	4.00
9	Bennet Alphonso	6.00	5.67	6.00	5.89
10	Swarnarekha	6.00	5.67	6.00	5.89
11	Mulgoa	4.00	5.67	6.00	5.22
12	Chandrakaran	4.00	4.33	4.00	4.11
13	Prior	4.00	4.33	4.00	4.11
	Mean	5.31	5.28	5.46	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.36	0.18	0.13	
	Year x Genotype	0.62	0.31	0.22	

Mulgoa (14.05 cm) recorded the highest stone length which was significantly different from the rest of the parents involved in breeding. Neelum (5.60 cm) recorded the lowest stone length.

Prior (12.07 cm) recorded the highest stone length among the local types. Muvandan (5.60 cm) recorded the lowest stone length which was on par with Chandrakaran (5.87 cm).

The data presented in Table 45b shows the variation in stone length of different genotypes during the three seasons. Among the hybrids, PKM 2 (11.23 cm) recorded the highest stone length which was significantly different from the rest of the hybrids. H 151 (7.70 cm) recorded the lowest stone length.

Mulgoa (13.94 cm) recorded the highest stone length which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (6.66 cm) recorded the lowest stone length.

Prior (11.60 cm) recorded the highest stone length and Chandrakaran (5.76 cm) recorded the lowest stone length among the local types.

4.1.5.2 Stone width

The data presented in Table 46a shows the variation in stone width of different genotypes during the two seasons. Among the hybrids, H 45 (12.07 cm) recorded the highest stone width which was significantly different from the rest of the hybrids. Sindhu (3.28 cm) recorded the lowest stone width.

Banganapalli (8.68 cm) recorded the highest stone width followed by Swarnarekha (8.33 cm) and Alphonso (8.08 cm) among the parents involved in breeding. Dashehari (4.18 cm) recorded the lowest stone width which was on par with Neelum (4.48 cm).

Prior (5.85 cm) recorded the highest stone width which was significantly different from the rest of the local types. Muvandan (3.17 cm) recorded the lowest stone width.

The data presented in Table 46b shows the variation in stone width of different genotypes during the three seasons. Among the hybrids, H 45 (12.45 cm) recorded the highest stone width which was significantly different from the rest of the hybrids. H 151 (7 cm) recorded the lowest stone width.

Table 45a. Stone length (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	10.10	10.40	10.25
2	Amrapali	8.60	9.50	9.05
3	Mallika	10.97	12.10	11.53
4	Ratna	11.47	11.90	11.68
5	Sindhu	6.30	6.77	6.53
6	H45	9.03	9.83	9.43
7	H 151	7.60	8.13	7.87
8	PKM1	8.33	8.83	8.58
9	PKM 2	10.67	13.00	11.83
10	Neelgoa	8.40	8.20	8.30
11	Banganapalli	9.40	9.93	9.67
12	Alphonso	9.63	9.57	9.60
13	Dashehari	8.73	10.00	9.37
14	Neelum	5.77	5.43	5.60
15	Himayuddin	8.37	9.43	8.90
16	Bennet Alphonso	6.67	6.83	6.75
17	Kalepady	8.27	8.00	8.13
18	Swarnarekha	8.97	9.37	9.17
19	Mulgoa	14.03	14.07	14.05
20	Tholikaippan	7.23	7.33	7.28
21	Chandrakaran	5.53	6.20	5.87
22	Vellaikolumban	8.43	8.70	8.57
23	Prior	11.70	12.43	12.07
24	Muvandan	6.40	4.80	5.60
	Mean	8.78	9.20	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.56	0.28	0.20
	Year x Genotype	0.79	0.40	0.28

Table 45b. Stone length (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.85	10.10	10.40	9.78
2	Ratna	8.45	11.47	11.90	10.61
3	H 45	9.22	9.03	9.83	9.36
4	H 151	7.37	7.60	8.13	7.70
5	PKM 2	10.01	10.67	13.00	11.23
6	Banganapalli	8.21	9.40	9.93	9.18
7	Alphonso	9.50	9.63	9.57	9.57
8	Himayuddin	8.40	8.37	9.43	8.73
9	Bennet Alphonso	6.48	6.67	6.83	6.66
10	Swarnarekha	9.17	8.97	9.37	9.17
11	Mulgoa	13.73	14.03	14.07	13.94
12	Chandrakaran	5.53	5.53	6.20	5.76
13	Prior	10.67	11.70	12.43	11.60
	Mean	8.89	9.47	10.09	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.43	0.22	0.15	
	Year x Genotype	0.75	0.38	0.27	

Table 46a. Stone width (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	7.37	6.00	6.68
2	Amrapali	3.77	3.97	3.87
3	Mallika	6.20	5.67	5.93
4	Ratna	9.70	10.60	10.15
5	Sindhu	3.30	3.27	3.28
6	H45	12.20	11.93	12.07
7	H 151	7.03	7.10	7.07
8	PKM1	5.23	5.47	5.35
9	PKM 2	8.53	6.37	7.45
10	Neelgoa	4.50	4.70	4.60
11	Banganapalli	8.30	9.07	8.68
12	Alphonso	8.10	8.07	8.08
13	Dashehari	4.27	4.10	4.18
14	Neelum	4.37	4.60	4.48
15	Himayuddin	6.87	7.93	7.40
16	Bennet Alphonso	5.00	5.17	5.08
17	Kalepady	5.13	4.83	4.98
18	Swarnarekha	8.77	7.90	8.33
19	Mulgoa	6.87	6.87	6.87
20	Tholikaippan	4.33	4.50	4.42
21	Chandrakaran	4.03	3.60	3.82
22	Vellaikolumban	4.67	4.77	4.72
23	Prior	5.43	6.27	5.85
24	Muvandan	3.10	3.23	3.17
	Mean	6.13	6.08	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.47	0.24	0.17
	Year x Genotype	0.66	0.33	0.24

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Table 46.b Stone width (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	10.65	7.37	6.00	8.00
2	Ratna	10.56	9.70	10.60	10.29
3	H 45	13.21	12.20	11.93	12.45
4	H 151	6.87	7.03	7.10	7.00
5	PKM 2	11.02	8.53	6.37	8.64
6	Banganapalli	9.26	8.30	9.07	8.88
7	Alphonso	9.19	8.10	8.07	8.45
8	Himayuddin	8.23	6.87	7.93	7.68
9	Bennet Alphonso	5.17	5.00	5.17	5.11
10	Swarnarekha	9.84	8.77	7.90	8.84
11	Mulgoa	8.30	6.87	6.87	7.34
12	Chandrakaran	3.70	4.03	3.60	3.78
13	Prior	5.27	5.43	6.27	5.66
	Mean	8.56	7.55	7.45	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.42	0.21	0.15	
	Year x Genotype	0.73	0.37	0.26	

Banganapalli (8.88 cm) recorded the highest stone width followed by Swarnarekha (8.84 cm) and Alphonso (8.45 cm) among the parents involved in breeding. Bennet Alphonso (5.11 cm) recorded the lowest stone width.

Prior (5.66 cm) recorded the highest stone width and Chandrakaran (3.78 cm) recorded the lowest stone width among the local types.

4.1.5.3 Stone thickness

The data presented in Table 47a shows the variation in stone thickness of different genotypes during the two seasons. Among the hybrids, Neelgoa (3.15 cm) recorded the highest stone thickness which was significantly different from the rest of the hybrids. PKM 1 (1.22 cm) recorded the lowest stone thickness which was on par with Mallika (1.28 cm), H 151 (1.29 cm), Ratna (1.38 cm), H 45 (1.45 cm) and Amrapali (1.48 cm).

Alphonso (2.37 cm) recorded the highest stone thickness followed by Swarnarekha (2.28 cm) and Bennet Alphonso (2.23 cm) among the parents involved in breeding. Banganapalli (1.23 cm) recorded the lowest stone thickness which was on par with Mulgoa (1.27 cm) , Himayuddin (1.37 cm) and Dashehari (1.42 cm).

Vellaikolumban (2.17cm) recorded the highest stone thickness followed by Prior (1.95 cm) among the local types. Muvandan (1.20 cm) recorded the lowest stone thickness which was on par with Tholikaippan (1.35 cm).

The data presented in Table 47b shows the variation in stone thickness of different genotypes during the three seasons. Among the hybrids, Arka Aruna (2.45 cm) recorded the highest stone thickness which was significantly different from the rest of the hybrids. H 151 (1.34 cm) recorded the lowest stone thickness.

Alphonso (2.42 cm) recorded the highest stone thickness followed by Bennet Alphonso (2.38 cm) and Swarnarekha (2.22 cm) among the parents involved in breeding. Mulgoa (1.24 cm) recorded the lowest stone thickness which was on par with Himayuddin (1.30 cm) and Banganapalli (1.31 cm).

Prior (2.00 cm) recorded the highest stone thickness and Chandrakaran (1.67 cm) recorded the lowest stone thickness among the local types.

Table 47a. Stone thickness (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	2.10	2.67	2.38
2	Amrapali	1.30	1.67	1.48
3	Mallika	1.27	1.30	1.28
4	Ratna	1.40	1.37	1.38
5	Sindhu	2.00	1.77	1.88
6	H45	1.47	1.43	1.45
7	H 151	1.24	1.33	1.29
8	PKM1	1.23	1.20	1.22
9	PKM 2	2.00	1.27	1.64
10	Neelgoa	3.17	3.13	3.15
11	Banganapalli	1.27	1.20	1.23
12	Alphonso	2.20	2.53	2.37
13	Dashehari	1.50	1.33	1.42
14	Neelum	1.63	1.67	1.65
15	Himayuddin	1.27	1.47	1.37
16	Bennet Alphonso	2.10	2.37	2.23
17	Kalepady	1.67	1.97	1.82
18	Swarnarekha	2.33	2.23	2.28
19	Mulgoa	1.33	1.20	1.27
20	Tholikaippan	1.30	1.40	1.35
21	Chandrakaran	1.67	1.80	1.73
22	Vellaikolumban	2.17	2.17	2.17
23	Prior	2.07	1.83	1.95
24	Muvandan	1.27	1.13	1.20
	Mean	1.71	1.73	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.25	0.12	0.09
	Year x Genotype	0.35	0.18	0.12

Table 47b. Stone thickness (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	2.58	2.10	2.67	2.45
2	Ratna	2.19	1.40	1.37	1.65
3	H 45	2.29	1.47	1.43	1.73
4	H 151	1.43	1.24	1.33	1.34
5	PKM 2	1.74	2.00	1.27	1.67
6	Banganapalli	1.47	1.27	1.20	1.31
7	Alphonso	2.54	2.20	2.53	2.42
8	Himayuddin	1.17	1.27	1.47	1.30
9	Bennet Alphonso	2.68	2.10	2.37	2.38
10	Swarnarekha	2.11	2.33	2.23	2.22
11	Mulgoa	1.20	1.33	1.20	1.24
12	Chandrakaran	1.53	1.67	1.80	1.67
13	Prior	2.10	2.07	1.83	2.00
	Mean	1.93	1.73	1.75	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.20	0.10	0.07	
	Year x Genotype	0.34	0.17	0.12	

4.1.5.4 Stone weight

The data presented in Table 48a shows the variation in stone weight of different genotypes during the two seasons. Among the hybrids, Mallika (45.50 g) recorded the highest stone weight which was significantly different from the rest of the hybrids. Sindhu (20.15 g) recorded the lowest stone weight which was on par with H 151 (22.33 g) and PKM 1 (23.52 g).

Mulgoa (47.73 g) recorded the highest stone weight which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (15.93 g) recorded the lowest stone weight.

Prior (29.43 g) recorded the highest stone weight which is significantly different from rest of the local types. Vellaikolumban (17.17 g) recorded the lowest stone weight which was on par with Chandrakaran (18.77 g).

The data presented in Table 48b shows the variation in stone weight of different genotypes during the three seasons. Among the hybrids, Arka Aruna (47.67 g) recorded the highest stone weight which was significantly different from the rest of the hybrids. H 151 (22.60 g) recorded the lowest stone weight.

Mulgoa (47.46 g) recorded the highest stone weight which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (16.05 g) recorded the lowest stone weight.

Prior (29.07 g) recorded the highest stone weight and Chandrakaran (18.49 g) recorded the lowest stone weight among the local types.

4.1.5.5 Seed length

The data presented in Table 49a shows the variation in seed length of different genotypes during the two seasons. Among the hybrids, Amrapali (7.38 cm) recorded the highest seed length followed by PKM 2 (7.27 cm), Mallika (7.23 cm), Ratna (6.87 cm) and H 45 (6.87 cm). H 151 (6.05 cm) recorded the lowest seed length which was on par with Sindhu (6.13 cm), Arka Aruna (6.28 cm), Neelgoa (6.53 cm) and PKM 1 (6.60 cm).

Table 48a. Stone weight (g) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	39.90	39.50	39.70
2	Amrapali	32.20	34.63	33.42
3	Mallika	45.77	45.23	45.50
4	Ratna	28.13	27.23	27.68
5	Sindhu	22.27	18.03	20.15
6	H45	27.73	26.63	27.18
7	H 151	23.67	21.00	22.33
8	PKM1	24.17	22.87	23.52
9	PKM 2	31.90	35.10	33.50
10	Neelgoa	36.67	42.23	39.45
11	Banganapalli	35.73	32.53	34.13
12	Alphonso	32.13	32.87	32.50
13	Dashehari	34.63	30.07	32.35
14	Neelum	19.43	23.10	21.27
15	Himayuddin	24.60	26.53	25.57
16	Bennet Alphonso	16.00	15.87	15.93
17	Kalepady	21.43	29.63	25.53
18	Swarnarekha	31.13	44.23	37.68
19	Mulgoa	43.77	51.70	47.73
20	Tholikaippan	18.90	25.73	22.32
21	Chandrakaran	17.20	20.33	18.77
22	Vellaikolumban	16.83	17.50	17.17
23	Prior	32.57	26.30	29.43
24	Muvandan	22.97	24.53	23.75
	Mean	28.32	29.73	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	3.99	2.01	1.42
	Year x Genotype	5.64	2.84	2.01

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Table 48b. Stone weight (g) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	45.61	39.90	39.50	41.67
2	Ratna	30.27	28.13	27.23	28.54
3	H 45	31.99	27.73	26.63	28.79
4	H 151	23.13	23.67	21.00	22.60
5	PKM 2	50.17	31.90	35.10	39.06
6	Banganappalli	38.43	35.73	32.53	35.57
7	Alphonso	34.96	32.13	32.87	33.32
8	Himayuddin	25.13	24.60	26.53	25.42
9	Bennet Alphonso	16.30	16.00	15.87	16.05
10	Swarnarekha	44.83	31.13	44.23	40.06
11	Mulgoa	46.90	43.77	51.70	47.46
12	Chandrakaran	17.93	17.20	20.33	18.49
13	Prior	28.33	32.57	26.30	29.07
	Mean	33.38	29.57	30.76	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.56	1.29	0.91	
	Year x Genotype	4.44	2.23	1.57	

Plate 37. Variations in stone characters of mango genotypes Arka Aruna, Amrapali, Mallika, Ratna and Sindhu selected under normal planting system

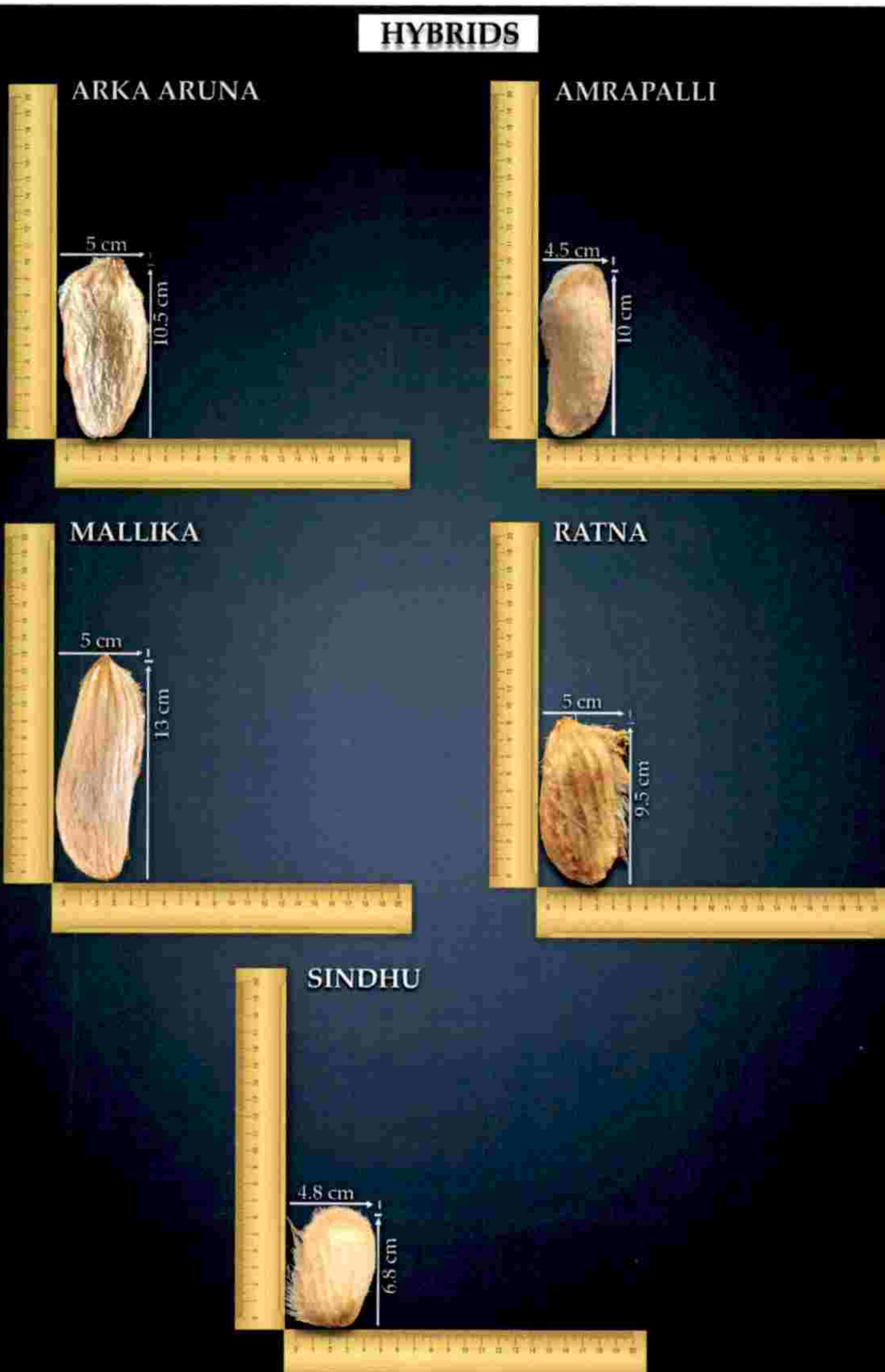

Plate 38. Variations in stone characters of mango genotypes H45, H151, PKM1, PKM 2 and Neelgoa selected under normal planting system

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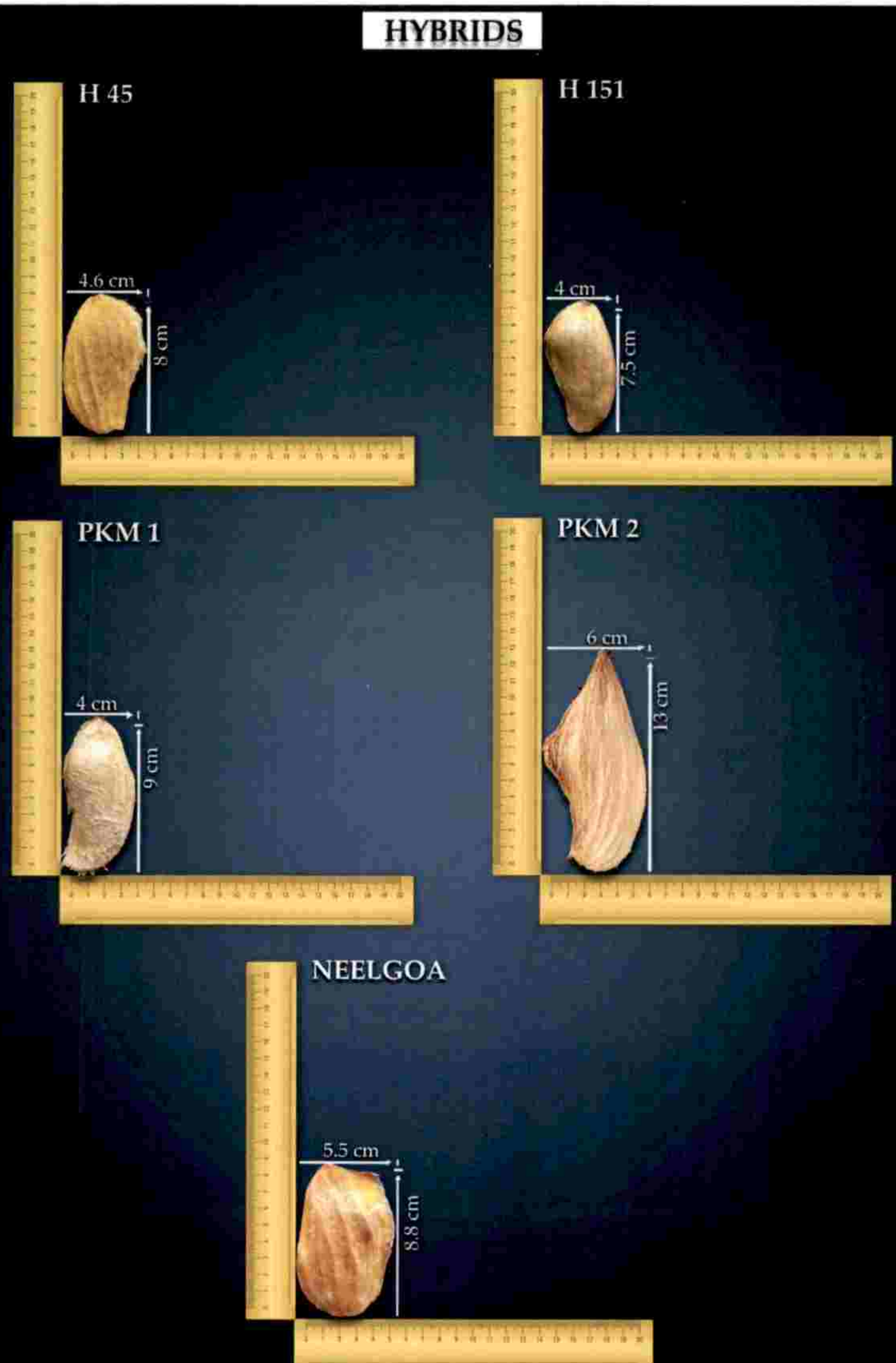

Plate 39. Variations in stone characters of mango genotypes Banganapalli, Alphonso, Dashehari, Neelum and Himayuddin selected under normal planting system

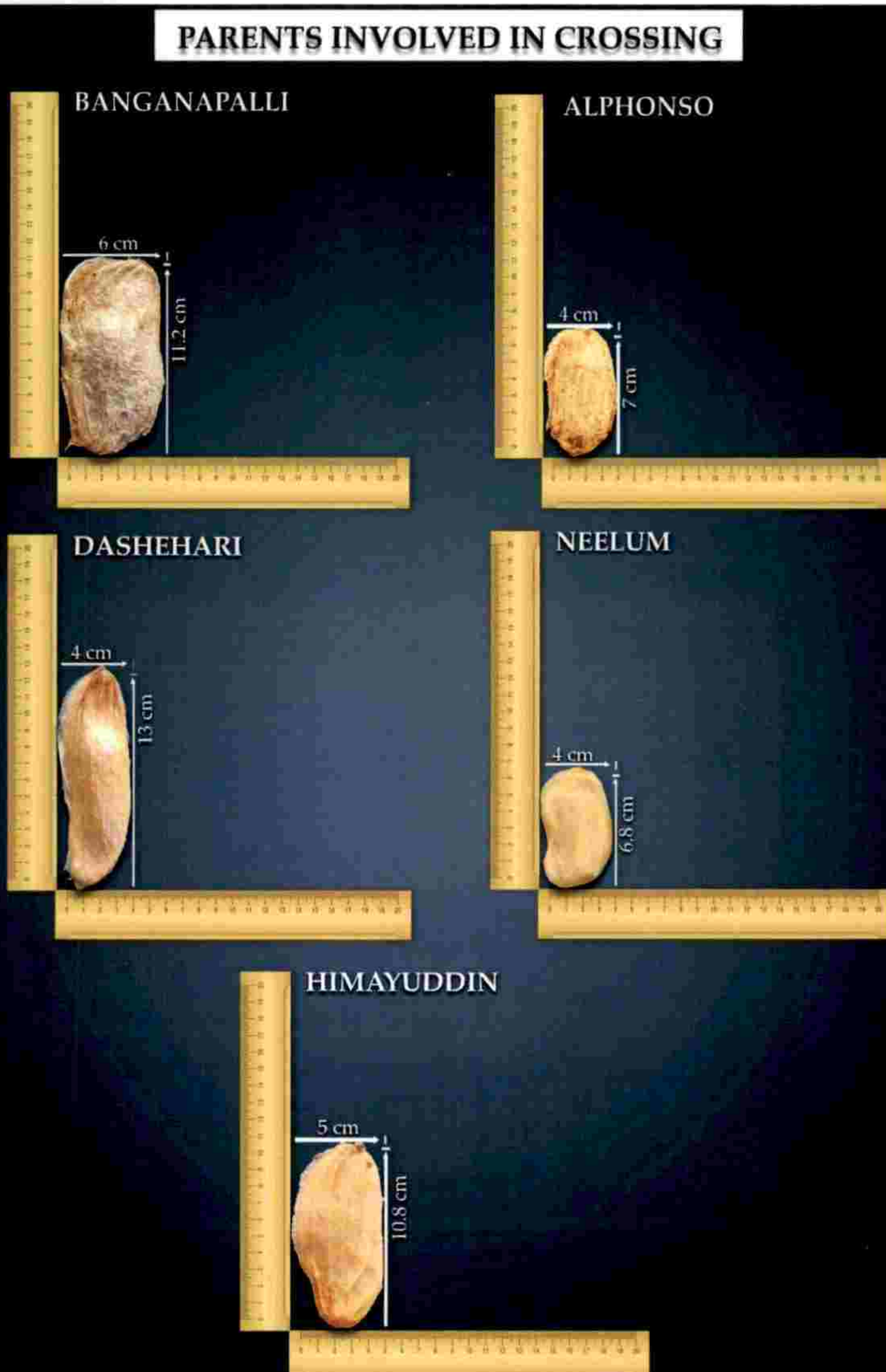

Plate 40. Variations in stone characters of mango genotypes Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa selected under normal planting system

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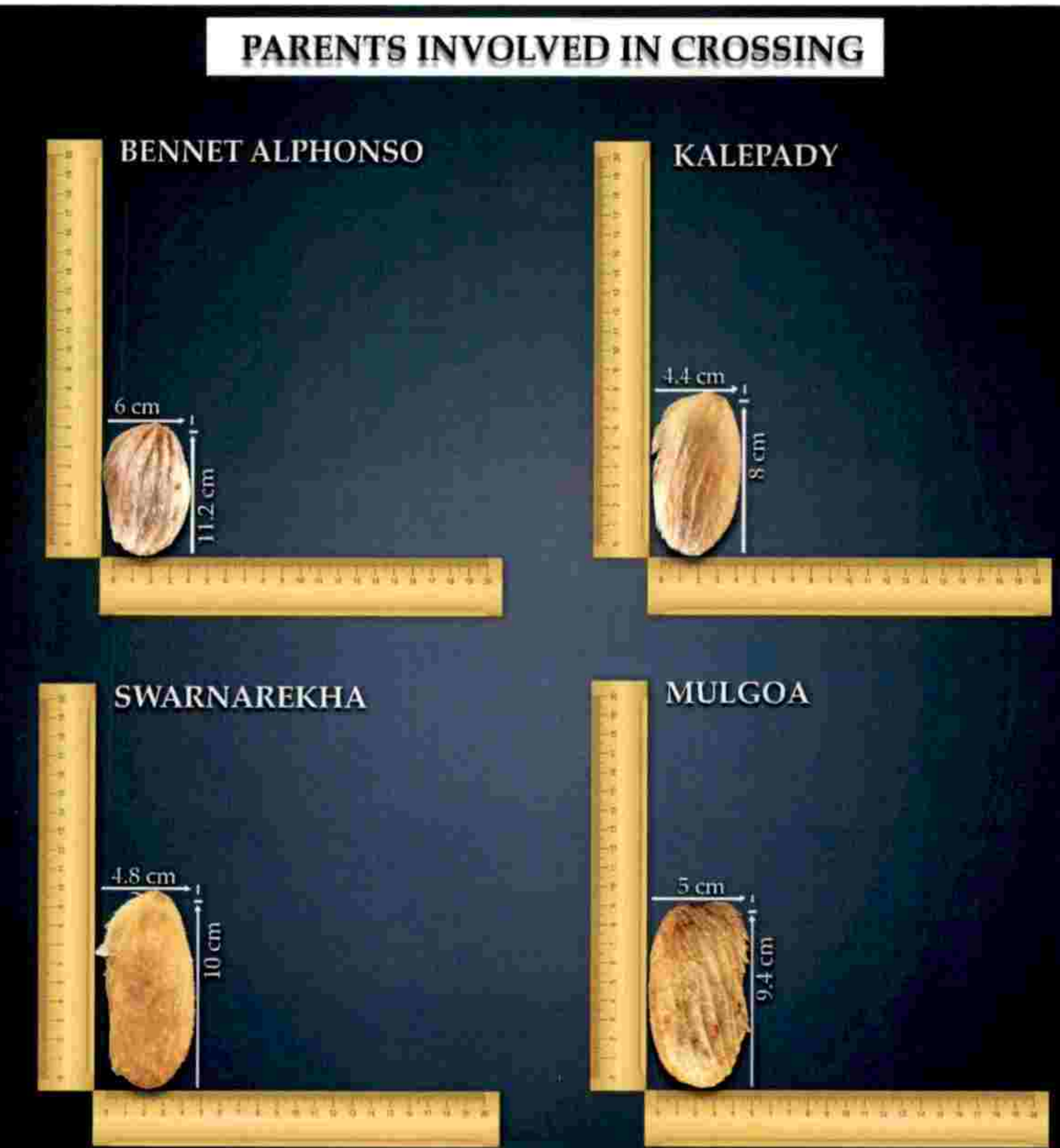
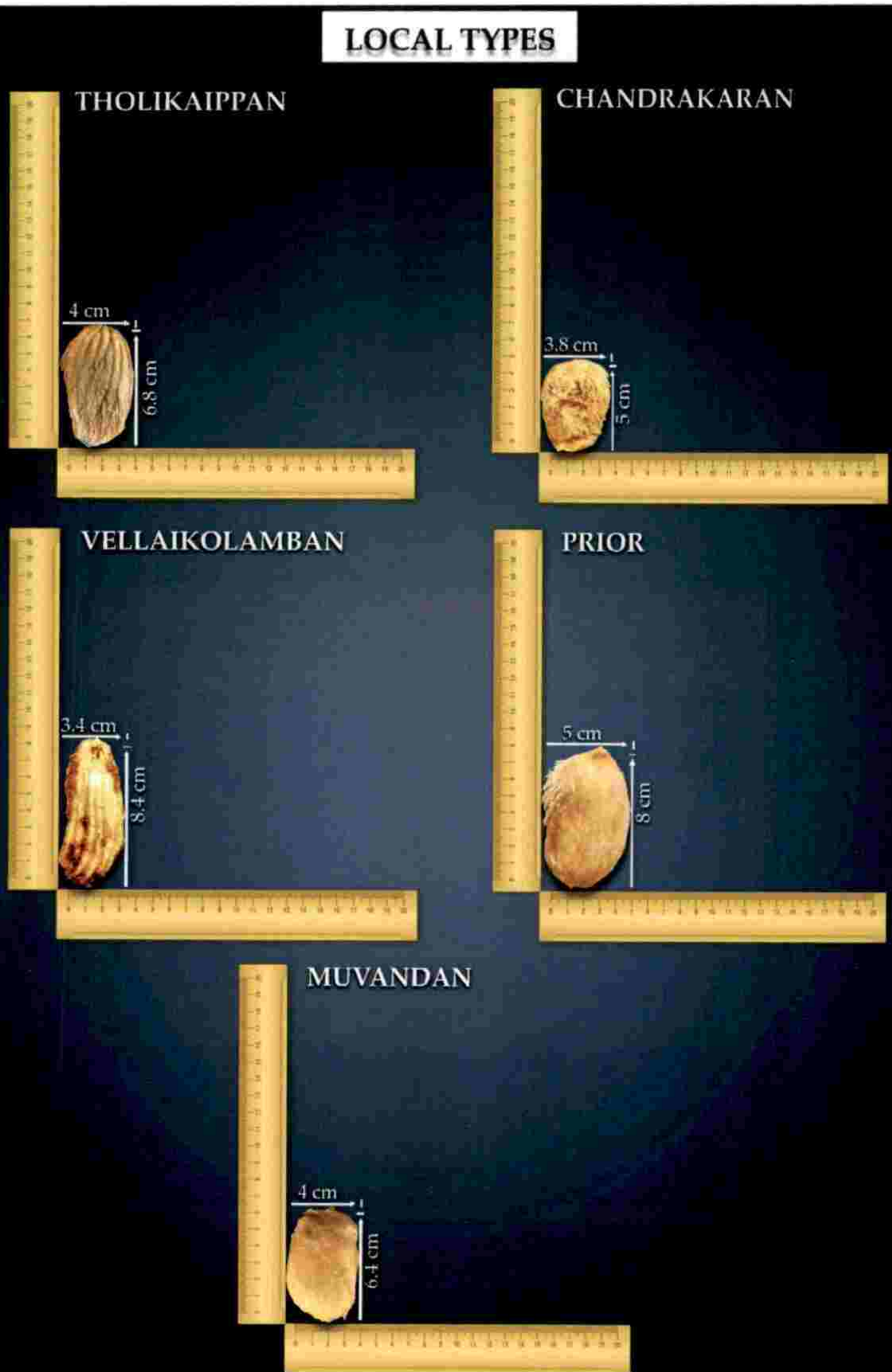


Plate 41. Variations in stone characters of mango genotypes Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan selected under normal planting system



Mulgoa (11.22 cm) recorded the highest seed length which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (4.28 cm) recorded the lowest seed length.

Tholikaippan (6.25 cm) recorded the highest seed length followed by Prior (6.23 cm) and Vellaikolumban (5.73 cm) among the local types. Chandrakaran (4.45 cm) recorded the lowest seed length which was on par with Muvandan (4.98 cm).

The data presented in Table 49b shows the variation in seed length of different genotypes during the three seasons. Among the hybrids, PKM 2 (7.55 cm) recorded the highest seed length followed by H 45 (7.45 cm). H 151 (5.92 cm) recorded the lowest seed length.

Mulgoa (10.89 cm) recorded the highest seed length which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (4.31 cm) recorded the lowest seed length.

Prior (6.00 cm) recorded the highest seed length and Chandrakaran (4.26 cm) recorded the lowest seed length among the local types.

4.1.5.6 Seed width

The data presented in Table 50a shows the variation in seed width of different genotypes during the two seasons. Among the hybrids, Ratna (8.45 cm) recorded the highest seed width which was significantly different from the rest of the hybrids. Sindhu (2.25 cm) recorded the lowest seed width.

Banganapalli (8.88 cm) recorded the highest seed width which was significantly different from the rest of the parents involved in breeding. Dashehari (3.37 cm) recorded the lowest seed width which was on par with Neelum (3.42 cm) and Kalepady (3.75 cm).

Tholikaippan (3.45 cm) recorded the highest seed width followed by Prior (3.08 cm) among the local types. Muvandan (2.31 cm) recorded the lowest seed width which was on par with Vellaikolumban (2.63 cm).

The data presented in Table 50b shows the variation in seed width of different genotypes during the three seasons. Among the hybrids, Ratna (8.51 cm) recorded the

Table 49a. Seed length (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	6.23	6.33	6.28
2	Amrapali	7.23	7.53	7.38
3	Mallika	7.20	7.27	7.23
4	Ratna	6.80	6.93	6.87
5	Sindhu	6.67	5.60	6.13
6	H45	7.40	6.33	6.87
7	H 151	5.80	6.30	6.05
8	PKM1	7.10	6.10	6.60
9	PKM 2	7.57	6.97	7.27
10	Neelgoa	6.23	6.83	6.53
11	Banganapalli	8.17	7.37	7.77
12	Alphonso	6.47	7.17	6.82
13	Dashehari	6.37	6.50	6.43
14	Neelum	4.80	5.60	5.20
15	Himayuddin	7.40	8.00	7.70
16	Bennet Alphonso	3.83	4.73	4.28
17	Kalepady	6.13	6.57	6.35
18	Swarnarekha	7.40	7.53	7.47
19	Mulgoa	11.00	11.43	11.22
20	Tholikaippan	6.40	6.10	6.25
21	Chandrakaran	4.60	4.30	4.45
22	Vellaikolumban	5.73	5.73	5.73
23	Prior	6.20	6.27	6.23
24	Muvandan	4.73	5.23	4.98
	Mean	6.56	6.61	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.59	0.30	0.21
	Year x Genotype	0.84	0.42	0.30

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Table 49b. Seed length (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	7.23	6.23	6.33	6.60
2	Ratna	7.56	6.80	6.93	7.10
3	H 45	8.61	7.40	6.33	7.45
4	H 151	5.67	5.80	6.30	5.92
5	PKM 2	8.11	7.57	6.97	7.55
6	Banganapalli	8.36	8.17	7.37	7.97
7	Alphonso	5.54	6.47	7.17	6.39
8	Himayuddin	6.40	7.40	8.00	7.27
9	Bennet Alphonso	4.36	3.83	4.73	4.31
10	Swarnarekha	7.10	7.40	7.53	7.34
11	Mulgoa	10.23	11.00	11.43	10.89
12	Chandrakaran	3.87	4.60	4.30	4.26
13	Prior	5.53	6.20	6.27	6.00
	Mean	6.81	6.84	6.90	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.40	0.20	0.14	
	Year x Genotype	0.70	0.35	0.25	

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Table 50a. Seed width (cm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	6.17	4.27	5.22
2	Amrapali	2.67	2.97	2.82
3	Mallika	4.07	3.83	3.95
4	Ratna	8.17	8.73	8.45
5	Sindhu	2.00	2.50	2.25
6	H 45	3.50	3.80	3.65
7	H 151	4.97	5.17	5.07
8	PKM1	3.80	3.80	3.80
9	PKM 2	2.80	3.13	2.97
10	Neelgoa	3.20	4.00	3.60
11	Banganapalli	9.13	8.63	8.88
12	Alphonso	5.30	5.47	5.38
13	Dashehari	3.43	3.30	3.37
14	Neelum	3.40	3.43	3.42
15	Himayuddin	7.37	6.47	6.92
16	Bennet Alphonso	6.87	6.30	6.58
17	Kalepady	3.57	3.93	3.75
18	Swarnarekha	8.03	7.97	8.00
19	Mulgoa	4.70	5.00	4.85
20	Tholikaippan	3.50	3.40	3.45
21	Chandrakaran	2.80	2.73	2.77
22	Vellaikolumban	2.83	2.43	2.63
23	Prior	3.23	2.93	3.08
24	Muvandan	2.44	2.17	2.31
	Mean	4.50	4.43	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.45	0.23	0.16
	Year x Genotype	0.64	0.32	0.23

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Table 50b. Seed width (cm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	5.66	6.17	4.27	5.37
2	Ratna	8.64	8.17	8.73	8.51
3	H 45	9.32	3.50	3.80	5.54
4	H 151	5.43	4.97	5.17	5.19
5	PKM 2	3.46	2.80	3.13	3.13
6	Banganapalli	9.03	9.13	8.63	8.93
7	Alphonso	6.37	5.30	5.47	5.71
8	Himayuddin	6.67	7.37	6.47	6.83
9	Bennet Alphonso	6.78	6.87	6.30	6.65
10	Swarnarekha	8.14	8.03	7.97	8.05
11	Mulgoa	5.10	4.70	5.00	4.93
12	Chandrakaran	3.03	2.80	2.73	2.86
13	Prior	2.87	3.23	2.93	3.01
	Mean	6.19	5.62	5.43	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.37	0.19	0.13	
	Year x Genotype	0.64	0.32	0.23	

highest seed width which was significantly different from rest of the hybrids. PKM 2 (3.13 cm) recorded the lowest seed width.

Banganapalli (8.93 cm) recorded the highest seed width which was significantly different from the rest of the parents involved in breeding. Mulgoa (4.93 cm) recorded the lowest seed width.

Prior (3.01 cm) recorded the highest stone width and Chandrakaran (2.86 cm) recorded the lowest stone width among the local types.

4.1.5.7 Seed weight

The data presented in Table 51a shows the variation in seed weight of different genotypes during the two seasons. Among the hybrids, Neelgoa (24.17 g) recorded the highest seed weight followed by Mallika (23.38 g), Amrapali (22.90 g) and PKM 2 (21.38 g). Sindhu (12.80 g) recorded the lowest seed weight which was on par with H 151 (14.50 g).

Mulgoa (28.98 g) recorded the highest seed weight which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (11.03 g), recorded the lowest seed weight which was on par with Neelum (14.62 g).

Tholikaippan (18.45 g) recorded the highest seed weight followed by Muvandan (17.77 g) and Prior (16.53 g) among the local types. Vellaikolumban (8.58 g) recorded the lowest seed weight which was on par with Chandrakaran (15.17 g).

The data presented in Table 51b shows the variation in seed weight of different genotypes during the three seasons. Among the hybrids, PKM 2 (23.71 g) recorded the highest seed weight followed by H 45 (22.99 g). H151 (15.13 g) recorded the lowest seed weight.

Mulgoa (26.49 g) recorded the highest seed weight which was significantly different from the rest of the parents involved in breeding. Bennet Alphonso (11.55 g) recorded the lowest seed weight.

Prior (18.31 g) recorded the highest seed weight and Chandrakaran (14.82 g) recorded the lowest seed weight among the local types.

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Table 51a. Seed weight (g) of different mango genotypes

Sl. No.	Genotypes	YEAR		Mean
		2016-17	2017-18	
1	Arka Aruna	18.07	17.10	17.58
2	Amrapali	25.10	20.70	22.90
3	Mallika	21.50	25.27	23.38
4	Ratna	20.20	20.80	20.50
5	Sindhu	14.00	11.60	12.80
6	H45	20.30	21.63	20.97
7	H 151	14.03	14.97	14.50
8	PKM1	21.17	18.80	19.98
9	PKM 2	21.90	20.87	21.38
10	Neelgoa	22.43	25.90	24.17
11	Banganapalli	16.10	16.07	16.08
12	Alphonso	20.40	19.23	19.82
13	Dashehari	15.77	16.10	15.93
14	Neelum	14.37	14.87	14.62
15	Himayuddin	17.87	18.83	18.35
16	Bennet Alphonso	10.47	11.60	11.03
17	Kalepady	18.77	19.73	19.25
18	Swarnarekha	22.67	23.47	23.07
19	Mulgoa	27.27	30.70	28.98
20	Tholikaippan	17.93	18.97	18.45
21	Chandrakaran	14.43	15.90	15.17
22	Vellaikolumban	7.83	9.33	8.58
23	Prior	15.83	17.23	16.53
24	Muvandan	16.50	19.03	17.77
	Mean	18.12	18.70	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.89	1.45	1.03
	Year x Genotype	NA	2.06	1.45

Table 51b. Seed weight (g) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	19.58	18.07	17.10	18.25
2	Ratna	19.86	20.20	20.80	20.29
3	H 45	27.03	20.30	21.63	22.99
4	H 151	16.40	14.03	14.97	15.13
5	PKM 2	28.37	21.90	20.87	23.71
6	Banganapalli	14.90	16.10	16.07	15.69
7	Alphonso	23.35	20.40	19.23	20.99
8	Himayuddin	18.90	17.87	18.83	18.53
9	Bennet Alphonso	12.60	10.47	11.60	11.55
10	Swarnarekha	20.22	22.67	23.47	22.12
11	Mulgoa	21.50	27.27	30.70	26.49
12	Chandrakaran	14.13	14.43	15.90	14.82
13	Prior	21.87	15.83	17.23	18.31
	Mean	19.90	18.43	19.11	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.18	1.09	0.77	
	Year x Genotype	3.78	1.89	1.34	

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4.1.5.8 Quantity of fibre on stone

Low, intermediate and high quantity of fibre on stone were observed among the different varieties/cultivars (Table 52).

Grouping the hybrids, cluster I included trees with intermediate quantity of fibre on stone. Cluster II included trees with low quantity of fibre on stone. And cluster III included trees with high quantity of fibre on stone (Table 53 and Table 54).

Grouping the parents involved in breeding, cluster I and II included trees with low quantity of fibre on stone. Cluster III included trees with intermediate quantity of fibre on stone (Table 55 and Table 56).

Cluster I Grouping the local types, Cluster I included trees with intermediate quantity of fibre on stone. Cluster II included trees with high quantity of fibre on stone. and cluster III included trees with low quantity of fibre on stone (Table 57 and Table 58).

4.1.5.9 Adherence of fibre to stone

Weak, intermediate and strong adherence of fibre to stone were observed among the different varieties/cultivars (Table 52).

Grouping the hybrids, cluster I included trees with weak, intermediate and strong adherence of fibre to stone. Cluster II included trees with strong and intermediate adherence of fibre to stone. Cluster III included trees with strong and weak adherence of fibre to stone (Table 53 and Table 54).

Grouping the parents involved in breeding, cluster I included trees with weak and intermediate adherence of fibre to stone. Cluster II included trees with intermediate adherence of fibre to stone. And cluster III included trees with strong adherence of fibre to stone (Table 55 and Table 56).

Grouping the local types, Cluster I included trees with intermediate and weak adherence of fibre to stone. Cluster II included trees with weak adherence of fibre to stone and cluster III included trees with strong adherence of fibre to stone (Table 57 and Table 58).

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Table 52. Quantity of fibre on stone, adherence of fibre to stone, texture of stone fibre and seed shape of different mango genotypes

Sl. No.	Genotypes	Quantity of fibre on stone	Adherence of fibre to stone	Texture of stone fibre	Seed shape
1	Arka Aruna	Intermediate	Weak	Soft	Ellipsoid
2	Amrapali	Low	Strong	Coarse	Ellipsoid
3	Mallika	Low	Intermediate	Coarse	Reniform
4	Ratna	Intermediate	Intermediate	Soft	Reniform
5	Sindhu	Low	Strong	Coarse	Oblong
6	H45	Low	Intermediate	Coarse	Reniform
7	H 151	High	Strong	Coarse	Oblong
8	PKM1	High	Weak	Coarse	Ellipsoid
9	PKM 2	Intermediate	Intermediate	Soft	Ellipsoid
10	Neelgoa	Intermediate	Intermediate	Coarse	Oblong
11	Banganapalli	Low	Weak	Soft	Ellipsoid
12	Alphonso	Low	Intermediate	Coarse	Reniform
13	Dashehari	Intermediate	Intermediate	Coarse	Oblong
14	Neelum	Intermediate	Strong	Coarse	Ellipsoid
15	Himayuddin	Intermediate	Strong	Coarse	Ellipsoid
16	Bennet Alphonso	Low	Intermediate	Soft	Reniform
17	Kalepady	Intermediate	Strong	Coarse	Oblong
18	Swarnarekha	Low	Intermediate	Coarse	Reniform
19	Mulgoa	Low	Intermediate	Coarse	Oblong
20	Tholikaippan	Intermediate	Weak	Coarse	Ellipsoid
21	Chandrakaran	High	Weak	Coarse	Reniform
22	Vellaikolumban	Intermediate	Intermediate	Coarse	Ellipsoid
23	Prior	Low	Strong	Coarse	Reniform
24	Muvandan	High	Weak	Coarse	Reniform

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Table 53. Cluster wise listing of hybrids according to stone characters

Clusters		
I	**II**	**III**
Arka Aruna	Amrapali	H 151
Ratna	Sindhu	PKM 1
Pkm 2	Mallika	
Neelgoa	H 45	

Table 54. Cluster wise summary statistics of hybrids according to stone characters

Characters	Clusters		
	I	**II**	**III**
Quantity of fibre on stone	Intermediate	Low	High
Adherence of fibre to stone	Weak, Intermediate, Strong	Strong, Intermediate	Strong, Weak
Texture of stone fibre	Soft, Coarse	Coarse	Coarse
Seed shape	Ellipsoid, Reniform, Oblong	Ellipsoid, Oblong, Reniform	Oblong, Ellipsoid

Table 55. Cluster wise listing of parents according to stone characters

Clusters		
I	**II**	**III**
Banganapalli	Alphonso	Neelum
Bennet Alphonso	Swarnarekha	Himayuddin
	Mulgoa	Kalepady
	Dashehari	

Table 56. Cluster wise summary statistics of parents according to stone characters

Characters	Clusters		
	I	II	III
Quantity of fibre on stone	Low	Low	Intermediate
Adherence of fibre to stone	Weak, Intermediate	Intermediate	Strong
Texture of stone fibre	Soft	Coarse	Coarse
Seed shape	Ellipsoid, Reniform	Reniform, Oblong	Ellipsoid, Oblong

Table 57. Cluster wise listing of local types according to stone characters

Clusters		
I	II	III
Tholikaippan	Chandrakaran	Prior
Vellaikolumban	Muvandan	

Table 58. Cluster wise summary statistics of local types according to stone characters

Characters	Clusters		
	I	II	III
Quantity of fibre on stone	Intermediate	High	Low
Adherence of fibre to stone	Intermediate, Weak	Weak	Strong
Texture of stone fibre	Coarse	Coarse	Coarse
Seed shape	Ellipsoid	Reniform	Reniform

Plate 42. Variations in seed characters of mango genotypes Arka Aruna, Amrapalli, Mallika, Ratna and Sindhu selected under normal planting system

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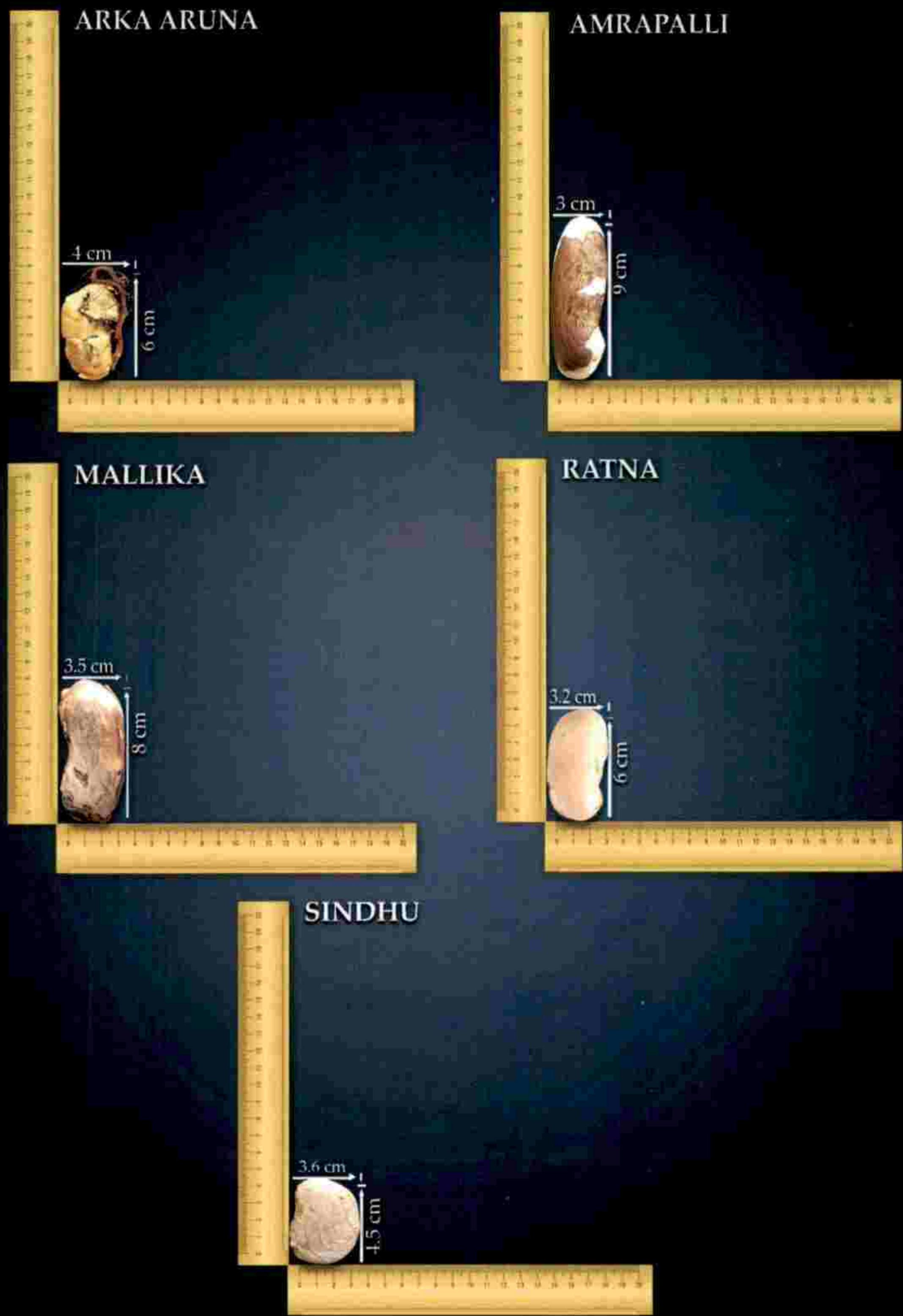


Plate 43. Variations in seed characters of mango genotypes H45, H151, PKM1, PKM 2 and Neelgoa selected under normal planting system

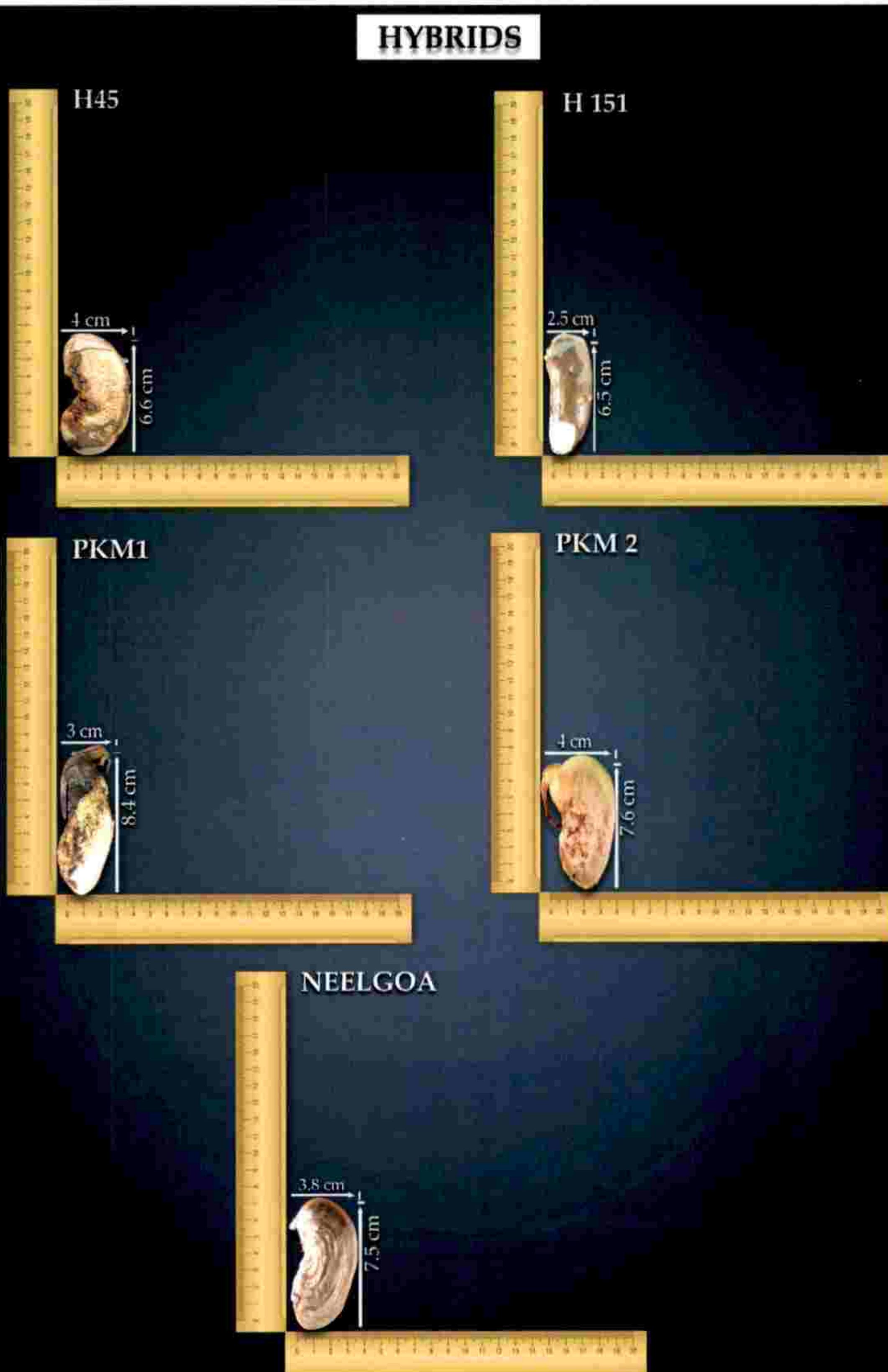


Plate 44. Variations in stone characters of mango genotypes Banganapalli, Alphonso, Dashehari, Neelum and Himayuddin selected under normal planting system

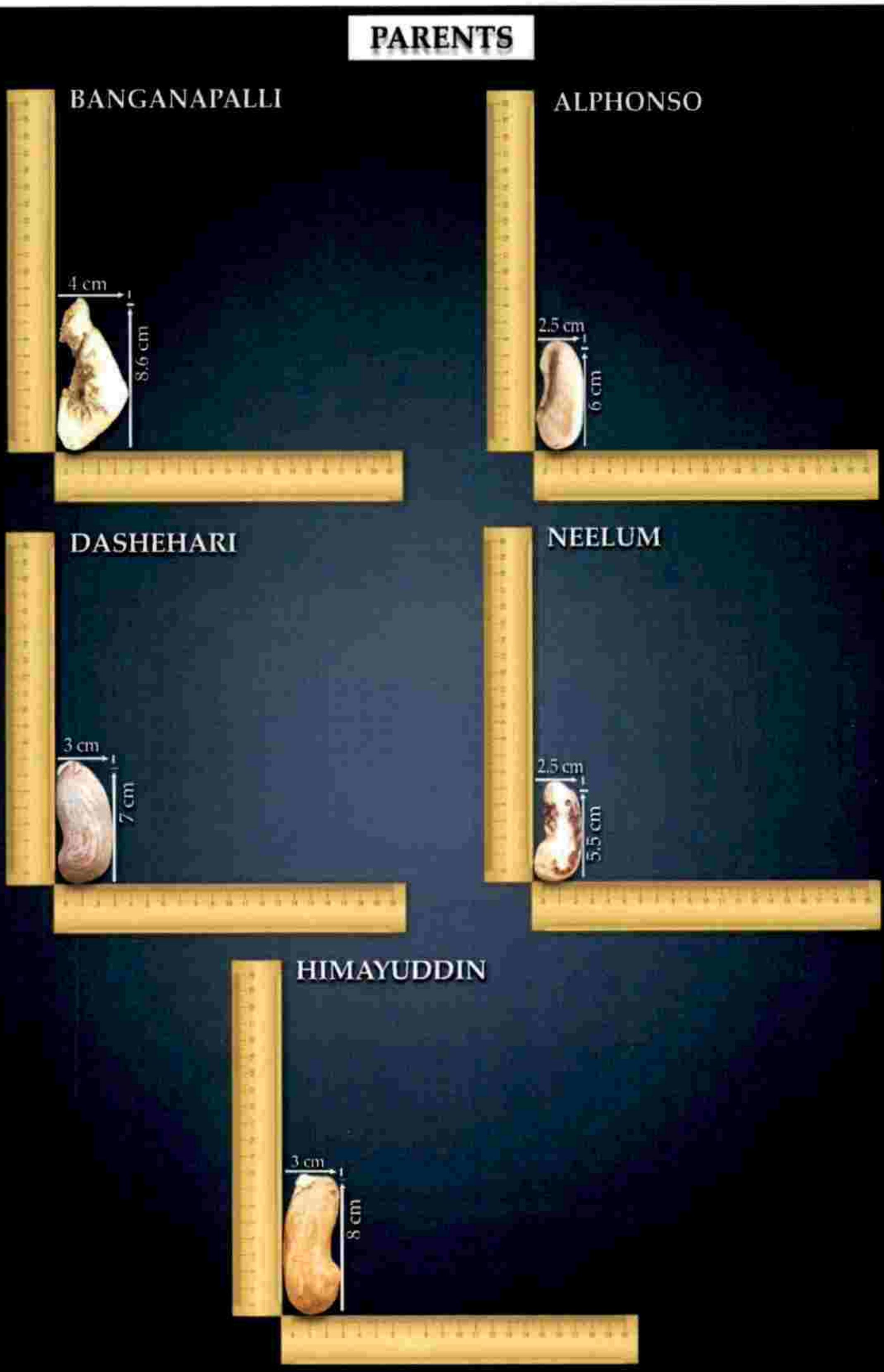


Plate 45. Variations in seed characters of mango genotypes Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa selected under normal planting system

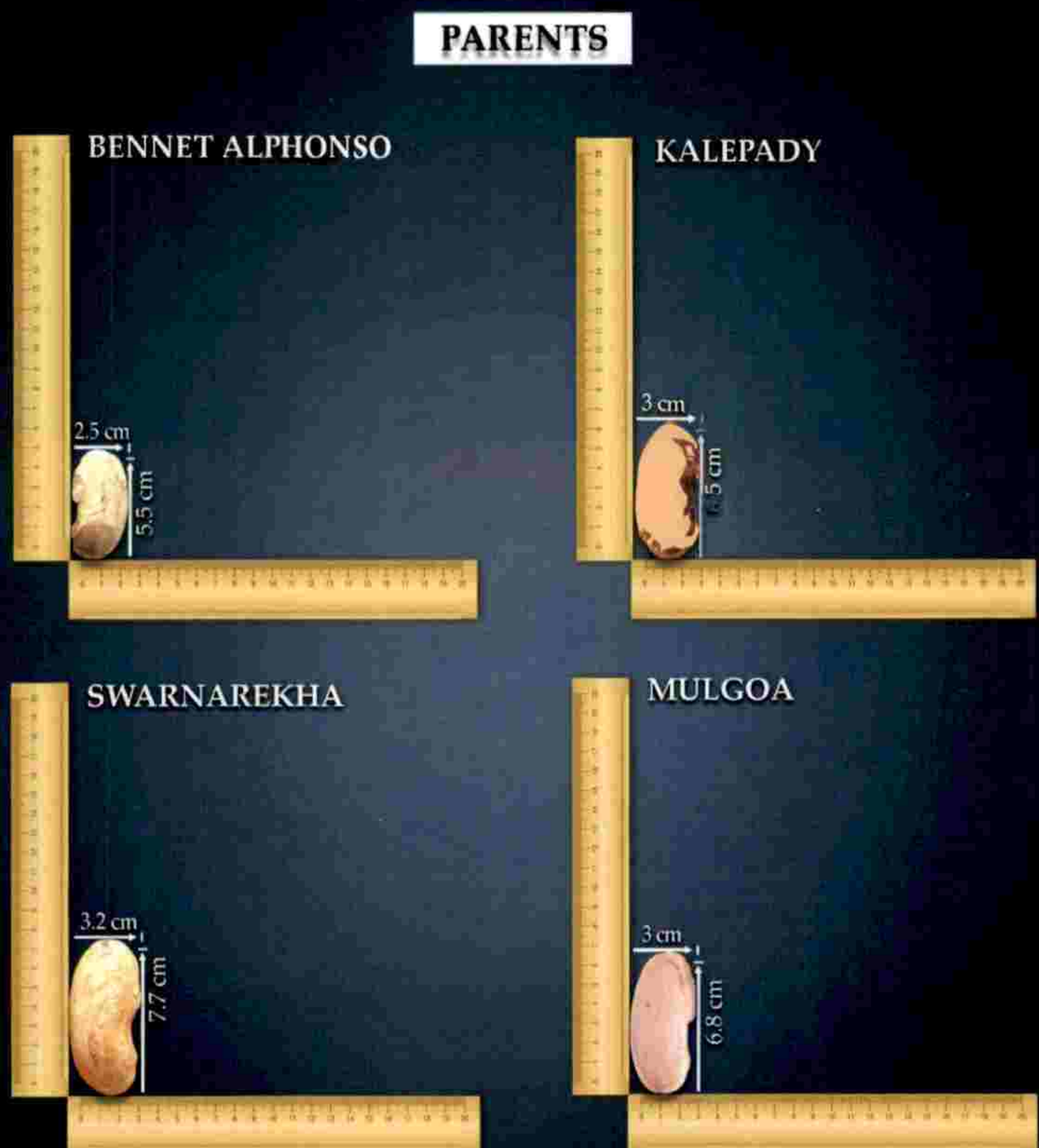
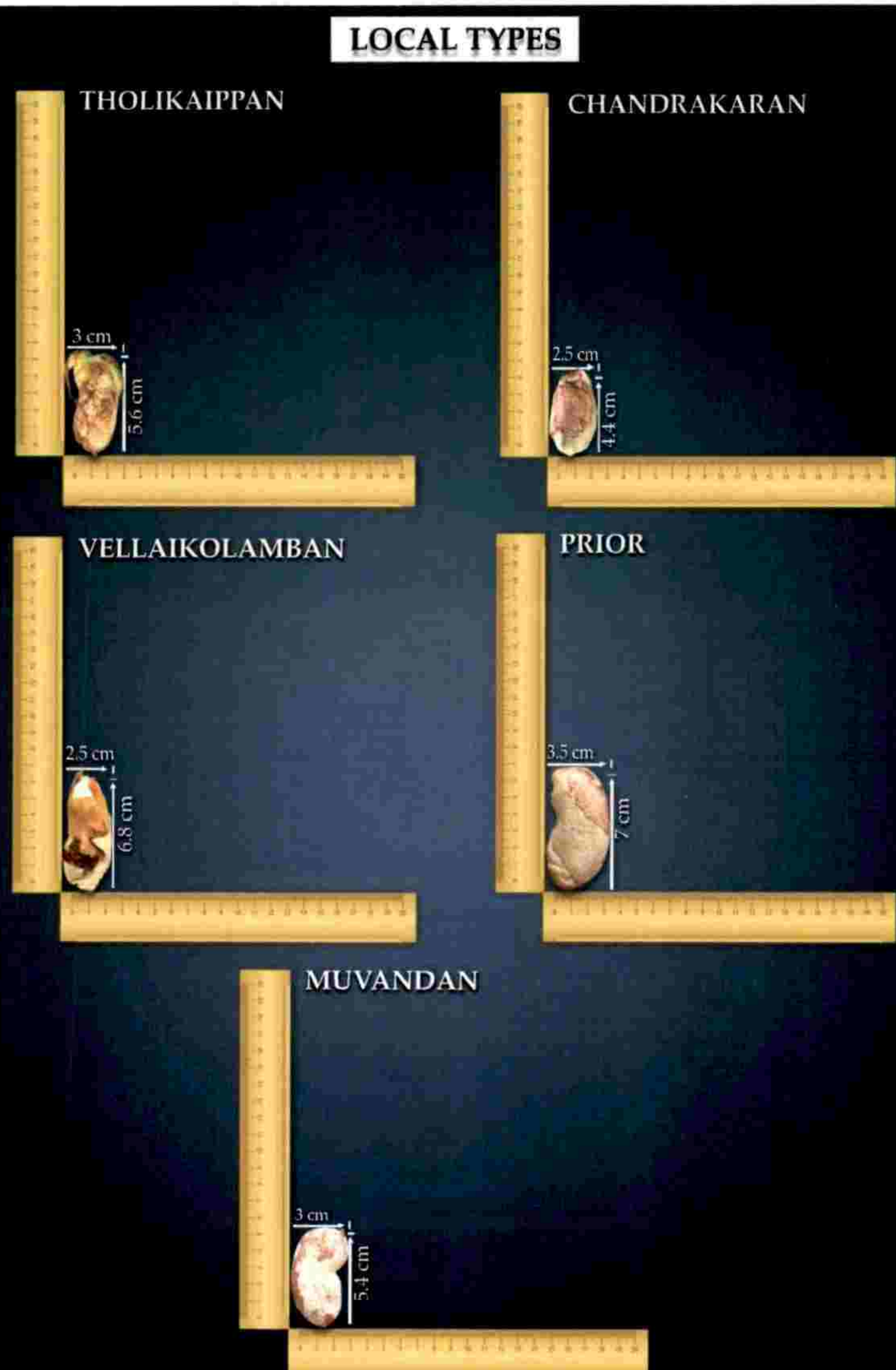


Plate 46. Variations in seed characters of mango genotypes Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan selected under normal planting system



4.1.5.10 Texture of stone fibre

Coarse and soft texture of stone fibre were observed among the different varieties/cultivars (Table 52).

Grouping the hybrids, cluster I included trees with soft and coarse texture of stone fibre. Cluster II and III included trees with coarse texture of stone fibre (Table 53 and Table 54).

Grouping the parents involved in breeding, cluster I included trees with soft texture of stone fibre. Cluster II and III included trees with coarse texture of stone fibre (Table 55 and Table 56).

Grouping the local types, Cluster I, II and III had trees with coarse texture of stone fibre (Table 57 and Table 58).

4.1.5.11 Seed shape

Ellipsoid, reniform and oblong seed shapes were observed among the different varieties/cultivars (Table 52).

Grouping the hybrids, cluster I and II included trees with ellipsoid, reniform and oblong seed shapes. Cluster III included trees with oblong and ellipsoid seed shape (Table 53 and Table 54).

Grouping the parents involved in breeding, cluster I included trees with ellipsoid and reniform seed shape. Cluster II included trees with reniform and oblong seed shape. Cluster III included trees with oblong and ellipsoid seed shape (Table 55 and Table 56).

Grouping the local types, Cluster I included trees with ellipsoid seed shape. Cluster II and III included trees with reniform seed shape (Table 57 and Table 58).

4.2. Quality attributes

Different quality attributes like acidity (%), ascorbic acid (mg $100g^{-1}$), total carotenoids (mg $100g^{-1}$), β carotene (mg $100g^{-1}$), total sugar (%), reducing sugar (%), crude fibre (%) and TSS (^{o}Brix), were recorded and presented from table 59a to table 66b.

4.2.1 Acidity

The data presented in Table 59a shows the variation in acidity of different genotypes during the two seasons. Among the hybrids, PKM 1 (0.06 %) recorded the highest acidity which followed by the rest of the hybrids. H 151 (0.02%) recorded the lowest acidity.

Himayuddin (0.12%) recorded the highest acidity which was significantly different from the rest of the parents involved in breeding. Kalepady (0.02%) recorded the lowest acidity which was on par with Mulgoa (0.03%), Swarnarekha (0.03%), Bennet Alphonso (0.04%), Neelum (0.04%), and Banganapalli (0.04%).

Muvandan (0.09 %) recorded the highest acidity followed by Vellaikolumban (0.06%) and Prior (0.06%) among the local types. Chandrakaran (0.04 %) and Tholikaippan (0.04%) recorded the lowest acidity.

The data presented in Table 59b shows the variation in acidity of different genotypes during the three seasons. Among the hybrids, Arka Aruna (0.05%) recorded the highest acidity followed by the rest of the hybrids. H 151 (0.02%) recorded the lowest acidity.

Among the parents involved in breeding Himayuddin (0.09 %) recorded the highest acidity followed by Alphonso (0.06). Mulgoa (0.03 %), recorded the lowest acidity which was on par with Swarnarekha (0.03 %) and Bennet Alphonso (0.03%).

Prior (0.05%) recorded the highest acidity and Chandrakaran (0.04%) recorded the lowest acidity among the local types.

4.2.2 Ascorbic acid

The data presented in Table 60a shows the variation in ascorbic acid of different genotypes during the two seasons. Among the hybrids, H 151 (66.67 mg $100g^{-1}$) recorded the highest ascorbic acid followed by Neelgoa (47.62 mg $100g^{-1}$). Arka Aruna (12.17 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with Mallika (24.34 mg $100g^{-1}$).

Neelum (59.26 mg $100g^{-1}$) recorded the highest ascorbic acid followed by Alphonso (56.51 mg $100g^{-1}$), Bennet Alphonso (52.91 mg $100g^{-1}$), Mulgoa (51.77 mg $100g^{-1}$) and Dashehari (51.32 mg $100g^{-1}$) among the parents involved in breeding.

Table 59a. Acidity (%) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	0.07	0.04	0.06
2	Amrapali	0.01	0.04	0.03
3	Mallika	0.02	0.05	0.04
4	Ratna	0.02	0.03	0.03
5	Sindhu	0.04	0.05	0.05
6	H45	0.02	0.07	0.04
7	H 151	0.01	0.03	0.02
8	PKM1	0.03	0.09	0.06
9	PKM 2	0.03	0.04	0.03
10	Neelgoa	0.03	0.03	0.03
11	Banganapalli	0.04	0.04	0.04
12	Alphonso	0.09	0.04	0.07
13	Dashehari	0.05	0.08	0.07
14	Neelum	0.03	0.05	0.04
15	Himayuddin	0.22	0.02	0.12
16	Bennet Alphonso	0.02	0.05	0.04
17	Kalepady	0.02	0.02	0.02
18	Swarnarekha	0.03	0.03	0.03
19	Mulgoa	0.03	0.02	0.03
20	Tholikaippan	0.02	0.06	0.04
21	Chandrakaran	0.05	0.03	0.04
22	Vellaikolumban	0.03	0.09	0.06
23	Prior	0.03	0.08	0.06
24	Muvandan	0.06	0.11	0.09
	Mean	0.04	0.05	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.04	0.02	0.01
	Year x Genotype	0.05	0.03	0.02

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Table 59b. Acidity (%) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.03	0.07	0.04	0.05
2	Ratna	0.03	0.02	0.03	0.03
3	H 45	0.02	0.02	0.07	0.04
4	H 151	0.02	0.01	0.03	0.02
5	PKM 2	0.03	0.03	0.04	0.03
6	Banganappalli	0.03	0.04	0.04	0.04
7	Alphonso	0.04	0.09	0.04	0.06
8	Himayuddin	0.03	0.22	0.02	0.09
9	Bennet Alphonso	0.03	0.02	0.05	0.03
10	Swarnarekha	0.03	0.03	0.03	0.03
11	Mulgoa	0.03	0.03	0.02	0.03
12	Chandrakaran	0.04	0.05	0.03	0.04
13	Prior	0.04	0.03	0.08	0.05
	Mean	0.03	0.05	0.04	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.03	0.02	0.01	
	Year x Genotype	0.06	0.03	0.02	

Table 60a. Ascorbic acid (mg $100g^{-1}$) content of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	10.58	13.76	12.17
2	Amrapali	28.57	40.21	34.39
3	Mallika	29.63	19.05	24.34
4	Ratna	37.04	41.27	39.16
5	Sindhu	45.98	31.75	38.86
6	H45	33.86	35.98	34.92
7	H 151	70.90	62.43	66.67
8	PKM1	38.09	20.10	29.10
9	PKM 2	44.44	35.98	40.21
10	Neelgoa	51.85	43.39	47.62
11	Banganapalli	33.86	49.73	41.80
12	Alphonso	54.92	58.10	56.51
13	Dashehari	48.68	53.97	51.32
14	Neelum	50.79	67.73	59.26
15	Himayuddin	27.51	34.92	31.22
16	Bennet Alphonso	57.15	48.68	52.91
17	Kalepady	29.63	23.28	26.46
18	Swarnarekha	23.28	16.93	20.11
19	Mulgoa	60.32	43.23	51.77
20	Tholikaippan	35.98	23.28	29.63
21	Chandrakaran*	48.47	38.10	43.28
22	Vellaikolumban*	19.05	14.81	16.93
23	Prior	42.33	27.51	34.92
24	Muvandan*	65.08	79.89	72.49
	Mean	41.17	38.50	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	14.42	7.25	5.13
	Year x Genotype	NS	10.26	7.25

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Table 60b. Ascorbic acid (mg $100g^{-1}$) content of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.46	10.58	13.76	10.93
2	Ratna	31.75	37.04	41.27	36.69
3	H 45	32.81	33.86	35.98	34.22
4	H 151	37.04	70.90	62.43	56.79
5	PKM 2	32.81	44.44	35.98	37.74
6	Banganappalli	34.92	33.86	49.73	39.51
7	Alphonso	69.84	54.92	58.10	60.95
8	Himayuddin	12.70	27.51	34.92	25.04
9	Bennet Alphonso	52.91	57.15	48.68	52.91
10	Swarnarekha	15.87	23.28	16.93	18.69
11	Mulgoa	45.51	60.32	43.23	49.68
12	Chandrakaran	64.55	48.47	38.10	50.37
13	Prior	31.75	42.33	27.51	33.86
	Mean	36.22	41.90	38.97	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	11.50	5.77	4.08	
	Year x Genotype	NS	9.99	7.06	

Swarnarekha (20.11 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with Kalepady (26.46 mg $100g^{-1}$) and Himayuddin (31.22 mg $100g^{-1}$).

Muvandan (72.49 mg $100g^{-1}$) recorded the highest ascorbic acid which was significantly different from the rest of the local types. Vellaikolumban (16.93 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with Tholikaippan (29.63 mg $100g^{-1}$).

The data presented in Table 60b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, H 151 (56.79 mg $100g^{-1}$) recorded the highest ascorbic acid which was significantly different from the rest of the hybrids. Arka Aruna (10.93 mg $100g^{-1}$) recorded the lowest ascorbic acid.

Alphonso (60.95 mg $100g^{-1}$) recorded the highest ascorbic acid followed by Bennet Alphonso (52.91 mg $100g^{-1}$) and Mulgoa (49.68 mg $100g^{-1}$) among the parents involved in breeding. Swarnarekha (18.69 mg $100g^{-1}$) recorded the lowest ascorbic acid.

Chandrakaran (50.37 mg $100g^{-1}$) recorded the highest ascorbic acid and Prior (33.86 mg $100g^{-1}$) recorded the lowest ascorbic acid among the local types.

4.2.3 Total carotenoids

The data presented in Table 61a shows the variation in total carotenoids of different genotypes during the two seasons. Among the hybrids, H 151 (5.79 mg $100g^{-1}$) recorded the highest total carotenoids followed by Amrapali (5.72 mg $100g^{-1}$) and Mallika (5.59 mg $100g^{-1}$). Arka Aruna (0.86 mg $100g^{-1}$) recorded the lowest total carotenoids.

Alphonso (8.47 mg $100g^{-1}$) recorded the highest total carotenoids which was significantly different from the rest of the parents involved in breeding. Neelum (0.16 mg $100g^{-1}$) recorded the lowest total carotenoids.

Tholikaippan (5.34 mg $100g^{-1}$) recorded the highest total carotenoids which was significantly different from the rest of the local types. Vellaikolumban (1.28 mg $100g^{-1}$) recorded the lowest total carotenoids which was on par with Prior (2.04 mg $100g^{-1}$) and Chandrakaran (3.26 mg $100g^{-1}$).

The data presented in Table 61b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, H 151 (5.32 mg $100g^{-1}$)

Table 61a. Carotenoids (mg $100g^{-1}$) content of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	0.79	0.92	0.86
2	Amrapali	5.86	5.58	5.72
3	Mallika	5.91	5.26	5.59
4	Ratna	4.35	3.01	3.68
5	Sindhu	2.06	1.87	1.97
6	H45	3.35	3.33	3.34
7	H 151	6.83	4.76	5.79
8	PKM1	2.24	2.25	2.25
9	PKM 2	2.17	2.06	2.12
10	Neelgoa	1.78	1.64	1.71
11	Banganapalli	3.15	2.14	2.64
12	Alphonso	9.21	7.73	8.47
13	Dashehari	1.90	1.81	1.85
14	Neelum	0.16	0.15	0.16
15	Himayuddin	1.90	1.86	1.88
16	Bennet Alphonso	4.18	4.38	4.28
17	Kalepady	3.09	3.29	3.19
18	Swarnarekha	2.57	2.82	2.70
19	Mulgoa	3.17	3.52	3.35
20	Tholikaippan	6.63	4.06	5.34
21	Chandrakaran	3.14	3.38	3.26
22	Vellaikolumban	1.32	1.24	1.28
23	Prior	2.39	1.68	2.04
24	Muvandan	2.39	4.98	3.69
	Mean	3.36	3.07	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.85	0.43	0.30
	Year x Genotype	1.21	0.61	0.43

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Table 61b. Carotenoids (mg $100g^{-1}$) content of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.86	0.79	0.92	0.86
2	Ratna	2.95	4.35	3.01	3.44
3	H 45	2.78	3.35	3.33	3.15
4	H 151	4.37	6.83	4.76	5.32
5	PKM 2	2.30	2.17	2.06	2.18
6	Banganappalli	1.72	3.15	2.14	2.33
7	Alphonso	8.52	9.21	7.73	8.49
8	Himayuddin	1.59	1.90	1.86	1.78
9	Bennet Alphonso	2.60	4.18	4.38	3.72
10	Swarnarekha	2.63	2.57	2.82	2.67
11	Mulgoa	3.12	3.17	3.52	3.27
12	Chandrakaran	3.10	3.14	3.38	3.21
13	Prior	1.27	2.39	1.68	1.78
	Mean	2.91	3.63	3.20	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.63	0.32	0.22	
	Year x Genotype	1.09	0.55	0.39	

recorded the highest total carotenoids which was significantly different from the rest of the hybrids. Arka Aruna (0.86 mg $100g^{-1}$) recorded the lowest total carotenoids.

Alphonso (8.49 mg $100g^{-1}$) recorded the highest total carotenoids which was significant different from the rest of the parents involved in breeding. Himayuddin (1.78 mg $100g^{-1}$) recorded the lowest carotenoids which was on par with Banganapalli (2.33 mg $100g^{-1}$).

Chandrakaran (3.21 mg $100g^{-1}$) recorded the highest total carotenoids and Prior (1.78 mg $100g^{-1}$) recorded the lowest total carotenoids among the local types.

4.2.4 β carotene

The data presented in Table 62a shows the variation in β carotene of different genotypes during the two seasons. Among the hybrids, Sindhu (32.57 mg $100g^{-1}$) recorded the highest β carotene which was significantly different from the rest of the hybrids. Arka Aruna (10.60 mg $100g^{-1}$) recorded the lowest β carotene which was on par with PKM 2 (11.67 mg $100g^{-1}$) and Amrapali (13.99 mg $100g^{-1}$).

Dashehari (45.06 mg $100g^{-1}$) recorded the highest β carotene which was significantly different from the rest of the parents involved in breeding. Mulgoa (9.75 mg $100g^{-1}$) recorded the lowest β carotene which was on par with Swarnarekha (11.62 mg $100g^{-1}$), Banganapalli (11.65 mg $100g^{-1}$) and Himayuddin (11.66 mg $100g^{-1}$).

Tholikaippan (20.08 mg $100g^{-1}$) recorded the highest β carotene which was significantly different form the rest of the local types. Prior (11.16 mg $100g^{-1}$) recorded the lowest β carotene which was on par with Muvandan (11.83 mg $100g^{-1}$).

The data presented in Table 62b shows the variation in β carotene of different genotypes during the three seasons. Among the hybrids, H151 (25.28 mg $100g^{-1}$) recorded the highest β carotene which was significantly different from the rest of the hybrids. Arka Aruna (10.88 mg $100g^{-1}$) recorded the lowest β carotene.

Among the parents involved in breeding Alphonso (39.08 mg $100g^{-1}$) recorded the highest β carotene which was significantly different from the rest of the parents involved in breeding. Mulgoa (9.59 mg $100g^{-1}$) recorded the lowest β carotene which

Table 62a. β carotene (mg $100g^{-1}$) content of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	10.39	10.81	10.60
2	Amrapali	13.84	14.15	13.99
3	Mallika	18.86	17.19	18.03
4	Ratna	20.89	20.02	20.45
5	Sindhu	33.64	31.49	32.57
6	H45	15.50	14.46	14.98
7	H 151	28.97	23.89	26.43
8	PKM1	20.63	24.20	22.42
9	PKM 2	11.14	12.20	11.67
10	Neelgoa	15.00	14.93	14.96
11	Banganapalli	11.92	11.37	11.65
12	Alphonso	35.13	46.67	40.90
13	Dashehari	46.14	43.97	45.06
14	Neelum	33.14	33.00	33.07
15	Himayuddin	11.48	11.84	11.66
16	Bennet Alphonso	15.08	14.71	14.90
17	Kalepady	19.59	19.27	19.43
18	Swarnarekha	11.71	11.53	11.62
19	Mulgoa	9.60	9.90	9.75
20	Tholikaippan	20.64	19.52	20.08
21	Chandrakaran	15.25	16.11	15.68
22	Vellaikolumban	14.55	17.07	15.81
23	Prior	10.85	11.47	11.16
24	Muvandan	11.47	12.20	11.83
	Mean	18.98	19.25	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	4.04	2.03	1.44
	Year x Genotype	NS	2.88	2.03

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Table 62b. β carotene (mg $100g^{-1}$) content of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	11.42	10.39	10.81	10.88
2	Ratna	21.07	20.89	20.02	20.66
3	H 45	15.25	15.50	14.46	15.07
4	H 151	22.97	28.97	23.89	25.28
5	PKM 2	10.54	11.14	12.20	11.29
6	Banganappalli	11.49	11.92	11.37	11.60
7	Alphonso	35.45	35.13	46.67	39.08
8	Himayuddin	14.82	11.48	11.84	12.71
9	Bennet Alphonso	14.86	15.08	14.71	14.88
10	Swarnarekha	11.09	11.71	11.53	11.44
11	Mulgoa	9.27	9.60	9.90	9.59
12	Chandrakaran	15.82	15.25	16.11	15.73
13	Prior	11.46	10.85	11.47	11.26
	Mean	15.81	15.99	16.54	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.33	1.67	1.18	
	Year x Genotype	NS	2.89	2.04	

was on par with Swarnarekha (11.44 mg $100g^{-1}$), Banganapalli (11.60 mg $100g^{-1}$) and Himayuddin (12.71 mg $100g^{-1}$).

Chandrakaran (15.73 mg $100g^{-1}$) recorded the highest β carotene and Prior (11.26 mg $100g^{-1}$) recorded the lowest β carotene among the local types.

4.2.5 Total sugar

The data presented in Table 63a shows the variation in total sugar of different genotypes during the two seasons. Among the hybrids, PKM 1 (22.43%) recorded the highest total sugar followed by Neelgoa (22.09%), Sindhu (22.05%) and PKM 2 (20.88 %). H 151 (13.85 recorded the lowest total sugar which was on par with Arka Aruna (14.68%) and Amrapali (14.81%).

Swarnarekha (27.81 %) recorded the highest total sugar which was significantly different from the rest of the parents involved in breeding. Kalepady (13.14 %) recorded the lowest total sugar which was on par with Himayuddin (14.07%) Bennet Alphonso (14.78%) and Alphonso (14.83%).

Vellaikolumban (17.29 %) recorded the highest total sugar which was significantly different from the rest of the local types. Tholikaippan (12.55 %) recorded the lowest total sugar.

The data presented in Table 63b shows the variation in total sugar of different genotypes during the three seasons. Among the hybrids, PKM 2 (20.95%) recorded the highest total sugar followed by H 45 (19.63 %). Arka Aruna (14.68%) recorded the lowest total sugar which was on par with H 151 (15.35 %) and Ratna (15.82 %).

Swarnarekha (25.01%) recorded the highest total sugar which was significantly different from the rest of the parents involved in breeding. Banganapalli (15.10%) recorded the lowest total sugar which was on par with Himayuddin (15.64%).

Chandrakaran (17.79%) recorded the highest total sugar and Prior (16.34%) recorded the lowest total sugar among the local types.

Table 63a. Total sugar (%) content of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	11.40	17.88	14.64
2	Amrapali	12.95	16.67	14.81
3	Mallika	15.39	19.21	17.30
4	Ratna	12.78	20.18	16.48
5	Sindhu	25.24	18.85	22.05
6	H45	19.23	18.86	19.05
7	H 151	13.87	13.83	13.85
8	PKM1	21.91	22.95	22.43
9	PKM 2	20.03	21.73	20.88
10	Neelgoa	23.18	20.99	22.09
11	Banganapalli	14.28	16.18	15.23
12	Alphonso	14.13	15.53	14.83
13	Dashehari	17.54	13.90	15.72
14	Neelum	19.10	15.12	17.11
15	Himayuddin	14.67	13.48	14.07
16	Bennet Alphonso	15.18	14.38	14.78
17	Kalepady	13.65	12.62	13.14
18	Swarnarekha	16.76	38.85	27.81
19	Mulgoa	17.38	15.90	16.64
20	Tholikaippan	13.77	11.33	12.55
21	Chandrakaran	19.67	13.08	16.38
22	Vellaikolumban	16.00	18.57	17.29
23	Prior	13.87	17.82	15.85
24	Muvandan	15.33	13.88	14.61
	Mean	16.56	17.58	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.05	1.03	0.73
	Year x Genotype	2.90	1.46	1.03

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Table 63b. Total sugar (%) content of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	14.77	11.40	17.88	14.68
2	Ratna	14.50	12.78	20.18	15.82
3	H 45	20.81	19.23	18.86	19.63
4	H 151	18.36	13.87	13.83	15.35
5	PKM 2	21.08	20.03	21.73	20.95
6	Banganappalli	14.85	14.28	16.18	15.10
7	Alphonso	25.22	14.13	15.53	18.29
8	Himayuddin	18.77	14.67	13.48	15.64
9	Bennet Alphonso	36.93	15.18	14.38	22.17
10	Swarnarekha	19.42	16.76	38.85	25.01
11	Mulgoa	18.56	17.38	15.90	17.28
12	Chandrakaran	20.62	19.67	13.08	17.79
13	Prior	17.33	13.87	17.82	16.34
	Mean	20.09	15.64	18.28	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.54	0.77	0.55	
	Year x Genotype	2.66	1.34	0.94	

4.2.6 Reducing sugar

The data presented in Table 64a shows the variation in reducing sugar of different genotypes during the two seasons. Among the hybrids, H 151 (9.18%) recorded the highest reducing sugar followed by Arka Aruna (9.03%) and Amrapali (8.59%). Pkm 1 (5.58%) recorded the lowest reducing sugar which was on par with Neelgoa (5.68%), Sindhu (5.80 %) and Pkm 2 (6.00 %).

Kalepady (9.55%) recorded the highest reducing sugar followed by Himayuddin (8.91 %) among the parents involved in breeding. Swarnarekha (5.37%) recorded the lowest reducing sugar.

Tholikaippan (10.38%) recorded the highest reducing sugar which was significantly different from the rest from the rest of the local types. Vellaikolumban (7.41%) recorded the lowest reducing sugar which was on par with Chandrakaran (7.98 %) and Prior (8.22%).

The data presented in Table 64b shows the variation in reducing sugar of different genotypes during the three seasons. Among the hybrids, Arka Aruna (8.81%) recorded the highest reducing sugar followed by H 151 (8.40%), PKM 2 (5.98%) recorded the lowest reducing sugar which was on par with H 45 (6.40%).

Banganapalli (8.31%) recorded the highest reducing sugar which was on par with Himayuddin (8.18%) among the parents involved in breeding. Swarnarekha (5.72%) recorded the lowest reducing sugar.

Prior (7.90%) recorded the highest reducing sugar and Chandrakaran (7.34%) recorded the lowest reducing sugar among the local types.

4.2.7 Crude fibre

The data presented in Table 65a shows the variation in crude fibre of different genotypes during the two seasons. Among the hybrids, Arka Aruna (16.50 %) recorded the highest crude fibre which was significantly different from the rest of the hybrids. PKM 2 (2.85%) recorded the lowest crude fibre.

Table 64a. Reducing sugar (%) content of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	11.00	7.06	9.03
2	Amrapali	9.66	7.51	8.59
3	Mallika	8.13	6.64	7.38
4	Ratna	9.79	6.21	8.00
5	Sindhu	4.95	6.65	5.80
6	H45	6.53	6.64	6.59
7	H 151	9.29	9.07	9.18
8	PKM1	5.71	5.45	5.58
9	PKM 2	6.25	5.76	6.00
10	Neelgoa	5.39	5.96	5.68
11	Banganapalli	8.76	7.75	8.26
12	Alphonso	8.85	8.09	8.47
13	Dashehari	7.27	9.05	8.16
14	Neelum	6.67	8.33	7.50
15	Himayuddin	8.54	9.28	8.91
16	Bennet Alphonso	8.25	8.69	8.47
17	Kalepady	9.19	9.91	9.55
18	Swarnarekha	7.48	3.25	5.37
19	Mulgoa	7.25	7.87	7.56
20	Tholikaippan	9.58	11.19	10.38
21	Chandrakaran	6.39	9.57	7.98
22	Vellaikolumban	8.09	6.73	7.41
23	Prior	9.37	7.07	8.22
24	Muvandan	8.16	9.04	8.60
	Mean	7.94	7.62	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.98	0.49	0.35
	Year x Genotype	1.38	0.69	0.49

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Table 64b. Reducing sugar (%) content of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.47	11.00	7.06	8.84
2	Ratna	8.65	9.79	6.21	8.22
3	H 45	6.02	6.53	6.64	6.40
4	H 151	6.84	9.29	9.07	8.40
5	PKM 2	5.93	6.25	5.76	5.98
6	Banganappalli	8.42	8.76	7.75	8.31
7	Alphonso	4.99	8.85	8.09	7.31
8	Himayuddin	6.73	8.54	9.28	8.18
9	Bennet Alphonso	3.39	8.25	8.69	6.78
10	Swarnarekha	6.44	7.48	3.25	5.72
11	Mulgoa	6.78	7.25	7.87	7.30
12	Chandrakaran	6.07	6.39	9.57	7.34
13	Prior	7.27	9.37	7.07	7.90
	Mean	6.61	8.29	7.41	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.30	0.15	0.11	
	Year x Genotype	1.08	0.54	0.38	

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Table 65a. Crude fiber (%) content of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	14.85	18.15	16.50
2	Amrapali	8.82	7.46	8.14
3	Mallika	7.41	8.59	8.00
4	Ratna	10.85	6.85	8.85
5	Sindhu	11.01	9.88	10.45
6	H45	5.19	5.86	5.53
7	H 151	8.26	10.37	9.32
8	PKM1	7.17	8.74	7.95
9	PKM 2	3.11	2.60	2.85
10	Neelgoa	7.30	7.74	7.52
11	Banganapalli	3.28	6.85	5.07
12	Alphonso	2.33	3.00	2.67
13	Dashehari	7.74	6.88	7.31
14	Neelum	5.81	4.45	5.13
15	Himayuddin	11.10	9.23	10.17
16	Bennet Alphonso	6.87	9.29	8.08
17	Kalepady	6.25	7.17	6.71
18	Swarnarekha	10.74	13.29	12.02
19	Mulgoa	4.56	4.53	4.55
20	Tholikaippan	9.19	10.49	9.84
21	Chandrakaran	10.34	11.62	10.98
22	Vellaikolumban	7.92	7.58	7.75
23	Prior	8.83	8.34	8.59
24	Muvandan	9.17	8.95	9.06
	Mean	7.84	8.25	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.97	0.49	0.34
	Year x Genotype	1.37	0.69	0.49

Table 65b. Crude fiber (%) content of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	13.60	14.85	18.15	15.53
2	Ratna	5.93	10.85	6.85	7.88
3	H 45	7.27	5.19	5.86	6.11
4	H 151	7.62	8.26	10.37	8.75
5	PKM 2	2.52	3.11	2.60	2.74
6	Banganappalli	5.50	3.28	6.85	5.21
7	Alphonso	2.74	2.33	3.00	2.69
8	Himayuddin	13.21	11.10	9.23	11.18
9	Bennet Alphonso	7.31	6.87	9.29	7.82
10	Swarnarekha	11.22	10.74	13.29	11.75
11	Mulgoa	4.44	4.56	4.53	4.51
12	Chandrakaran	10.52	10.34	11.62	10.83
13	Prior	8.79	8.83	8.34	8.65
	Mean	7.74	7.72	8.46	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.11	0.55	0.39	
	Year x Genotype	1.92	0.96	0.68	

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Swarnarekha (12.02%) recorded the highest crude fibre which was significantly different from the rest of the parents involved in breeding. Alphonso (2.67%) recorded the lowest crude fibre.

Among the local types Chandrakaran (10.98%) recorded the highest crude fibre which was significantly different from the rest of the local types. Vellaikolumban (7.75%) recorded the lowest crude fibre which was on par with Prior (8.59%).

The data presented in Table 65b shows the variation in crude fibre of different genotypes during the three seasons. Among the hybrids, Arka Aruna (15.53 %) recorded the highest crude fibre which was significantly different from the rest of the hybrids. PKM 2 (2.74%) recorded the lowest crude fibre.

Swarnarekha (11.75%) recorded the highest crude fibre followed by Himayuddin (11.18%) among the parents involved in breeding. Alphonso (2.69%) recorded the lowest crude fibre.

Chandrakaran (10.83 %) recorded the highest crude fibre and Prior (8.65 %) recorded the lowest crude fibre among the local types.

4.2.8 TSS

The data presented in Table 66a shows the variation in TSS of different genotypes during the two seasons. Among the hybrids, Neelgoa (26.65 °Brix) recorded the highest TSS which was significantly different from the rest of the hybrids. Arka Aruna (16.53 °Brix) recorded the lowest TSS which was on par with PKM 2 (17.10 °Brix).

Himayuddin (27.68 °Brix) recorded the highest TSS which was significantly different from the rest of the parents involved in breeding. Kalepady (16.18 °Brix) recorded the lowest TSS.

Tholikaippan (23.80 °Brix) recorded the highest TSS followed by Chandrakaran (22.48 °Brix) among the local types. Muvandan (16.95 °Brix) recorded the lowest TSS which was on par with Prior (17.90 °Brix) and Vellaikolumban (18.02 °Brix).

The data presented in Table 66b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, H 151 (23.78 °Brix) recorded

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Table 66a. TSS (° Brix) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	14.60	18.47	16.53
2	Amrapali	19.50	21.03	20.27
3	Mallika	26.63	23.23	24.93
4	Ratna	23.83	25.70	24.77
5	Sindhu	20.53	21.40	20.97
6	H45	21.30	18.80	20.05
7	H 151	23.90	26.27	25.08
8	PKM1	21.10	16.07	18.58
9	PKM 2	16.00	18.20	17.10
10	Neelgoa	25.87	27.43	26.65
11	Banganapalli	22.33	20.50	21.42
12	Alphonso	16.63	20.63	18.63
13	Dashehari	19.37	18.53	18.95
14	Neelum	30.37	18.87	24.62
15	Himayuddin	27.87	27.50	27.68
16	Bennet Alphonso	22.60	21.73	22.17
17	Kalepady	16.63	15.73	16.18
18	Swarnarekha	20.37	16.40	18.38
19	Mulgoa	20.80	21.07	20.93
20	Tholikaippan	22.60	25.00	23.80
21	Chandrakaran	24.00	20.97	22.48
22	Vellaikolumban	15.83	20.20	18.02
23	Prior	18.30	17.50	17.90
24	Muvandan	17.10	16.80	16.95
	Mean	21.17	20.75	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	1.55	0.78	0.55
	Year x Genotype	2.19	1.10	0.78

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Table 66b. TSS (° Brix) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	15.77	14.60	18.47	16.28
2	Ratna	17.00	23.83	25.70	22.18
3	H 45	19.07	21.30	18.80	19.72
4	H 151	21.17	23.90	26.27	23.78
5	PKM 2	16.47	16.00	18.20	16.89
6	Banganappalli	21.73	22.33	20.50	21.52
7	Alphonso	16.53	16.63	20.63	17.93
8	Himayuddin	25.70	27.87	27.50	27.02
9	Bennet Alphonso	14.67	22.60	21.73	19.67
10	Swarnarekha	16.50	20.37	16.40	17.76
11	Mulgoa	18.60	20.80	21.07	20.16
12	Chandrakaran	20.17	24.00	20.97	21.71
13	Prior	16.77	18.30	17.50	17.52
	Mean	18.47	20.96	21.06	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.35	0.68	0.48	
	Year x Genotype	2.33	1.17	0.83	

the highest TSS which was significantly different from the rest of the hybrids. Arka Aruna (16.28 °Brix) recorded the lowest TSS which was on par with PKM 2 (16.89 °Brix).

Himayuddin (27.02 °Brix) recorded the highest TSS which was significantly different from the rest of the parents involved in breeding. Swarnarekha (17.76 °Brix) recorded the lowest TSS which was on par with Alphonso (17.93 °Brix).

Chandrakaran (21.71 °Brix) recorded the highest TSS and Prior (17.52 °Brix) recorded the lowest TSS among the local types.

4.3. Sensory evaluation

In mango, colour, sweetness, taste, flavour, appearance and texture contribute to the fruit quality. Hence for quality assessment, sensory evaluation was carried out on a nine-point Hedonic scale using score card for seven attributes namely appearance, sweetness, colour, texture, flavour and taste. Each character was scored on the scale and ranking was given based on Kendall's coefficient of concordance. Sensory evaluation was conducted using ripe fruits and the ranking on the sensory evaluations are given in Table 67 a, b and c.

Among the hybrids, the highest rank for appearance was given for Mallika followed by H 151 and Ratna. For colour highest rank was given for Ratna followed by Sindhu and H 151. Mallika got the highest rank for flavour followed by H 151 and Ratna. Mallika recorded highest rank for sweetness followed by Ratna and H 151. Ratna also recorded highest rank for taste followed by H 151 and Mallika. Mallika was given highest rank for texture followed by H 151 and Ratna (Table 67a).

Among the parents involved in breeding, the highest rank for appearance was given for Kalepady followed by Banganappally and Swarnarekha. For colour highest rank was given for Swarnarekha followed by Banganappally and Alphonso. Neelum got the highest rank for flavour followed by Himayuddin and Dashehari. Neelum recorded highest rank for sweetness followed by Himayuddin and Alphonso. Himayuddin also recorded highest rank for taste followed by Neelum and Dashehari. Neelum was given highest rank for texture followed by Himayuddin and Alphonso (Table 67b)

Table 67a. Sensory evaluation of mango hybrids by Kendall's coefficient of concordance

Appearance		Colour		Flavour		Sweetness		Taste		Texture	
Genotypes	Rank Mean	Genotypes	Rank mean	Genotypes	Rank Mean	Genotypes	Rank Mean	Genotypes	Rank Mean	Genotypes	Rank Mean
Mallika	7.75	Ratna	7.85	Mallika	7.30	Mallika	7.15	Ratna	8.10	Mallika	7.85
H 151	7.35	Sindhu	7.55	H 151	6.95	Ratna	7.00	H 151	7.25	H 151	7.55
Ratna	6.70	H 151	6.95	Ratna	6.85	H 151	6.85	Mallika	6.60	Ratna	6.30
Amrapali	5.60	Mallika	6.20	Sindhu	6.00	Amrapali	6.60	Amrapali	6.15	PKM 1	5.50
H 45	5.40	Amrapali	5.55	PKM 2	5.95	Sindhu	6.30	PKM 2	5.80	Amrapali	5.10
PKM 2	5.20	Arka Aruna	5.25	H 45	5.65	PKM 2	5.00	H 45	5.40	PKM 2	5.05
PKM 1	5.00	H 45	5.20	Amrapali	4.90	H 45	4.95	Sindhu	5.00	Arka aruna	5.05
Sindhu	4.95	PKM 2	4.70	Arka Aruna	4.70	Arka Aruna	4.80	Arka Aruna	4.85	H 45	5.00
Arka aruna	4.35	PKM 1	3.25	PKM 1	4.00	PKM 1	3.90	PKM 1	3.55	Sindhu	4.60
Neelgoa	2.70	Neelgoa	2.50	Neelgoa	2.70	Neelgoa	2.45	Neelgoa	2.30	Neelgoa	3.00
Kendall's Wa	0.28	Kendall's Wa	0.38	Kendall's Wa	0.25	Kendall's Wa	0.30	Kendall's Wa	0.35	Kendall's Wa	0.25

Table 67b. Sensory evaluation of parents involved in breeding by Kendall's coefficient of concordance

Appearance		Colour		Flavour		Sweetness		Taste		Texture	
Genotypes	Rank Mean	Genotypes	Rank mean	Genotypes	Rank Mean	Genotypes	Rank Mean	Genotypes	Rank Mean	Genotypes	Rank Mean
Kalapady	6.45	Swarnarekha	6.65	Neelam	7.10	Neelam	7.45	Himayuddin	7.65	Neelam	6.65
Banganappalli	6.40	Banganappalli	6.20	Himayuddin	6.10	Himayuddin	6.35	Neelam	7.45	Himayuddin	6.55
Swarnarekha	6.40	Alphonso	5.45	Dashehari	5.80	Alphonso	6.00	Dashehari	5.40	Alphonso	5.55
Alphonso	5.05	Neelam	5.40	Kalapady	5.65	Dashehari	5.35	Kalapady	5.15	Dashehari	5.45
Neelam	5.00	Bennet Alphonso	5.15	Alphonso	5.05	Bennet Alphonso	5.05	Alphonso	4.95	Swarnarekha	5.40
Bennet Alphonso	4.80	Kalapady	4.70	Mulgoa	4.50	Kalapady	4.60	Bennet Alphonso	4.55	Kalapady	4.85
Dashehari	4.50	Himayuddin	4.50	Bennet Alphonso	4.10	Mulgoa	4.00	Mulgoa	3.90	Bennet Alphonso	4.45
Himayuddin	4.10	Dashehari	3.85	Swarnarekha	3.40	Swarnarekha	3.80	Banganappalli	3.20	Banganappalli	4.40
Mulgoa	2.30	Mulgoa	3.10	Banganappalli	3.30	Banganappalli	2.40	Swarnarekha	2.75	Mulgoa	1.70
Kendall's Wa	0.28	Kendall's Wa	0.20	Kendall's Wa	0.25	Kendall's Wa	0.33	Kendall's Wa	0.42	Kendall's Wa	0.328

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Table 67c. Sensory evaluation of local types by Kendall's coefficient of concordance

Appearance		Colour		Flavour		Sweetness		Taste		Texture	
Genotypes	Rank Mean	Genotypes	Rank mean	Genotypes	Rank Mean	Genotypes	Rank Mean	Genotypes	Rank Mean	Genotypes	Rank Mean
Muvandan	4.45	Chandrakaran	3.80	Prior	4.65	Prior	5.20	Prior	4.85	Prior	4.90
Prior	3.90	Prior	3.80	Chandrakaran	3.85	Muvandan	3.60	Muvandan	4.20	Muvandan	3.90
Chandrakaran	2.65	Muvandan	2.65	Muvandan	3.50	Chandrakaran	3.55	Chandrakaran	3.40	Tholikaippan	3.20
Tholikaippan	2.15	Tholikaippan	2.55	Vellaikolumban	3.30	Tholikaippan	3.00	Tholikaippan	3.35	Vellaikolumban	3.15
Vellaikolumban	1.85	Vellaikolumban	2.20	Tholikaippan	2.90	Vellaikolumban	2.85	Vellaikolumban	2.80	Chandrakaran	3.05
Kendall's Wa	0.56	Kendall's Wa	0.26	Kendall's Wa	0.50	Kendall's Wa	0.55	Kendall's Wa	0.31	Kendall's Wa	0.11

Among the local types, the highest rank for appearance was given for Muvandan followed by Prior and Chandrakaran. For colour highest rank was given for Chandrakaran followed by Prior and Muvandan. Prior got the highest rank for flavour followed by Chandrakaran and Muvandan. Prior recorded highest rank for sweetness followed Muvandan and Chandrakaran. Prior also recorded highest rank for taste followed by Muvandan and Chandrakaran. Prior was given highest rank for texture followed by Muvandan and Tholikaippan (Table 67c).

4.4 Pollen studies

Size and shape of pollen grains, pollen fertility, *in vitro* pollen germination, estimation of pollen production and pollen storage were recorded and presented in table 68a to table 72.

4.4 Size of pollen grains

The data presented in Table 68 a shows the variation in pollen length of different genotypes during the two seasons. Among the hybrids, Arka Aruna (41.92 µm) recorded the highest pollen length followed by PKM 1(41.77 µm). Neelgoa (26.40 µm) recorded the lowest pollen length.

Himayuddin (45.72 µm) recorded the highest pollen length which was significantly different from rest of the parents involved in breeding. Swarnarekha (27.11 µm) recorded the lowest pollen length which was on par with Mulgoa (28.31 µm) and Kalepady (29.15 µm).

Chandrakaran (45.22 µm) recorded the highest pollen length followed by Vellaikolumban (44.04 µm) among the local types. Muvandan (30.10 µm) recorded the lowest pollen length.

The data presented in Table 68b shows the variation in pollen length of different genotypes during the three seasons. Among the hybrids, Ratna (43.17 µm) recorded the highest pollen length which was significantly different from rest of the hybrids. H 151 (35.61 µm) recorded the lowest pollen length which was on par with PKM 2 (37.42 µm).

Bennet Alphonso (46.53 µm) recorded the highest pollen length which was significantly different from rest of the parents involved in breeding. Banganapalli

Table 68a. Pollen length (μm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	42.27	41.56	41.92
2	Amrapali	38.93	27.51	33.22
3	Mallika	26.60	41.11	33.86
4	Ratna	45.41	33.28	39.35
5	Sindhu	36.49	40.36	38.42
6	H45	37.38	36.35	36.86
7	H 151	34.19	42.20	38.20
8	PKM1	45.04	38.49	41.77
9	PKM 2	35.68	31.50	33.59
10	Neelgoa	31.60	21.19	26.40
11	Banganapalli	24.15	36.38	30.27
12	Alphonso	35.38	47.29	41.33
13	Dashehari	42.56	36.05	39.31
14	Neelum	38.90	45.47	42.18
15	Himayuddin	42.56	48.87	45.72
16	Bennet Alphonso	42.71	32.13	37.42
17	Kalepady	32.23	26.07	29.15
18	Swarnarekha	31.04	23.18	27.11
19	Mulgoa	22.01	34.61	28.31
20	Tholikaippan	33.41	42.78	38.09
21	Chandrakaran	41.93	48.51	45.22
22	Vellaikolumban	41.82	46.26	44.04
23	Prior	42.33	27.76	35.05
24	Muvandan	36.30	23.90	30.10
	Mean	36.71	36.37	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.38	1.20	0.85
	Year x Genotype	3.37	1.70	1.20

Table 68b. Pollen length (μm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	36.00	42.27	36.30	38.19
2	Ratna	42.97	45.41	41.11	43.17
3	H 45	41.23	37.38	40.36	39.66
4	H 151	36.30	34.19	36.35	35.61
5	PKM 2	38.08	35.68	38.49	37.42
6	Banganappalli	21.60	24.15	21.19	22.31
7	Alphonso	33.23	35.38	36.38	35.00
8	Himayuddin	42.08	42.56	45.47	43.37
9	Bennet Alphonso	48.01	42.71	48.87	46.53
10	Swarnarekha	30.66	31.04	26.07	29.25
11	Mulgoa	24.71	22.01	23.18	23.30
12	Chandrakaran	40.82	41.93	42.78	41.84
13	Prior	44.27	42.33	46.26	44.29
	Mean	36.92	36.70	37.14	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.08	1.04	0.74	
	Year x Genotype	3.60	1.81	1.28	

Table 68c. Pollen breadth (μm) of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	41.19	35.49	38.34
2	Amrapali	35.93	26.34	31.14
3	Mallika	24.60	24.97	24.79
4	Ratna	33.27	33.69	33.48
5	Sindhu	28.34	29.21	28.78
6	H45	35.53	35.32	35.42
7	H 151	30.41	32.48	31.45
8	PKM1	27.30	26.49	26.90
9	PKM 2	32.86	35.85	34.35
10	Neelgoa	27.63	28.50	28.07
11	Banganapalli	27.60	24.37	25.99
12	Alphonso	30.49	39.17	34.83
13	Dashehari	31.82	33.21	32.52
14	Neelum	32.86	37.78	35.32
15	Himayuddin	27.66	30.40	29.03
16	Bennet Alphonso	36.07	32.24	34.16
17	Kalepady	28.28	27.39	27.84
18	Swarnarekha	30.85	31.78	31.32
19	Mulgoa	27.67	26.25	26.96
20	Tholikaippan	34.66	35.56	35.11
21	Chandrakaran	31.60	30.25	30.93
22	Vellaikolumban	22.92	26.00	24.46
23	Prior	28.99	30.40	29.70
24	Muvandan	21.78	24.06	22.92
	Mean	30.43	30.72	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.34	1.18	0.83
	Year x Genotype	3.30	1.66	1.18

Table 68d. Pollen breadth (μm) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	34.60	41.19	35.49	37.09
2	Ratna	32.34	33.27	33.69	33.10
3	H 45	35.34	35.53	35.32	35.40
4	H 151	32.48	30.41	32.48	31.79
5	PKM 2	31.30	32.86	35.85	33.34
6	Banganappalli	23.71	27.60	24.37	25.23
7	Alphonso	35.64	30.49	39.17	35.10
8	Himayuddin	27.83	27.66	30.40	28.63
9	Bennet Alphonso	33.44	36.07	32.24	33.92
10	Swarnarekha	30.53	30.85	31.78	31.05
11	Mulgoa	24.82	27.67	26.25	26.25
12	Chandrakaran	24.15	31.60	30.25	28.67
13	Prior	31.70	28.99	30.40	30.36
	Mean	30.61	31.86	32.13	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.31	1.16	0.82	
	Year x Genotype	3.99	2.00	1.42	

(22.31 μm) recorded the lowest pollen length which was on par with Mulgoa (23.30 μm).

Prior (44.29 μm) recorded the highest pollen length and Chandrakaran (41.84 μm) recorded the lowest pollen length among the local types.

The data presented in Table 68c shows the variation in pollen width of different genotypes during the two seasons. Among the hybrids, Arka Aruna (38.34 μm) recorded the highest pollen width which was significantly different from the rest of the hybrids. Mallika (24.79 μm) recorded the lowest pollen width which was on par with PKM 1(26.90 μm).

Neelam (35.32 μm) recorded the highest pollen width followed by Alphonso (34.83 μm) and Bennet Alphonso (34.16 μm) mong the parents involved in breeding. Banganapalli (25.99 μm) recorded the lowest pollen width which was on par with Mulgoa (26.96 μm) and Kalepady (27.84 μm).

Tholikaippan (35.11 μm) recorded the highest pollen width which was significantly different from rest of the local types. Muvandan (22.92 μm) recorded the lowest pollen width which was on par with Vellaikolumban (24.46 μm).

The data presented in Table 68d shows the variation in pollen width of different genotypes during the three seasons. Among the hybrids, Arka Aruna (37.09 μm) recorded the highest pollen width followed by H 45 (35.40 μm). H 151 (31.79 μm) recorded the lowest pollen width which was on par with Ratna (33.10 μm) and PKM 2 (33.34 μm).

Alphonso (35.10 μm) recorded the highest pollen width followed by Bennet Alphonso (33.92 μm) among the parents involved in breeding. Banganapalli (25.23 μm) recorded the lowest pollen width which was on par with Mulgoa (26.25 μm).

Prior (30.36 μm) recorded the highest pollen width and Chandrakaran (28.67 μm) recorded the lowest pollen width among the local types.

4.4 Shape of pollen grains

The data presented in Table 69 shows the variation in shape of pollen grains of different genotypes during. Among the hybrids, Arka Aruna, Amrapali, Sindhu, H 45,

Table 69. Pollen shape of different mango genotypes

Sl. No.	Genotypes	Pollen shape
1	Arka Aruna	Oblong
2	Amrapali	Oblong
3	Mallika	Oval
4	Ratna	Oval
5	Sindhu	Oblong
6	H45	Oblong
7	H 151	Oblong
8	PKM1	Oblong
9	PKM 2	Oblong
10	Neelgoa	Oblong
11	Banganapalli	Oblong
12	Alphonso	Oblong
13	Dashehari	Oblong
14	Neelum	Oblong
15	Himayuddin	Oblong
16	Bennet Alphonso	Oblong
17	Kalepady	Oblong
18	Swarnarekha	Round
19	Mulgoa	Oval
20	Tholikaippan	Round
21	Chandrakaran	Oval
22	Vellaikolumban	Oblong
23	Prior	Oblong
24	Muvandan	Oblong

Plate 47. Variations size and shape of pollen grains of mango genotypes Arka Aruna, Amrapali, Mallika, Ratna and Sindhu

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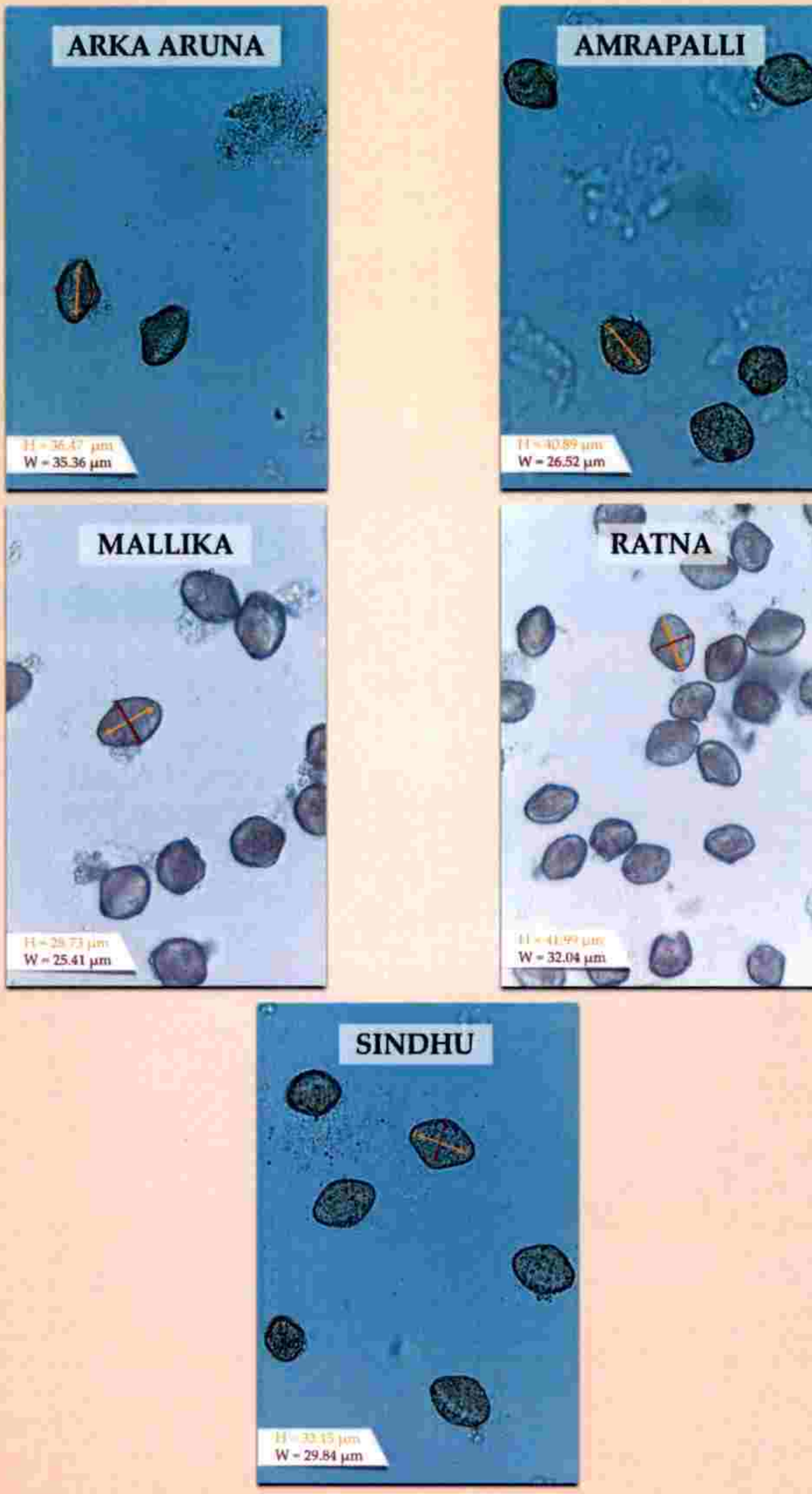

Plate 48. Variations size and shape of pollen grains of mango genotypes H45, H151, PKM1, PKM 2 and Neelgoa

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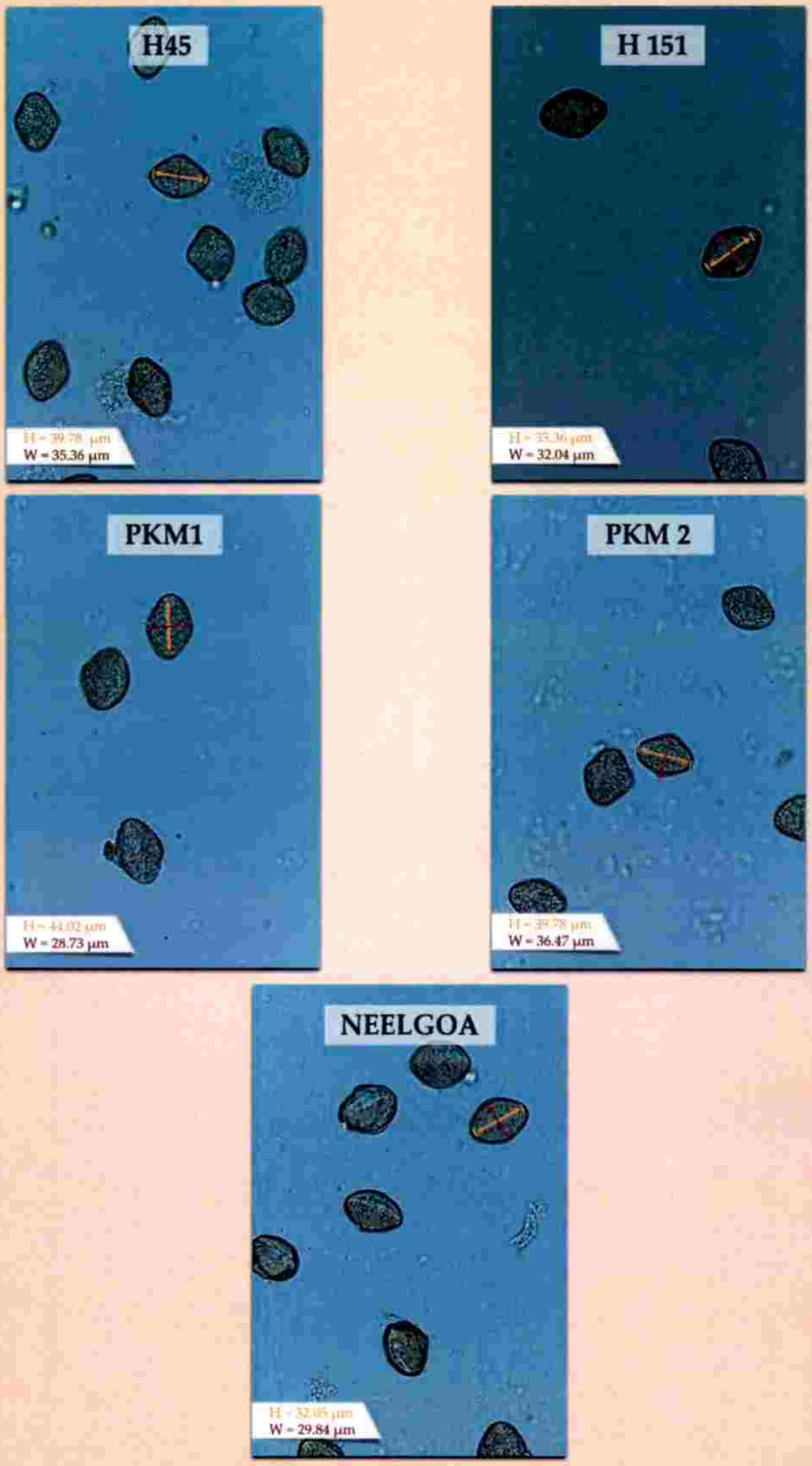

Plate 49. Variations size and shape of pollen grains of mango genotypes Banganapalli, Alphonso, Dashehari, Neelum and Himayuddin

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Plate 50. Variations size and shape of pollen grains of mango genotypes Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa

247

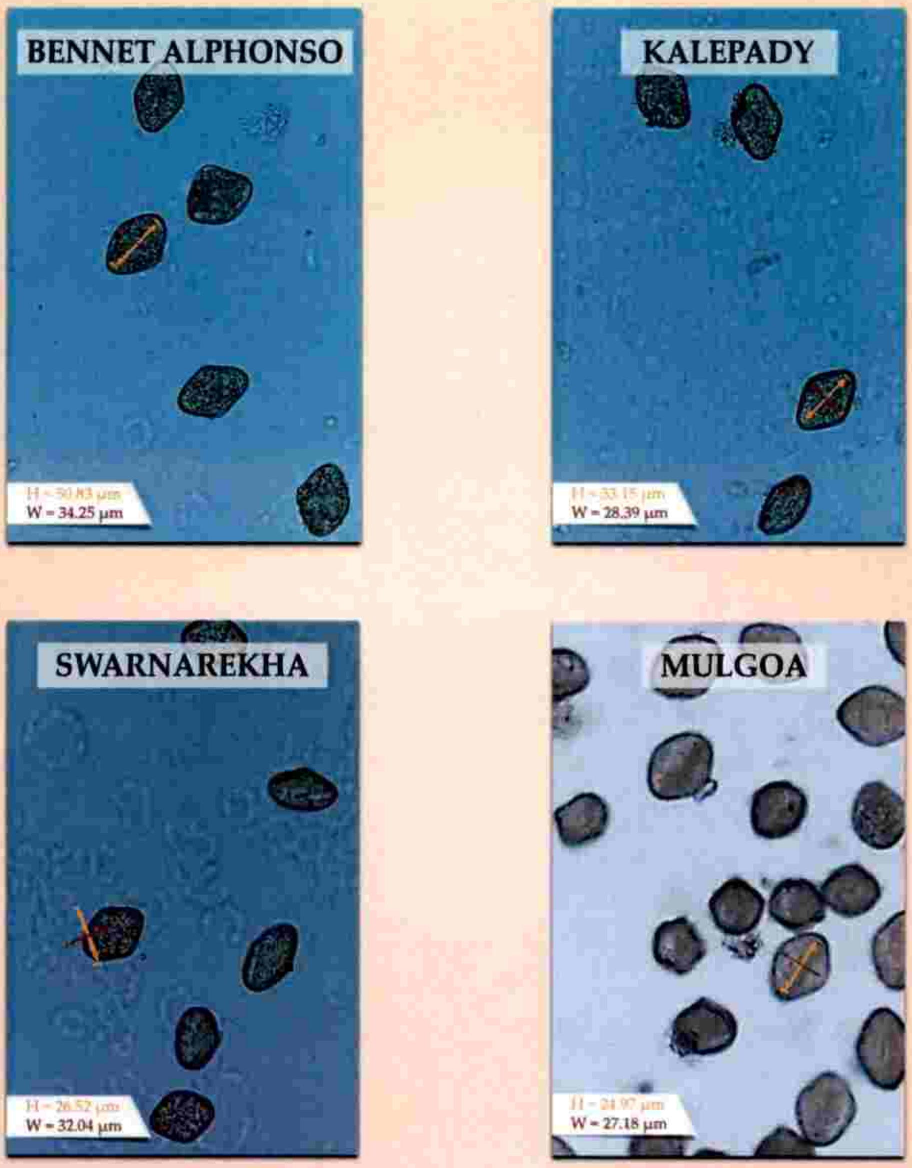
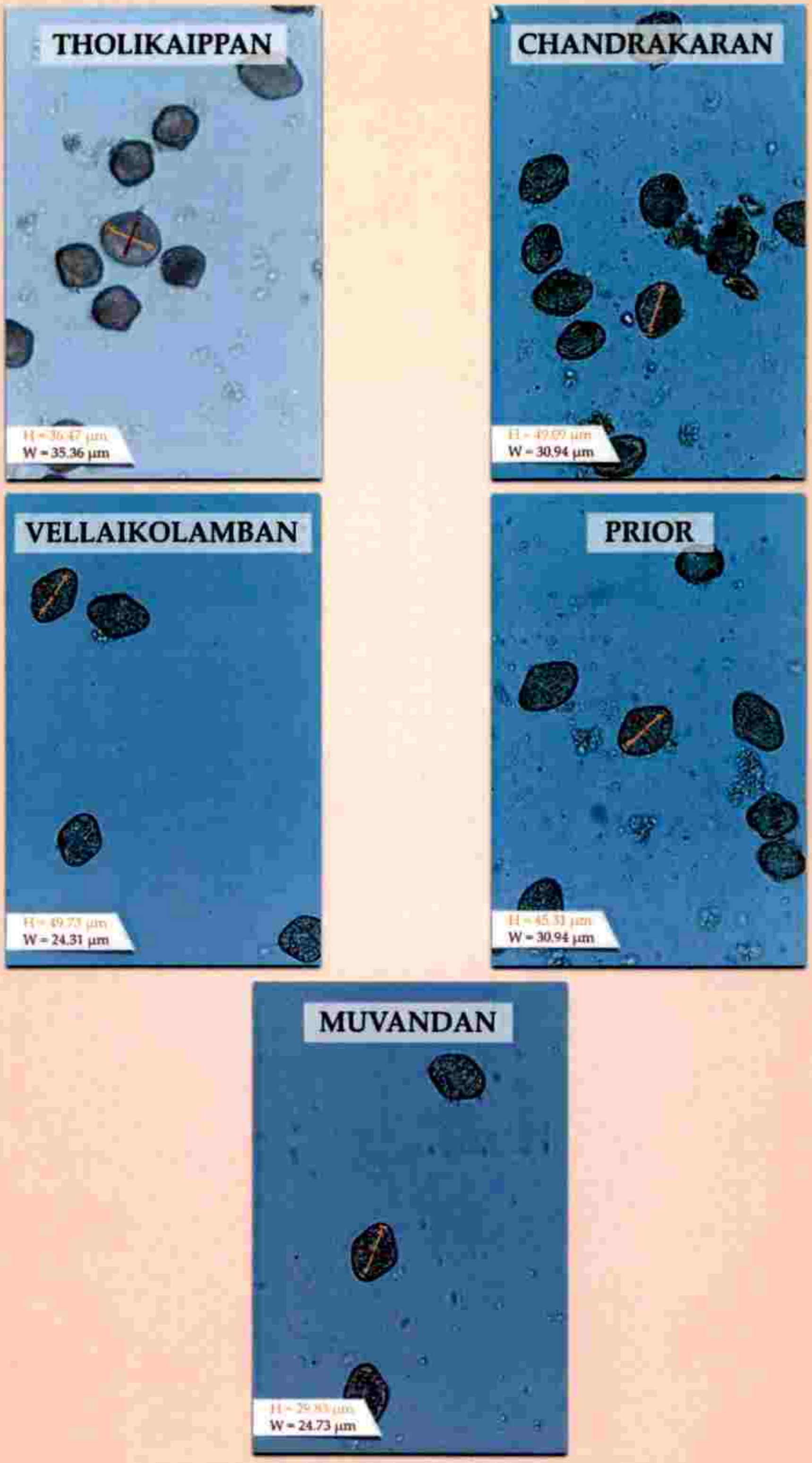


Plate 51. Variations size and shape of pollen grains of mango genotypes Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan



H 151, PKM 1, PKM 2 and Neelgoa had oblong pollen whereas Mallika and Ratna had oval pollen grains.

All the parents involved in breeding had oblong pollen grains except Swarnarekha and Mulgoa. Swarnarekha had round pollen grains whereas Mulgoa had oval pollen grains.

Vellaikolumban, Prior and Muvandan had oblong pollen grains among the local types whereas Chandrakaran recorded oval pollen grains and Tholikaippan recorded roundish pollen grains.

4.4 Pollen fertility

The data presented in Table 70a shows the variation in pollen fertility of different genotypes during the two seasons. Among the hybrids, Ratna (93.54 %) recorded the highest fertility followed by the rest of the hybrids. Neelgoa (87.16%) recorded the lowest fertility.

Dashehari (92.18%) recorded the highest fertility followed by the rest of the parents except Kalepady (84.81%) among the parents involved in breeding. Mulgoa (82.70%) recorded the lowest pollen fertility which was on par with Kalepady (84.81%).

Tholikaippan (93.60%) recorded the highest pollen fertility followed by Chandrakaran (92.57%) among the local types. Prior (86.22%) recorded the lowest pollen fertility which was on par with Muvandan (87.63%) and Vellaikolumban (87.69%).

The data presented in Table 70b shows the variation in pollen fertility of different genotypes during the three seasons. Among the hybrids, Ratna (78.79%) recorded the highest pollen fertility followed by PKM 2 (78.53%). Arka Aruna (71.93%) recorded the lowest pollen fertility which was on par with H 151 (72.10 %) and H 45 (73.02%).

Swarnarekha (80.45%) recorded the highest pollen fertility followed by Alphonso (80.18%) among the parents involved in breeding. Himayuddin (74.89%) recorded the lowest pollen fertility which was on par with Mulgoa (75.28%), Banganapalli (75.67%) and Bennet Alphonso (76.05%).

Chandrakaran (80.47%) recorded the highest pollen fertility and Prior (73.85%) recorded the lowest pollen fertility among the local types.

Table 70a. Pollen fertility of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	**2017-18**	
1	Arka Aruna	92.46	92.53	92.50
2	Amrapali	88.14	91.00	89.57
3	Mallika	94.78	83.45	89.11
4	Ratna	91.76	95.33	93.54
5	Sindhu	94.84	91.78	93.31
6	H45	89.02	93.29	91.16
7	H 151	90.96	90.21	90.58
8	PKM1	93.88	86.74	90.31
9	PKM 2	93.47	90.75	92.11
10	Neelgoa	91.20	83.12	87.16
11	Banganapalli	92.06	88.78	90.42
12	Alphonso	88.22	91.21	89.72
13	Dashehari	93.79	90.57	92.18
14	Neelum	87.60	94.34	90.97
15	Himayuddin	94.40	84.85	89.63
16	Bennet Alphonso	92.79	88.80	90.80
17	Kalepady	94.53	75.10	84.81
18	Swarnarekha	92.16	91.49	91.83
19	Mulgoa	74.25	91.14	82.70
20	Tholikaippan	92.27	94.93	93.60
21	Chandrakaran*	90.09	95.05	92.57
22	Vellaikolumban*	85.87	89.51	87.69
23	Prior	86.00	86.43	86.22
24	Muvandan*	92.90	82.37	87.63
	Mean	90.73	89.28	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	4.47	2.25	1.59
	Year x Genotype	6.32	3.18	2.25

Table 70b. Pollen fertility of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	30.79	92.46	92.53	71.93
2	Ratna	49.28	91.76	95.33	78.79
3	H 45	36.76	89.02	93.29	73.02
4	H 151	35.13	90.96	90.21	72.10
5	PKM 2	51.38	93.47	90.75	78.53
6	Banganappalli	46.18	92.06	88.78	75.67
7	Alphonso	61.12	88.22	91.21	80.18
8	Himayuddin	45.42	94.40	84.85	74.89
9	Bennet Alphonso	46.57	92.79	88.80	76.05
10	Swarnarekha	57.70	92.16	91.49	80.45
11	Mulgoa	60.45	74.25	91.14	75.28
12	Chandrakaran	56.27	90.09	95.05	80.47
13	Prior	49.12	86.00	86.43	73.85
	Mean	48.17	89.82	90.76	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.48	1.75	1.24	
	Year x Genotype	6.04	3.03	2.14	

4.4 Estimation of pollen production

The data presented in Table 71a shows the variation in estimation of pollen production of different genotypes during the two seasons. Among the hybrids, Amrapali (438.17) recorded the highest pollen production followed by Mallika (426.67) and Neelgoa (416.17). H 151 (299.00) recorded the lowest pollen production which was on par with Ratna (303.67), Sindhu (319.33), PKM 1(320.83), PKM 2 (337.00) and Arka Aruna (345.17).

Banganapalli (489.00) recorded the highest pollen production followed by Himayuddin (444.50) among the parents involved in breeding. Neelum (315.83) recorded the lowest pollen production which was on par with Bennet Alphonso (326.83), Mulgoa (329.17), Kalepady (347.33) and Dashehari (348.50).

Prior (541.83) recorded the highest pollen production which was significantly different from rest of the local types and Muvandan (347.33) recorded the lowest pollen production.

The data presented in Table 71b shows the variation in estimation of pollen production of different genotypes during the three seasons. Among the hybrids, Arka Aruna (263.56) recorded the highest pollen production followed by H 45 (258.33) and PKM 2 (254.56). H 151 (218.67) recorded the lowest pollen production.

Banganapalli (347.56) recorded the highest pollen production followed by Himayuddin (320.67) among the parents involved in breeding. Bennet Alphonso (237.89) recorded the lowest pollen production which was on par with Mulgoa (248.89) and Alphonso (264.89).

Prior (403.00) recorded the highest pollen production and Chandrakaran (315.56) recorded the lowest pollen production among the local types.

4.4 Pollen storage

In order to study the optimal condition for storing pollen with minimum loss of viability, pollen collected irrespective of the varieties was subjected to storage in different atmospheric conditions. The results are presented in table 72. The studies showed that the mango pollen can be stored without much loss in viability up to 72 h after dehiscence when it is stored in refrigerated conditions, but the viability was high

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Table 71a. Pollen production of different mango genotypes

Sl. No.	Genotypes	Year		Mean
		2016-17	2017-18	
1	Arka Aruna	331.33	359.00	345.17
2	Amrapali	439.33	437.00	438.17
3	Mallika	414.33	439.00	426.67
4	Ratna	338.33	269.00	303.67
5	Sindhu	301.00	337.67	319.33
6	H45	343.67	357.67	350.67
7	H 151	299.67	298.33	299.00
8	PKM1	296.00	345.67	320.83
9	PKM 2	321.67	352.33	337.00
10	Neelgoa	421.67	410.67	416.17
11	Banganapalli	545.00	433.00	489.00
12	Alphonso	399.00	337.00	368.00
13	Dashehari	291.33	405.67	348.50
14	Neelum	331.33	300.33	315.83
15	Himayuddin	453.67	435.33	444.50
16	Bennet Alphonso	305.00	348.67	326.83
17	Kalepady	301.33	393.33	347.33
18	Swarnarekha	377.33	449.67	413.50
19	Mulgoa	333.00	325.33	329.17
20	Tholikaippan	453.00	412.33	432.67
21	Chandrakaran	372.33	437.33	404.83
22	Vellaikolumban	414.00	424.67	419.33
23	Prior	553.33	530.33	541.83
24	Muvandan	371.33	323.33	347.33
	Mean	375.33	381.78	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	47.36	23.82	16.84
	Year x Genotype	66.98	33.69	23.82

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Table 71b. Pollen production of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	100.33	331.33	359.00	263.56
2	Ratna	86.67	338.33	269.00	231.33
3	H 45	73.67	343.67	357.67	258.33
4	H 151	58.00	299.67	298.33	218.67
5	PKM 2	89.67	321.67	352.33	254.56
6	Banganappalli	64.67	545.00	433.00	347.56
7	Alphonso	58.67	399.00	337.00	264.89
8	Himayuddin	73.00	453.67	435.33	320.67
9	Bennet Alphonso	60.00	305.00	348.67	237.89
10	Swarnarekha	75.33	377.33	449.67	300.78
11	Mulgoa	88.33	333.00	325.33	248.89
12	Chandrakaran	137.00	372.33	437.33	315.56
13	Prior	125.33	553.33	530.33	403.00
	Mean	83.90	382.56	379.46	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	34.26	17.17	12.14	
	Year x Genotype	59.34	29.75	21.03	

Table 72. Pollen storage studies

Treatment	Interval after storage					
	24 h		48 h		72 h	
	Mean	**S.E.**	**Mean**	**S.E.**	**Mean**	**S.E.**
Keeping in refrigerator at 4 ^{0}C	78.52	1.75	8.71	0.24	7.11	0.04
Keeping over calcium chloride and refrigeration at 4 ^{0}C	62.46	0.82	55.56	1.11	42.52	0.84
Keeping over calcium chloride in a desiccator	72.52	0.76	11.40	0.87	8.20	0.11
Keeping at room temperature	51.34	1.07	42.13	0.67	33.78	0.87
CD	**3.36**		**2.28**		**1.75**	
SE(m)	1.17		0.79		0.61	
SE(d)	1.65		1.12		0.86	

(78.52 %) after 24 h of storage but then declining to 8.71 % and 7.11% after 48 hours and 72 h respectively. Keeping over calcium chloride in desiccator retained the viability up to 72.52 % after 24 hours of storage but thereafter suddenly reduced to 11.40 % and 8.20 % after 48 h and 72 h respectively. Keeping over calcium chloride and placing under refrigerated condition retained the viability up to 62.46 % after 24 h of storage but thereafter suddenly reduced to 55.56 % and 42.52 % after 48 h and 72 hours respectively. Keeping pollen at room temperature conditions recorded 51.34% viability after 24 h of storage which further declined to 42.13% and 33.78% after 48 h and 72 h respectively.

4.5 Physiological characters

Relative water content (%), radiation interception (μ mol m^{-2} s^{-2}), stomatal index, stomatal frequency, stomatal conductance (μ mol m^{-2} s^{-2}), stomatal resistance (μ mol m^{-2} s^{-2}), photosynthetic rate (μ mol m^{-2} s^{-2}), transpiration (mol m^{-2} s^{-2}), leaf area index (LAI) and atmospheric pollution tolerance index (APTI) were recorded and presented from table 73 to table 82.

4.5.1 Relative water content (RWC)

The data presented in Table 73 shows the variation in estimation of relative water content (%) of different genotypes during the three seasons. Among the hybrids, H 151 (35.37 %) recorded the highest RWC followed by Amrapali (37.07%), PKM 1 (31.80%) and Neelgoa (31.64%). Ratna (19.00%) recorded the lowest RWC which was on par with H 45 (23.65%).

Neelum (35.82%) recorded the highest relative water content followed by Bennet Alphonso (34.86%) and Kalepady (31.34%) among the parents involved in breeding. Alphonso (22.71%) recorded the lowest RWC which was on par with Mulgoa (24.45%), Banganapalli (24.93%) and Dashehari (26.46%).

Vellaikolumban (34.74%) recorded the highest RWC followed by Muvandan (32.85%) among the local types. Tholikaippan (24.31%) recorded the lowest RWC which was on par with Prior (26.44%).

Table 73. Relative water content (%) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	28.42	30.50	26.75	28.56
2	Amrapali	26.03	31.40	47.78	35.07
3	Mallika	29.07	37.00	19.79	28.62
4	Ratna	18.37	26.10	12.53	19.00
5	Sindhu	21.13	15.80	43.33	26.76
6	H45	27.10	21.67	22.20	23.65
7	H 151	42.80	32.47	30.83	35.37
8	PKM1	31.20	33.57	30.63	31.80
9	PKM 2	25.70	28.50	28.75	27.65
10	Neelgoa	34.17	26.17	34.58	31.64
11	Banganapalli	26.67	29.10	19.02	24.93
12	Alphonso	19.90	24.07	24.18	22.71
13	Dashehari	21.00	28.07	30.31	26.46
14	Neelum	32.20	27.83	47.42	35.82
15	Himayuddin	30.07	31.00	25.71	28.93
16	Bennet Alphonso	26.40	31.10	47.09	34.86
17	Kalepady	35.37	38.17	20.49	31.34
18	Swarnarekha	36.40	26.93	23.80	29.04
19	Mulgoa	23.70	26.80	22.86	24.45
20	Tholikaippan	25.10	26.47	21.35	24.31
21	Chandrakaran	26.28	23.17	34.34	27.93
22	Vellaikolumban	24.80	25.07	54.37	34.74
23	Prior	24.30	31.87	23.16	26.44
24	Muvandan	31.47	38.85	28.23	32.85
	Mean	27.82	28.82	29.98	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	6.01	3.04	2.15	
	Year x Genotype	10.41	5.26	3.72	

4.5.2 Radiation interception

The data presented in Table 74 shows the variation in estimation of radiation interception (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Among the hybrids, H 151 (0.85 μ mol m^{-2} s^{-2}) followed by the rest of the hybrids. H 45 (0.76 μ mol m^{-2} s^{-2}) recorded the lowest radiation interception.

Mulgoa (0.92 μ mol m^{-2} s^{-2}) recorded the highest radiation interception followed by the rest of the parents involved in breeding. Dashehari (0.76 μ mol m^{-2} s^{-2}) recorded the lowest radiation interception.

Muvandan (0.87 μ mol m^{-2} s^{-2}) recorded the highest radiation interception followed by Vellaikolumban (0.86 μ mol m^{-2} s^{-2}) and Prior (0.79 μ mol m^{-2} s^{-2}) among the local types. Tholikaippan (0.68 μ mol m^{-2} s^{-2}) recorded the lowest radiation interception.

4.5.3 Stomatal index

The data presented in Table 75 shows the variation in estimation of stomatal index of different genotypes during the three seasons. Among the hybrids, Mallika (22.44) recorded the highest stomatal index followed by Sindhu (20.85) and Amrapali (20.79). Arka Aruna (18.69) recorded the lowest stomatal index which was on par with Neelgoa (18.91), Pkm 2 (19.42), H 45 (19.58), H 151 (19.59) and Ratana (20.06).

Banganapalli (20.80) recorded the highest stomatal index followed by the rest of the parents except Bennet Alphonso (18.55) among the parents involved in breeding. Kalepady (18.11) recorded the lowest stomatal index which was on par with Bennet Alphonso (18.55).

Chandrakaran (20.00) recorded the highest stomatal index followed by the rest of the local types among the local types. Prior (15.59) recorded the lowest stomatal index.

4.5.4 Stomatal frequency

The data presented in Table 76 shows the variation in estimation of stomatal frequency of different genotypes during the three seasons. Among the hybrids, Mallika (85.11) recorded the highest stomatal frequency followed by H 151 (80.11), PKM 1 (77.89), Neelgoa (77.89) and PKM 2 (76.33). H 45 (65.22) recorded the lowest

Table 74. Radiation interception (μ mol m^{-2} s^{-2}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.83	0.91	0.73	0.82
2	Amrapali	0.89	0.89	0.76	0.85
3	Mallika	0.74	0.76	0.81	0.77
4	Ratna	0.81	0.86	0.78	0.82
5	Sindhu	0.86	0.97	0.70	0.84
6	H45	0.77	0.93	0.58	0.76
7	H 151	0.95	0.91	0.69	0.85
8	PKM1	0.83	0.90	0.76	0.83
9	PKM 2	0.76	0.94	0.68	0.80
10	Neelgoa	0.80	0.96	0.65	0.80
11	Banganapalli	0.84	0.89	0.73	0.82
12	Alphonso	0.93	0.77	0.83	0.84
13	Dashehari	0.77	0.80	0.71	0.76
14	Neelum	0.90	0.87	0.94	0.90
15	Himayuddin	0.86	0.90	0.83	0.86
16	Bennet Alphonso	0.86	0.89	0.85	0.87
17	Kalepady	0.88	0.88	0.88	0.88
18	Swarnarekha	0.85	0.91	0.79	0.85
19	Mulgoa	0.91	0.94	0.90	0.92
20	Tholikaippan	0.62	0.89	0.54	0.68
21	Chandrakaran	0.76	0.85	0.65	0.75
22	Vellaikolumban	0.84	0.94	0.78	0.86
23	Prior	0.76	0.90	0.72	0.79
24	Muvandan	0.92	0.92	0.76	0.87
	Mean	0.83	0.89	0.75	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.11	0.05	0.04	
	Year x Genotype	NS	0.09	0.07	

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Table 75. Stomatal index of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	19.53	18.56	17.97	18.69
2	Amrapali	18.49	20.55	23.32	20.79
3	Mallika	21.18	19.71	26.42	22.44
4	Ratna	17.77	19.50	22.90	20.06
5	Sindhu	19.25	22.33	20.97	20.85
6	H45	18.48	20.64	19.60	19.58
7	H 151	18.90	21.26	18.63	19.59
8	PKM1	18.81	24.04	17.49	20.11
9	PKM 2	19.11	21.90	17.26	19.42
10	Neelgoa	18.56	17.78	20.40	18.91
11	Banganapalli	18.90	21.56	21.95	20.80
12	Alphonso	20.92	18.23	17.79	18.98
13	Dashehari	21.19	17.73	18.37	19.09
14	Neelum	16.52	19.08	23.78	19.79
15	Himayuddin	20.42	18.23	21.86	20.17
16	Bennet Alphonso	18.21	21.22	16.21	18.55
17	Kalepady	17.79	16.16	20.38	18.11
18	Swarnarekha	17.62	19.19	19.88	18.90
19	Mulgoa	21.59	19.19	17.74	19.51
20	Tholikaippan	20.92	19.44	19.45	19.94
21	Chandrakaran	18.48	19.59	21.93	20.00
22	Vellaikolumban	16.55	19.71	17.97	18.08
23	Prior	19.63	11.22	15.91	15.59
24	Muvandan	19.36	20.22	19.21	19.60
	Mean	19.09	19.46	19.89	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.15	1.09	0.77	
	Year x Genotype	3.73	1.89	1.33	

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Table 76. Stomatal frequency of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	63.33	60.33	74.67	66.11
2	Amrapali	62.67	72.00	88.67	74.44
3	Mallika	68.00	74.33	113.00	85.11
4	Ratna	56.67	59.00	81.00	65.56
5	Sindhu	62.00	64.67	80.33	69.00
6	H45	65.33	56.00	74.33	65.22
7	H 151	73.33	77.00	90.00	80.11
8	PKM1	84.33	72.33	77.00	77.89
9	PKM 2	75.33	73.33	80.33	76.33
10	Neelgoa	83.67	60.67	89.33	77.89
11	Banganapalli	84.00	87.67	94.67	88.78
12	Alphonso	74.00	84.67	77.00	78.56
13	Dashehari	72.00	92.00	81.00	81.67
14	Neelum	78.67	89.00	82.00	83.22
15	Himayuddin	73.67	93.67	85.00	84.11
16	Bennet Alphonso	82.00	82.00	83.33	82.44
17	Kalepady	76.67	74.67	110.00	87.11
18	Swarnarekha	84.67	79.00	82.33	82.00
19	Mulgoa	79.33	75.00	79.00	77.78
20	Tholikaippan	79.00	70.67	96.33	82.00
21	Chandrakaran	75.00	93.33	88.00	85.44
22	Vellaikolumban	72.00	70.33	76.67	73.00
23	Prior	69.33	71.00	83.33	74.56
24	Muvandan	66.67	68.00	77.33	70.67
	Mean	73.40	75.03	85.19	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	9.22	4.66	3.30	
	Year x Genotype	15.98	8.08	5.71	

stomatal frequency which was on par with Ratna (65.56), Arka Aruna (66.11), Sindhu (69.00) and Amrapali (74.44).

Banganapalli (88.78) recorded the highest stomatal frequency followed by the rest of the parents except Alphonso (78.56). Mulgoa (77.78) recorded the lowest stomatal frequency which was on par with Alphonso (78.56).

Chandrakaran (85.44) recorded the highest stomatal frequency followed by Tholikaippan (82.00) among the local types. Muvandan (70.67) recorded the lowest stomatal frequency which was on par with Vellaikolumban (73.00) and Prior (74.56).

4.5.5 Stomatal conductance

The data presented in Table 77 shows the variation in estimation of stomatal conductance (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. The variation in stomatal conductance was not significant among the different genotypes over the three seasons.

4.5.6 Stomatal resistance

The data presented in Table 78 shows the variation in estimation of stomatal resistance (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Among the hybrids, H 45 (15.36 μ mol m^{-2} s^{-2}) recorded the highest stomatal resistance followed by the rest of the hybrids except Neelgoa (7.42 μ mol m^{-2} s^{-2}) and Ratna (7.19 μ mol m^{-2} s^{-2}). PKM 1 recorded the lowest stomatal resistance which was on par with Ratna (7.19 μ mol m^{-2} s^{-2}) and Neelgoa (7.42 μ mol m^{-2} s^{-2}).

Swarnarekha (37.92 μ mol m^{-2} s^{-2}) recorded the highest stomatal resistance which was significantly different from rest of the parents involved in breeding. Dashehari (5.33 μ mol m^{-2} s^{-2}) recorded the lowest stomatal resistance which was on par with Himayuddin (7.29 μ mol m^{-2} s^{-2}) and Bennet Alphonso (8.16 μ mol m^{-2} s^{-2}).

Tholikaippan (16.29 μ mol m^{-2} s^{-2}) recorded the highest stomatal resistance followed by Chandrakaran (15.58 μ mol m^{-2} s^{-2}) and Vellaikolumban (10.71 μ mol m^{-2} s^{-2}) among the local types. Prior (8.31 μ mol m^{-2} s^{-2}) recorded the lowest stomatal resistance which was on par with Muvandan (8.45 μ mol m^{-2} s^{-2}).

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Table 77. Stomatal conductance (μ mol m^{-2} s^{-2}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.40	0.09	0.10	0.19
2	Amrapali	0.14	0.16	0.05	0.12
3	Mallika	0.21	0.08	0.15	0.14
4	Ratna	0.14	0.17	0.12	0.15
5	Sindhu	0.20	0.07	0.07	0.11
6	H45	0.12	0.04	0.14	0.10
7	H 151	0.18	0.11	0.08	0.12
8	PKM1	0.24	0.10	0.22	0.19
9	PKM 2	0.18	0.12	0.33	0.21
10	Neelgoa	0.14	0.10	0.25	0.16
11	Banganapalli	0.40	0.05	0.06	0.17
12	Alphonso	0.13	0.16	0.06	0.12
13	Dashehari	0.25	0.15	9.00	3.13
14	Neelum	0.14	0.05	0.15	0.11
15	Himayuddin	0.26	0.12	0.15	0.18
16	Bennet Alphonso	0.78	0.11	0.15	0.35
17	Kalepady	0.13	0.05	0.20	0.12
18	Swarnarekha	0.03	0.09	0.02	0.05
19	Mulgoa	0.03	0.08	0.03	0.05
20	Tholikaippan	0.03	0.13	0.37	0.18
21	Chandrakaran	0.28	0.12	0.03	0.14
22	Vellaikolumban	0.17	0.05	0.63	0.28
23	Prior	0.34	0.08	0.19	0.21
24	Muvandan	0.27	0.13	0.15	0.18
	Mean	0.22	0.10	0.53	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	NS	0.85	0.60	
	Year x Genotype	NS	1.47	1.04	

Table 78. Stomatal resistance (μ mol m^{-2} s^{-2}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	8.12	16.19	12.07	12.13
2	Amrapali	7.09	9.10	29.81	15.33
3	Mallika	4.79	15.19	7.16	9.05
4	Ratna	7.12	6.34	8.12	7.19
5	Sindhu	5.01	14.65	18.57	12.74
6	H45	8.96	29.57	7.55	15.36
7	H 151	5.72	9.60	12.54	9.29
8	PKM1	4.21	10.21	5.30	6.57
9	PKM 2	5.56	19.29	3.05	9.30
10	Neelgoa	7.30	9.80	5.16	7.42
11	Banganapalli	4.80	21.03	20.83	15.55
12	Alphonso	7.96	12.93	21.00	13.96
13	Dashehari	4.23	8.29	3.48	5.33
14	Neelum	7.03	32.81	6.84	15.56
15	Himayuddin	4.90	10.02	6.95	7.29
16	Bennet Alphonso	1.30	16.17	7.02	8.16
17	Kalepady	7.95	29.87	22.86	20.23
18	Swarnarekha	40.18	12.05	61.53	37.92
19	Mulgoa	29.55	14.89	29.38	24.61
20	Tholikaippan	37.34	7.48	4.06	16.29
21	Chandrakaran	4.06	10.62	32.04	15.58
22	Vellaikolumban	6.17	24.19	1.77	10.71
23	Prior	2.93	16.25	5.75	8.31
24	Muvandan	3.85	11.78	9.71	8.45
	Mean	9.42	15.35	14.27	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	7.74	3.91	2.77	
	Year x Genotype	13.41	6.78	4.79	

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4.5.7 Photosynthetic rate

The data presented in Table 79 shows the variation in estimation of photosynthetic rate (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Among the hybrids, PKM 1 (14.14 μ mol m^{-2} s^{-2}) recorded the highest photosynthetic rate followed by PKM 2 (13.55 μ mol m^{-2} s^{-2}), Ratna (12.82 μ mol m^{-2} s^{-2}), Neelgoa (12.12 μ mol m^{-2} s^{-2}) and Amrapali (10.71 μ mol m^{-2} s^{-2}). H 151 (7.57 μ mol m^{-2} s^{-2}) recorded the lowest photosynthetic rate which was on par with Mallika (8.87 μ mol m^{-2} s^{-2}), Sindhu (9.25 μ mol m^{-2} s^{-2}), H 45 (9.59 μ mol m^{-2} s^{-2}) and Arka Aruna (10.61 μ mol m^{-2} s^{-2}).

Swarnarekha (17.54 μ mol m^{-2} s^{-2}) recorded the highest photosynthetic rate followed by the rest of the parents involved in breeding except Alphonso (10.42 μ mol m^{-2} s^{-2}). Neelum (8.95 μ mol m^{-2} s^{-2}) recorded the lowest photosynthetic rate which was on par with Alphonso (10.42 μ mol m^{-2} s^{-2}).

Tholikaippan (17.91 μ mol m^{-2} s^{-2}) recorded the highest photosynthetic rate wfollowed by Prior (13.94 μ mol m^{-2} s^{-2}) and Muvandan (13.30 μ mol m^{-2} s^{-2}) among the local types. Chandrakaran (8.64 μ mol m^{-2} s^{-2}) recorded the lowest photosynthetic rate which was on par with Vellaikolumban (11.61 μ mol m^{-2} s^{-2}).

4.5.8 Transpiration

The data presented in Table 80 shows the variation in estimation of transpiration (mol m^{-2} s^{-2}) of different genotypes during the three seasons. Among the hybrids, Sindhu (3.31 μ mol m^{-2} s^{-2}) recorded the highest transpiration followed by the rest of the hybrids except Arka Aruna (2.17 μ mol m^{-2} s^{-2}) and PKM 1 (2.09 μ mol m^{-2} s^{-2}). H 45 (1.91 μ mol m^{-2} s^{-2}) recorded the lowest transpiration which was on par with PKM 1 (2.09 μ mol m^{-2} s^{-2}) and Arka Aruna (2.17 μ mol m^{-2} s^{-2}).

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Table 79. Evaluation of mango genotypes for photosynthetic rate (μ mol m^{-2} s^{-2})

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	6.33	12.80	12.70	10.61
2	Amrapali	4.59	13.30	14.22	10.71
3	Mallika	4.30	8.93	13.39	8.87
4	Ratna	5.89	11.17	21.40	12.82
5	Sindhu	3.92	11.94	11.90	9.25
6	H45	3.61	12.25	12.93	9.59
7	H 151	3.33	10.93	8.45	7.57
8	PKM1	12.29	8.55	21.59	14.14
9	PKM 2	6.38	10.79	23.49	13.55
10	Neelgoa	7.13	11.53	17.71	12.12
11	Banganapalli	8.15	9.47	17.89	11.84
12	Alphonso	4.30	3.95	23.01	10.42
13	Dashehari	12.96	10.31	24.77	16.01
14	Neelum	6.52	14.13	6.21	8.95
15	Himayuddin	8.86	10.54	12.14	10.51
16	Bennet Alphonso	11.18	10.94	17.51	13.21
17	Kalepady	9.21	12.53	12.22	11.32
18	Swarnarekha	17.98	8.25	26.40	17.54
19	Mulgoa	15.13	9.42	9.56	11.37
20	Tholikaippan	14.62	9.37	29.73	17.91
21	Chandrakaran	5.21	1.33	19.37	8.64
22	Vellaikolumban	7.37	12.98	14.49	11.61
23	Prior	18.00	12.89	10.93	13.94
24	Muvandan	12.15	13.38	14.37	13.30
	Mean	8.73	10.49	16.52	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.48	1.76	1.24	
	Year x Genotype	6.03	3.05	2.15	

Table 80. Transpiration (mol m^{-2} s^{-2}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	1.67	2.19	2.65	2.17
2	Amrapali	1.93	3.70	2.69	2.77
3	Mallika	2.93	2.19	2.34	2.49
4	Ratna	2.44	3.81	1.26	2.50
5	Sindhu	3.13	2.46	4.33	3.31
6	H45	2.12	1.19	2.44	1.91
7	H 151	1.39	2.54	4.89	2.94
8	PKM1	1.23	2.61	2.44	2.09
9	PKM 2	3.04	2.21	2.38	2.54
10	Neelgoa	3.44	3.59	2.24	3.09
11	Banganapalli	3.67	1.70	2.15	2.50
12	Alphonso	3.03	2.84	2.66	2.85
13	Dashehari	3.32	4.08	5.05	4.15
14	Neelum	2.63	1.32	2.44	2.13
15	Himayuddin	3.33	3.78	2.38	3.16
16	Bennet Alphonso	1.29	2.77	2.16	2.08
17	Kalepady	1.27	1.44	1.55	1.42
18	Swarnarekha	2.18	2.38	1.05	1.87
19	Mulgoa	2.50	2.19	2.30	2.33
20	Tholikaippan	2.30	3.45	0.43	2.06
21	Chandrakaran	1.65	2.55	2.01	2.07
22	Vellaikolumban	1.46	1.51	1.26	1.41
23	Prior	2.31	2.87	2.49	2.56
24	Muvandan	3.29	3.27	3.11	3.22
	Mean	2.40	2.61	2.45	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.92	0.47	0.33	
	Year x Genotype	1.59	0.81	0.57	

Dashehari (4.15 μ mol m^{-2} s^{-2}) recorded the highest transpiration which was significantly different from the rest of the parents involved in breeding. Kalepady (1.42 μ mol m^{-2} s^{-2}) recorded the lowest transpiration which was on par with Swarnarekha (1.87 μ mol m^{-2} s^{-2}), Bennet Alphonso (2.08 μ mol m^{-2} s^{-2}), Neelum (2.13 μ mol m^{-2} s^{-2}) and Mulgoa (2.33 μ mol m^{-2} s^{-2}).

Muvandan (3.22 μ mol m^{-2} s^{-2}) recorded the highest transpiration followed by Prior (2.56 μ mol m^{-2} s^{-2}) among the local types. Vellaikolumban (1.41 μ mol m^{-2} s^{-2}) recorded the lowest transpiration which was on par with Tholikaippan (2.06 μ mol m^{-2} s^{-2}) and Chandrakaran (2.078 μ mol m^{-2} s^{-2}).

4.5.9 Leaf Area Index (LAI)

The data presented in Table 81 shows the variation in estimation of leaf area index (LAI) of different genotypes during the three seasons. The variation in leaf area index was not significant among the different genotypes over the three seasons.

4.5.10 Atmospheric Pollution Tolerance Index (APTI)

The data presented in Table 82 shows the variation in estimation of atmospheric pollution tolerance index (APTI) of different genotypes during the three seasons. Among the hybrids, Mallika (68.53) recorded the highest APTI which was significantly different from the rest of the hybrids except Sindhu (60.59), PKM 2 (61.41) and Neelgoa (61.45). H 151 (58.92) recorded the lowest APTI which was on par with Sindhu (60.59), PKM 2 (61.41) and Neelgoa (61.45).

Among the parents involved in breeding Bennet Alphonso (60.39) recorded the highest APTI which was significantly different from rest of the parents involved in breeding except Himayuddin (47.49) and Mulgoa (49.28). Swarnarekha (46.14) recorded the lowest APTI which was on par with Himayuddin (47.95) and Mulgoa (49.28).

Chandrakaran (63.50) recorded the highest APTI which was significantly different from the rest of the local types. Muvandan (42.07) recorded the lowest APTI.

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Table 81. Leaf area index (LAI) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	2.32	2.77	1.04	2.04
2	Amrapali	1.25	1.46	1.66	1.46
3	Mallika	0.76	0.86	2.16	1.26
4	Ratna	1.55	1.83	1.88	1.75
5	Sindhu	0.97	1.24	1.06	1.09
6	H45	1.44	1.92	1.30	1.55
7	H 151	2.11	2.50	1.06	1.89
8	PKM1	1.29	1.43	1.75	1.49
9	PKM 2	0.72	0.77	2.45	1.31
10	Neelgoa	1.39	1.59	1.00	1.33
11	Banganapalli	1.54	2.24	0.77	1.52
12	Alphonso	1.23	1.75	3.08	2.02
13	Dashehari	0.52	0.55	1.01	0.69
14	Neelum	1.93	2.75	1.47	2.05
15	Himayuddin	1.48	1.69	1.46	1.54
16	Bennet Alphonso	4.07	1.26	1.50	2.27
17	Kalepady	2.22	2.78	0.51	1.84
18	Swarnarekha	1.10	1.57	2.06	1.58
19	Mulgoa	1.62	2.65	1.43	1.90
20	Tholikaippan	1.14	1.51	1.10	1.25
21	Chandrakaran	0.83	0.94	1.31	1.03
22	Vellaikolumban	0.99	0.95	0.82	0.92
23	Prior	1.72	2.25	2.00	1.99
24	Muvandan	1.74	2.61	1.87	2.07
	Mean	1.50	1.74	1.49	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.46	0.33	0.46	
	Year x Genotype	0.80	0.57	0.80	

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Table 82. Atmospheric pollution tolerance index (APTI) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	59.52	67.10	69.32	65.31
2	Amrapali	56.13	59.32	74.63	63.36
3	Mallika	62.89	69.26	73.45	68.53
4	Ratna	63.15	61.84	77.32	67.44
5	Sindhu	53.65	56.91	71.19	60.59
6	H45	52.80	67.38	74.69	64.96
7	H 151	66.16	52.72	57.87	58.92
8	PKM1	62.54	61.63	77.77	67.31
9	PKM 2	63.84	47.73	72.67	61.41
10	Neelgoa	58.79	58.44	67.12	61.45
11	Banganapalli	49.66	60.27	71.20	60.37
12	Alphonso	59.27	38.19	68.14	55.20
13	Dashehari	50.76	48.01	78.38	59.05
14	Neelum	49.75	60.07	67.02	58.95
15	Himayuddin	36.90	44.69	62.28	47.95
16	Bennet Alphonso	57.58	51.80	71.80	60.39
17	Kalepady	59.62	44.09	72.70	58.80
18	Swarnarekha	46.76	42.25	49.43	46.14
19	Mulgoa	37.05	47.53	63.25	49.28
20	Tholikaippan	46.88	40.27	56.60	47.92
21	Chandrakaran	53.47	58.76	78.26	63.50
22	Vellaikolumban	48.34	53.59	68.66	56.86
23	Prior	58.25	58.78	49.65	55.56
24	Muvandan	58.30	34.79	33.11	42.07
	Mean	54.67	53.56	66.94	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	5.86	2.96	2.09	
	Year x Genotype	10.15	5.13	3.63	

4.6 Biochemical analysis of plants

Total phenol content (mg g^{-1}), soluble protein content (mg g^{-1}), ascorbic acid (mg $100g^{-1}$), pH of the leaf and chlorophyll content (mg g^{-1}) were recorded and presented from table 83 to table 87c.

4.6.1 Total phenol content

The data presented in Table 83 shows the variation in total phenol content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, Ratna (19.07 mg g^{-1}) recorded the highest total phenol which was significantly different from rest of the hybrids. Mallika (5.55 mg g^{-1}) recorded the lowest total phenol which was on par with Amrapali (6.40 mg g^{-1}).

Swarnarekha (10.54 mg g^{-1}) recorded the highest total phenol followed by the rest of the hybrids except Dashehari (6.93 mg g^{-1}) and Neelum (6.85 mg g^{-1}) among the parents involved in breeding. Banganapalli (6.32 recorded the lowest total phenol which was on par with Neelum (6.85) and Dashehari (6.93 mg g^{-1}).

Chandrakaran (8.75 mg g^{-1}) recorded the highest total phenol followed by the rest of the local types except Prior (6.66 mg g^{-1}). Muvandan (4.54 mg g^{-1}) recorded the lowest total phenol which was on par with Prior (6.66 mg g^{-1}).

4.6.2 Soluble protein content

The data presented in Table 84 shows the variation soluble protein content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, PKM 1 (19.24 mg g^{-1}) recorded the highest soluble protein followed by the rest of the hybrids except Ratna (13.19 mg g^{-1}), Sindhu (12.22 mg g^{-1}) and PKM 2 (11.68 mg g^{-1}). Neelgoa (9.83 mg g^{-1}) recorded the lowest soluble protein which was on par with PKM 2 (11.68 mg g^{-1}), Sindhu (12.22 mg g^{-1}) and Ratna (13.19 mg g^{-1}).

Mulgoa (18.42 mg g^{-1}) recorded the highest soluble protein followed by Neelum (18.15 mg g^{-1}) and Bennet Alphonso (3.37 mg g^{-1}) among the parents involved in breeding. Alphonso (9.54 mg g^{-1}) recorded the lowest soluble protein which was on par with Kalepady (12.27 mg g^{-1}), Banganapalli (13.03 mg g^{-1}), Dashehari (13.07 mg g^{-1}), Himayuddin (13.15 mg g^{-1}) and Swarnarekha (13.20 mg g^{-1}).

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Table 83. Total phenol content (mg g^{-1}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	4.28	9.89	9.72	7.96
2	Amrapali	3.79	7.35	8.07	6.40
3	Mallika	2.43	7.16	7.07	5.55
4	Ratna	13.28	21.91	22.01	19.07
5	Sindhu	11.13	16.14	14.00	13.76
6	H45	12.30	16.64	14.63	14.52
7	H 151	12.01	12.33	18.34	14.23
8	PKM1	5.13	11.94	13.06	10.04
9	PKM 2	7.02	11.94	16.97	11.98
10	Neelgoa	7.12	12.14	12.84	10.70
11	Banganapalli	2.72	7.64	8.61	6.32
12	Alphonso	5.16	12.33	13.89	10.46
13	Dashehari	2.52	8.23	10.03	6.93
14	Neelum	2.62	8.13	9.78	6.85
15	Himayuddin	7.51	9.50	8.59	8.53
16	Bennet Alphonso	4.87	11.55	11.10	9.17
17	Kalepady	3.89	12.14	12.57	9.53
18	Swarnarekha	6.34	13.12	12.18	10.54
19	Mulgoa	5.65	11.84	9.66	9.05
20	Tholikaippan	3.79	8.92	8.75	7.15
21	Chandrakaran	8.39	8.62	9.23	8.75
22	Vellaikolumban	4.87	9.11	6.50	6.83
23	Prior	3.21	7.64	9.13	6.66
24	Muvandan	1.35	6.18	6.09	4.54
	Mean	5.89	10.93	11.37	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.21	1.12	0.79	
	Year x Genotype	NS	1.94	1.37	

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Table 84. Soluble protein content (mg g^{-1}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	14.55	18.13	23.09	18.59
2	Amrapali	11.26	17.54	16.68	15.16
3	Mallika	7.20	17.70	24.43	16.44
4	Ratna	8.08	12.22	19.28	13.19
5	Sindhu	9.10	13.62	13.95	12.22
6	H45	12.40	15.07	18.16	15.21
7	H 151	10.88	16.64	18.87	15.46
8	PKM1	16.20	19.88	21.77	19.28
9	PKM 2	10.24	12.09	12.71	11.68
10	Neelgoa	6.81	9.31	13.35	9.83
11	Banganapalli	11.51	12.47	15.11	13.03
12	Alphonso	4.53	5.69	18.40	9.54
13	Dashehari	6.18	9.78	23.26	13.07
14	Neelum	15.94	17.98	20.52	18.15
15	Himayuddin	8.08	12.79	18.57	13.15
16	Bennet Alphonso	13.03	14.72	17.41	15.05
17	Kalepady	8.34	14.17	14.32	12.27
18	Swarnarekha	11.00	15.69	12.93	13.20
19	Mulgoa	20.12	22.90	12.24	18.42
20	Tholikaippan	10.74	14.36	22.19	15.76
21	Chandrakaran	7.45	9.54	13.78	10.26
22	Vellaikolumban	12.14	13.84	16.67	14.22
23	Prior	4.03	5.99	15.79	8.60
24	Muvandan	13.66	20.44	26.03	20.04
	Mean	10.56	14.27	17.90	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	4.37	2.21	1.56	
	Year x Genotype	NS	3.82	2.70	

Muvandan (20.04 mg g^{-1}) recorded the highest soluble protein followed by Tholikaippan (15.76 mg g^{-1}) among the local types. Prior (8.60 mg g^{-1}) recorded the lowest soluble protein which was on par with Chandrakaran (10.26 mg g^{-1}).

4.6.3 Ascorbic acid

The data presented in Table 85 shows the variation in ascorbic acid (mg $100g^{-1}$) of different genotypes during the three seasons. Among the hybrids, Ratna (97.21 mg $100g^{-1}$) recorded the highest ascorbic acid followed by Amrapali (97.05 mg $100g^{-1}$) and Mallika (89.84 mg $100g^{-1}$). PKM 2 (75.94 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with H 151 (76.35 mg $100g^{-1}$), Neelgoa (76.89 mg $100g^{-1}$), H 45 (79.97 mg $100g^{-1}$) and Sindhu (83.21 mg $100g^{-1}$).

Banganapalli (79.46 mg $100g^{-1}$) recorded the highest ascorbic acid followed by the rest of the parents except Himayuddin (64.05 mg $100g^{-1}$) among the parents involved in breeding. Swarnarekha (63.29 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with Himayuddin (64.05 mg $100g^{-1}$).

Chandrakaran (93.30 mg $100g^{-1}$) recorded the highest ascorbic acid content which was significantly different from the rest of the local types. Tholikaippan (66.88 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with Muvandan (67.00 mg $100g^{-1}$).

4.6.4 pH of the leaf

The data presented in Table 86 shows the pH of leaf of different genotypes during the three seasons. Among the hybrids, PKM 2 (6.45) recorded the highest pH followed by Neelgoa (6.39), H 45 (6.24) and PKM 1 (6.16). Amrapali (5.35) recorded the lowest pH which was on par with Ratna (5.57) and Sindhu (5.60).

Neelum (6.37) recorded the highest pH followed by Dashehari (6.26) among the parents involved in breeding. Mulgoa (5.37) recorded the lowest pH which was on par with Himayuddin (5.50) and Swarnarekha (5.64).

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Table 85. Ascorbic acid content (mg 100 g^{-1}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	84.04	88.12	91.51	87.89
2	Amrapali	86.29	88.37	110.57	95.08
3	Mallika	86.33	87.75	95.45	89.84
4	Ratna	90.52	92.57	108.56	97.21
5	Sindhu	80.56	75.37	93.71	83.21
6	H45	68.35	85.59	85.97	79.97
7	H 151	83.40	75.45	70.19	76.35
8	PKM1	81.27	77.64	101.13	86.68
9	PKM 2	80.34	59.94	87.55	75.94
10	Neelgoa	75.30	71.30	84.09	76.89
11	Banganapalli	69.37	76.86	92.14	79.46
12	Alphonso	81.76	47.60	95.47	74.94
13	Dashehari	62.66	69.19	96.25	76.03
14	Neelum	57.92	77.84	85.09	73.62
15	Himayuddin	50.52	63.58	78.05	64.05
16	Bennet Alphonso	79.94	63.59	92.70	78.74
17	Kalepady	75.34	58.56	86.48	73.46
18	Swarnarekha	64.30	62.49	63.08	63.29
19	Mulgoa	54.67	69.48	93.77	72.64
20	Tholikaippan	70.08	58.35	72.20	66.88
21	Chandrakaran	80.92	92.59	106.40	93.30
22	Vellaikolumban	64.91	75.92	83.65	74.83
23	Prior	84.75	86.23	62.19	77.72
24	Muvandan	85.53	59.58	55.89	67.00
	Mean	74.96	73.50	87.17	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	7.54	3.81	2.69	
	Year x Genotype	13.05	6.60	4.67	

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Table 86. Leaf pH of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	5.85	5.86	5.74	5.81
2	Amrapali	5.38	5.36	5.31	5.35
3	Mallika	5.77	6.37	5.69	5.94
4	Ratna	5.77	5.28	5.66	5.57
5	Sindhu	5.39	5.64	5.78	5.60
6	H45	6.12	6.17	6.43	6.24
7	H 151	6.40	5.27	6.40	6.02
8	PKM1	6.13	6.13	6.21	6.16
9	PKM 2	6.61	6.15	6.58	6.45
10	Neelgoa	6.42	6.44	6.32	6.39
11	Banganapalli	5.66	6.21	6.10	5.99
12	Alphonso	5.90	6.39	5.71	6.00
13	Dashehari	6.60	5.60	6.57	6.26
14	Neelum	6.84	6.40	5.87	6.37
15	Himayuddin	5.64	5.44	5.44	5.50
16	Bennet Alphonso	5.51	6.40	5.87	5.93
17	Kalepady	6.30	5.50	6.22	6.01
18	Swarnarekha	5.51	5.30	6.10	5.64
19	Mulgoa	5.40	5.38	5.32	5.37
20	Tholikaippan	5.44	5.44	6.18	5.68
21	Chandrakaran	5.34	5.20	6.00	5.51
22	Vellaikolumban	6.15	5.32	6.22	5.90
23	Prior	6.07	5.23	5.52	5.61
24	Muvandan	6.21	5.13	4.09	5.14
	Mean	5.93	5.73	5.89	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.29	0.15	0.11	
	Year x Genotype	0.51	0.26	0.18	

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Vellaikolumban (5.90) recorded the highest pH followed by Tholikaippan (5.68) among the local types. Muvandan (5.14) recorded the lowest pH.

4.6.5 Chlorophyll a content

The data presented in Table 87a shows the variation in chlorophyll a content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, Sindhu (1.31 mg g^{-1}) recorded the highest chlorophyll a content followed by H 45 (1.30 mg g^{-1}) and Mallika (1.10 mg g^{-1}). Amrapali (0.85 mg g^{-1}) recorded the lowest chlorophyll a content which was on par with Ratna (0.94 mg g^{-1}), Neelgoa (0.98 mg g^{-1}), PKM 1 (1.00 mg g^{-1}), Arka Aruna (1.03 mg g^{-1}), Pkm 2 (1.06 mg g^{-1}) and H 151 (1.07 mg g^{-1}).

Kalepady (1.19 mg g^{-1}) recorded the highest chlorophyll a content followed by the rest of the parents except Dashehari (0.96 mg g^{-1}) and Alphonso (0.91 mg g^{-1}) among the parents involved in breeding. Mulgoa (0.86 mg g^{-1}) recorded the lowest Chlorophyll content which was on par with Alphonso (0.91 mg g^{-1}) and Dashehari (0.96 mg g^{-1}).

Muvandan (1.25 mg g^{-1}) recorded the highest chlorophyll a content followed by Vellaikolumban (1.09 mg g^{-1}) among the local types. Chandrakaran (0.82 mg g^{-1}) recorded the lowest chlorophyll a content which was on par with Tholikaippan (0.83 mg g^{-1}) and Prior (0.99 mg g^{-1}).

4.6.6 Chlorophyll b content

The data presented in Table 87b shows the variation in chlorophyll b content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, Neelgoa (0.23 mg g^{-1}) recorded the highest chlorophyll b content followed by the rest of the hybrids except Amrapali (0.17 mg g^{-1}) and H 45 (0.17 mg g^{-1}). Mallika (0.16 mg g^{-1}) recorded the lowest chlorophyll b content which was on par with Amrapali (0.17 mg g^{-1}) and H 45 (0.17 mg g^{-1}).

Swarnarekha (0.21 mg g^{-1}) recorded the highest chlorophyll b content followed by rest of the parents involved in breeding. Banganapalli (0.13 mg g^{-1}) recorded the lowest chlorophyll b content.

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Table 87a. Chlorophyll a (mg g^{-1}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.88	1.08	1.13	1.03
2	Amrapali	0.77	0.79	0.98	0.85
3	Mallika	1.07	0.92	1.30	1.10
4	Ratna	0.91	0.90	1.01	0.94
5	Sindhu	1.03	1.47	1.42	1.31
6	H45	1.14	1.31	1.45	1.30
7	H 151	0.90	1.04	1.26	1.07
8	PKM1	0.92	1.15	0.93	1.00
9	PKM 2	0.94	1.14	1.09	1.06
10	Neelgoa	0.84	1.21	0.90	0.98
11	Banganapalli	1.08	1.18	1.02	1.10
12	Alphonso	1.02	0.82	0.90	0.91
13	Dashehari	1.05	0.76	1.06	0.96
14	Neelum	1.09	0.80	1.37	1.09
15	Himayuddin	0.98	0.93	1.58	1.17
16	Bennet Alphonso	1.27	1.04	1.25	1.19
17	Kalepady	1.01	1.17	1.39	1.19
18	Swarnarekha	1.08	0.79	1.12	1.00
19	Mulgoa	0.90	0.81	0.88	0.86
20	Tholikaippan	0.81	0.90	0.79	0.83
21	Chandrakaran	0.88	0.69	0.88	0.82
22	Vellaikolumban	0.81	1.22	1.25	1.09
23	Prior	0.68	0.98	1.31	0.99
24	Muvandan	1.13	1.42	1.18	1.25
	Mean	0.97	1.02	1.15	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.23	0.12	0.08	
	Year x Genotype	NS	0.20	0.14	

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Table 87b. Chlorophyll b (mg g^{-1}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.03	0.32	0.28	0.21
2	Amrapali	0.06	0.21	0.23	0.17
3	Mallika	0.09	0.18	0.21	0.16
4	Ratna	0.10	0.23	0.33	0.22
5	Sindhu	0.07	0.24	0.27	0.19
6	H45	0.07	0.14	0.31	0.17
7	H 151	0.11	0.26	0.25	0.21
8	PKM1	0.06	0.22	0.27	0.18
9	PKM 2	0.07	0.20	0.27	0.18
10	Neelgoa	0.08	0.19	0.42	0.23
11	Banganapalli	0.04	0.12	0.23	0.13
12	Alphonso	0.08	0.20	0.33	0.21
13	Dashehari	0.10	0.20	0.25	0.18
14	Neelum	0.10	0.15	0.29	0.18
15	Himayuddin	0.07	0.17	0.35	0.20
16	Bennet Alphonso	0.09	0.20	0.34	0.21
17	Kalepady	0.12	0.21	0.24	0.19
18	Swarnarekha	0.12	0.23	0.28	0.21
19	Mulgoa	0.05	0.27	0.28	0.20
20	Tholikaippan	0.08	0.13	0.56	0.26
21	Chandrakaran	0.08	0.20	0.25	0.18
22	Vellaikolumban	0.06	0.19	0.34	0.20
23	Prior	0.04	0.17	0.30	0.17
24	Muvandan	0.09	0.24	0.24	0.19
	Mean	0.08	0.20	0.30	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.05	0.02	0.02	
	Year x Genotype	0.08	0.04	0.03	

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Table 87c. Total Chlorophyll content (mg g^{-1}) of different mango genotypes

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Arka Aruna	0.90	1.40	1.42	1.24
2	Amrapali	0.84	1.00	1.21	1.02
3	Mallika	1.16	1.10	1.51	1.26
4	Ratna	1.00	1.13	1.33	1.16
5	Sindhu	1.01	1.72	1.68	1.47
6	H45	1.21	1.45	1.76	1.48
7	H 151	1.02	1.29	1.51	1.28
8	PKM1	0.98	1.37	1.20	1.18
9	PKM 2	1.01	1.34	1.37	1.24
10	Neelgoa	0.92	1.39	1.32	1.21
11	Banganapalli	1.12	1.30	1.25	1.23
12	Alphonso	1.10	1.03	1.23	1.12
13	Dashehari	1.15	0.96	1.31	1.14
14	Neelum	1.19	0.96	1.65	1.27
15	Himayuddin	1.06	1.10	1.93	1.36
16	Bennet Alphonso	1.36	1.24	1.59	1.40
17	Kalepady	1.13	1.38	1.64	1.38
18	Swarnarekha	1.19	1.03	1.40	1.21
19	Mulgoa	0.94	1.08	1.16	1.06
20	Tholikaippan	0.89	1.03	1.35	1.09
21	Chandrakaran	0.96	0.89	1.13	0.99
22	Vellaikolumban	0.86	1.41	1.58	1.29
23	Prior	0.72	1.14	1.62	1.16
24	Muvandan	1.23	1.66	1.42	1.44
	Mean	1.04	1.23	1.44	
	Factors	**C.D.**	**SE(d)**	**SE(m)**	
	Genotype	0.24	0.12	0.09	
	Year x Genotype	NS	0.21	0.15	

Tholikaippan (0.26 mg g^{-1}) recorded the highest chlorophyll b content among the local types Prior (0.17 mg g^{-1}) recorded the lowest chlorophyll b content which was on par with Chandrakaran (0.18 mg g^{-1}) and Muvandan (0.19 mg g^{-1}).

4.6.7 Total chlorophyll content

The data presented in Table 87c shows the variation in total chlorophyll content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, H 45 (1.48 mg g^{-1}) recorded the highest total chlorophyll followed by the rest of the hybrids except Ratna (1.16 mg g^{-1}), PKM 1 (1.18 mg g^{-1}) and Neelgoa (1.21 mg g^{-1}). Amrapali (1.02 mg g^{-1}) recorded the lowest chlorophyll content which was on par with Ratna (1.16 mg g^{-1}), PKM 1 (1.18 mg g^{-1}) and Neelgoa (1.21 mg g^{-1}).

Bennet Alphonso (1.40 mg g^{-1}) recorded the highest total chlorophyll followed by the rest of the parents except Dashehari (1.14 mg g^{-1}) and Alphonso (1.12 mg g^{-1}). Mulgoa (1.06 mg g^{-1}) recorded the lowest total chlorophyll.

Muvandan (1.44 mg g^{-1}) recorded the highest total chlorophyll followed by Vellaikolumban (1.29 mg g^{-1}) among the local types. Chandrakaran (0.99 mg g^{-1}) recorded the lowest total chlorophyll which was on par with Tholikaippan (1.09 mg g^{-1}) and Prior (1.16 mg g^{-1}).

Experiment II. Evaluation of selected mango genotypes in HDP

The studies were conducted utilizing 6 diverse mango genotypes planted in HDP in mango orchard of College of Horticulture, Vellanikara, Thrissur, Kerala. All the genotypes were of 5 years old and in bearing stage.

Details of experimental layout

Design of experiment – CRD

Number of treatments – 6

Number of replications – 5

Total number of trees - 6 x 5 = 30

Years of observation - 2016, 2017, 2018

Plate 7. General view of mango genotypes under HDP system

List of mango genotypes selected for the study

Sl. No.	Genotype
1	Prior
2	Mallika
3	Vellaikolumban
4	Ratna
5	Chandrakaran
6	Muvandan

4.7 Morphological characters

Various observations on morphological characters *viz.*, tree characters, leaf characters, inflorescence characters, fruit characters and seed characters were recorded, analysed and the results are presented in Tables 88 to table 107.

4.7.1 Tree characters

4.7.1.1 Age of tree

The trees of same age group (6 years) were selected for the study (Table 88).

4.7.1.2 Height of the tree

The data presented in Table 89 shows the variation in plant height of different genotypes. All the trees were pruned and maintained in a height of 3 m.

4.7.1.3 Trunk circumference

The observation on trunk circumference of mango trees during three seasons were presented in Table 90. Chandrakaran (31.29 cm) recorded the highest circumference which was significantly different from the rest of the varieties / local types. Prior (20.51 cm) recorded the lowest trunk circumference.

Table 88. Age (years) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year		
		2015-16	2016-17	2017-18
1	Prior	5	6	7
2	Mallika	5	6	7
3	Vellaikolumban	5	6	7
4	Ratna	5	6	7
5	Chandrakaran	5	6	7
6	Muvandan	5	6	7

Table 89. Plant height (m) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year		
		2015-16	2016-17	2017-18
1	Prior	3	3	3
2	Mallika	3	3	3
3	Vellaikolumban	3	3	3
4	Ratna	3	3	3
5	Chandrakaran	3	3	3
6	Muvandan	3	3	3

Table 90. Trunk circumference (cm) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Prior	22.12	19.54	19.88	20.51
2	Mallika	26.54	26.74	25.02	26.10
3	Vellaikolumban	23.50	23.34	23.54	23.46
4	Ratna	25.56	24.88	25.66	25.37
5	Chandrakaran	29.64	31.26	32.96	31.29
6	Muvandan	23.40	23.52	25.74	24.22
		25.13	24.88	25.47	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	2.19	1.10	0.78	
	Year x Genotype	NS	1.90	1.35	

4.7.1.4 Crown diameter

The crown diameter (North –South) of mango was measured and presented in Table 91a and Table 91b. Vellaikolumban (3.09 m) recorded the highest crown diameter (North -South) followed by Chandrakaran (3.00 m). Ratna (2.39m) recorded the lowest crown diameter (North -South) which was on par with Prior (2.60 m). The crown diameter (East-West) of mango was measured and presented in Table 95b which was not significant among the genotypes and season.

4.7.1.5 Crown shape

Different crown shapes like oblong, semi-circular, and spherical were noticed among the hybrids/local types (Table 92). Cluster I and II included trees with oblong crown shape, cluster III included trees with semi circular and spherical crown shape and cluster IV included trees with spherical crown shape (Table 93 and Table 94).

4.7.1.6 Tree growth habit

Different tree growth habit like erect and spreading were noticed among the hybrids/local types (Table 92). Cluster I and IV included trees with erect tree growth habit. Cluster II and III included trees with spreading tree growth habit (Table 93 and Table 94).

4.7.1.7 Foliage density

Dense and intermediate foliage density were noticed among the hybrid/local types (Table 92). Cluster I and III included trees with dense foliage density whereas cluster II and IV included trees with intermediate foliage density (Table 93 and Table 94).

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Table 91 a. Crown diameter North – South (m) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Prior	2.44	2.60	2.76	2.60
2	Mallika	2.88	2.66	2.62	2.72
3	Vellaikolumban	3.02	3.22	3.04	3.09
4	Ratna	2.71	2.56	1.90	2.39
5	Chandrakaran	3.07	2.90	3.04	3.00
6	Muvandan	2.71	2.94	2.68	2.78
		2.81	2.81	2.67	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.31	0.16	0.11	
	Year x Genotype	NS	0.27	0.19	

Table 91 b. Crown diameter East - West (m) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Prior	2.71	3.00	2.86	2.86
2	Mallika	3.05	2.93	2.66	2.88
3	Vellaikolumban	2.84	2.66	2.80	2.77
4	Ratna	2.80	3.40	3.30	3.17
5	Chandrakaran	3.00	3.24	2.84	3.03
6	Muvandan	2.74	3.04	2.86	2.88
		2.86	3.05	2.89	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	NS	0.15	0.11	
	Year x Genotype	NS	0.27	0.19	

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Table 92. Crown shape, tree growth habit and foliage density of different mango genotypes under HDP system

Sl. No.	Genotypes	Crown shape	Tree growth habit	Foliage density
1	Prior	Oblong	Erect	Dense
2	Mallika	Oblong	Spreading	Intermediate
3	Vellaikolumban	Semi circular	Spreading	Dense
4	Ratna	Spherical	Erect	Intermediate
5	Chandrakaran	Spherical	Spreading	Dense
6	Muvandan	Oblong	Erect	Dense

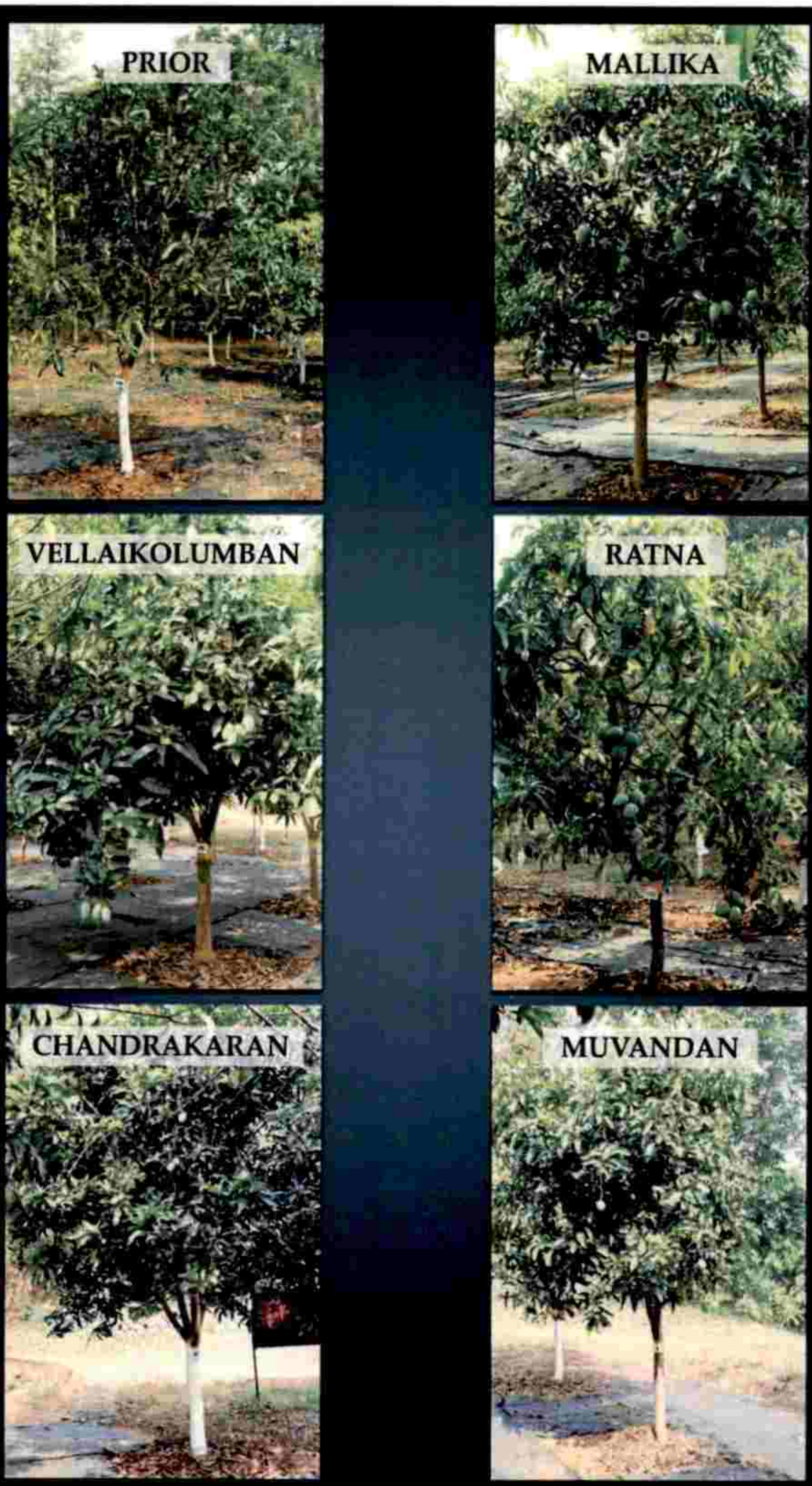
Table 93. Cluster wise listing of hybrids/local types according to tree characters under HDP system

Clusters			
I	**II**	**III**	**IV**
Prior	Mallika	Vellaikolumban	Ratna
Muvandan		Chandrakaran	

Table 94. Cluster wise summary statistics of hybrids/local types according to tree characters under HDP system

Characters	Clusters			
	I	**II**	**III**	**IV**
Crown shape	Oblong	Oblong	Semicircular, Spherical	Spherical
Tree growth habit	Erect	Spreading	Spreading	Erect
Foliage density	Dense	Intermediate	Dense	Intermediate

Plate 52. Mango genotypes Prior, Mallika, Vellaikolumban, Ratna, Chandrakaran and Muvandan selected under HDP system



4.7.2 Leaf characters

4.7.2.1 Leaf blade length

The data presented in Table 95 shows the variation in leaf lade length of different genotypes during three seasons. Ratna (25.40 cm) recorded the highest leaf blade length which was significantly different from the rest of the hybrid/local types. Muvandan (19.17 cm) recorded the lowest leaf blade length which was on par with Prior (19.95 cm) and Chandrakaran (20.22 cm).

4.7.2.2 Leaf blade width

The data presented in Table 96 shows the variation in leaf lade width of different genotypes during three seasons. Vellaikolumban (7.68 cm) recorded the highest leaf blade width which was significantly different form the rest of the hybrid/local types. Muvandan (4.84 cm) recorded the lowest leaf blade width which was on par with Prior (4.96 cm), Mallika (5.05 cm) and Chandrakaran (5.34 cm).

4.7.2.3 Petiole length

The data presented in Table 97 shows the variation in petiole length of different genotypes during three seasons. Ratna (4.18 cm) recorded the highest petiole length followed by Mallika (3.94 cm). Chandrakaran (2.29 cm) recorded the lowest petiole length.

4.7.2.4 Leaf blade shape

Elliptic, obovate, lanceolate and oblong leaf blade shape were noticed among the hybrids/local types (Table 98). Cluster I had trees with oblong and obovate leaf blade shape, cluster II included trees with lanceolate leaf blade shape. Cluster III included trees with elliptic and lanceolate leaf blade shape. Cluster IV included trees with oblong leaf blade shape (Table 99 and Table 100).

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Table 95. Leaf blade length (cm) of different mango genotypes under HDP

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Prior	20.22	18.98	20.66	19.95
2	Mallika	21.24	21.12	24.88	22.41
3	Vellaikolumban	27.42	19.62	20.90	22.65
4	Ratna	24.80	27.74	23.64	25.40
5	Chandrakaran	20.58	19.36	20.72	20.22
6	Muvandan	19.44	19.72	18.34	19.17
	Mean	22.28	21.09	21.52	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	1.90	0.95	0.67	
	Year x Genotype	3.28	1.64	1.16	

Table 96. Leaf blade width (cm) of different mango genotypes under HDP

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Prior	4.22	5.56	5.10	4.96
2	Mallika	4.39	5.16	5.58	5.05
3	Vellaikolumban	8.66	6.72	7.66	7.68
4	Ratna	5.53	6.68	6.54	6.25
5	Chandrakaran	5.23	5.12	5.66	5.34
6	Muvandan	4.40	5.14	4.98	4.84
	Mean	5.40	5.73	5.92	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.57	0.29	0.20	
	Year x Genotype	1.00	0.50	0.35	

Table 97. Leaf petiole length (cm) of different mango genotypes under HDP

Sl. No.	Genotypes	Year			Mean
		2015-16	2016-17	2017-18	
1	Prior	2.96	2.88	2.50	2.78
2	Mallika	4.00	4.22	3.60	3.94
3	Vellaikolumban	4.28	3.98	2.52	3.59
4	Ratna	4.73	4.18	3.62	4.18
5	Chandrakaran	2.56	2.22	2.08	2.29
6	Muvandan	3.38	3.30	2.12	2.93
		3.65	3.46	2.74	
	Factors	**CD**	**SE(d)**	**SE(m)**	
	Genotype	0.38	0.19	0.14	
	Year x Genotype	NS	0.33	0.23	

4.7.2.5 Leaf apex shape

Obtuse, acuminate and acute leaf apex shape were noticed among the hybrids/local types (Table 98). Cluster I had trees with obtuse and acuminate leaf apex shape, cluster II and IV included trees with acuminate leaf apex shape. Cluster III included trees with acute and acuminate leaf apex shape (Table 99 and Table 100).

4.7.2.6 Leaf base shape

Round, acute and obtuse leaf base shape were noticed among the hybrids/local types (Table 98). Cluster I and II included trees with acute leaf base shape. Cluster III included trees with round leaf base shape and cluster IV included trees with obtuse leaf base shape (Table 99 and Table 100).

4.7.2.7 Leaf margin

Wavy and entire leaf margin were noticed among the hybrids/local types (Table 98). Cluster I included trees with wavy and entire leaf margin. Cluster II had trees with wavy leaf margin. Cluster III and IV included trees with entire leaf margin (Table 99 and Table 100).

4.7.2.8 Leaf pubescence

Leaf pubescence was absent among all the hybrids/local types (Table 98).

4.7.2.9 Colour of young leaf

Reddish brown and light green colour of young leaf were noticed among the hybrids/local types (Table 98). Cluster I, II and III included trees with light green colour for young leaf. Cluster IV included trees with reddish brown colour for young leaf (Table 99 and Table 100).

Table 98. Leaf blade shape, leaf apex shape, leaf base shape, leaf margin, leaf pubescence, colour of young leaf, colour of fully developed leaf and leaf fragrance of different mango genotypes under HDP system

Sl. No.	Genotypes	Leaf blade shape	Leaf apex shape	Leaf base shape	Leaf margin	Leaf pubescence	Colour of young leaf	Colour of fully developed leaf	Leaf fragrance
1	Prior	Oblong	Obtuse	Acute	Wavy	Absent	Light green	Dark green	Mild
2	Mallika	Lanceolate	Acuminate	Acute	Wavy	Absent	Light green	Green	Strong
3	Vellaikolumban	Elliptic	Acuminate	Round	Entire	Absent	Light green	Green	Mild
4	Ratna	Oblong	Acuminate	Obtuse	Entire	Absent	Reddish brown	Green	Mild
5	Chandrakaran	Obovate	Acuminate	Acute	Entire	Absent	Light green	Dark green	Mild
6	Muvandan	Lanceolate	Acute	Round	Entire	Absent	Light green	Green	Mild

Table 99. Cluster wise listing of hybrids according to leaf characters under HDP system

Cluster			
I	II	III	IV
Prior	Mallika	Vellaikolumban	Ratna
Chandrakaran		Muvandan	

Table 100. Cluster wise summary statistics of hybrids according to leaf charactersunder HDP system

Characters	Clusters			
	I	II	III	IV
Leaf blade shape	Oblong, Obovate	Lanceolate	Elliptic, Lanceolate	Oblong
Leaf apex shape	Obtuse, Acuminate	Acuminate	Acuminate, Acute	Acuminate
Leaf base shape	Acute	Acute	Round	Obtuse
Leaf margin	Wavy, Entire	Wavy	Entire	Entire
Leaf pubescence	Absent	Absent	Absent	Absent
Colour of young leaf	Light green	Light green	Light green	Reddish brown
Colour of fully developed leaf	Dark green	Green	Green	Green
Leaf fragrance	Mild	Strong	Mild	Mild

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4.7.2.10 Colour of fully developed leaf

Dark green and green colour of fully developed were noticed among the hybrids/local types (Table 98). Cluster I included trees with dark green colour fully developed leaf and Cluster II, III and IV had trees with green colour for fully developed leaf (Table 99 and Table 100).

4.7.2.8 Leaf fragrance

Mild and strong leaf fragrance were noticed among the hybrids/local types (Table 98). Cluster I, III and IV included trees mild leaf fragrance. Cluster II included trees with strong leaf fragrance (Table 99 and Table 100).

4.7.3 Inflorescence characters

4.7.3.1 Flowering duration

Different flowering durations like January – February and December – January were noticed among the hybrids/local types (Table 101). Cluster I included trees that flowered from December-January and January-February. Cluster II included trees that flowered from January – February. Cluster III included trees that flowered from December-January (Table 102 and Table 103).

4.7.3.2 Secondary/off season flowering

Secondary/off season flowering were absent among all the hybrids/local types (Table 101).

4.7.3.3 Inflorescence position

All the hybrids/local types had trees with terminal inflorescence position (Table 101).

4.7.3.4 Inflorescence shape

Pyramidal and conical inflorescence shape were noticed among the hybrids/local types (Table 101). Cluster I and II included trees with conical inflorescence shape. Cluster III included trees with pyramidal inflorescence shape (Table 102 and Table 103).

4.7.3.5 Density of flowers in the inflorescence

Sparse, medium and dense flowers were observed among the inflorescence of different hybrids/local types (Table 101). Cluster I included trees with sparse and dense flowers in the inflorescence. Cluster II included trees with dense flowers in the inflorescence. Cluster III included trees with medium flowers in the inflorescence (Table 102 and Table 103).

4.7.3.6 Inflorescence colour

Yellowish green, green with red patches, light green and light greenish with red patches were the inflorescence colour observed among the different hybrids/local types (Table 101). Cluster I included trees with light greenish with red patches and light green inflorescence colour. Cluster II included trees with green with red patches inflorescence colour. And cluster III included trees with yellowish green inflorescence colour (Table 102 and Table 103).

4.7.3.7 Length of stamen in relation to pistil

Shorter and equal length of stamen in relation to pistil were found among the hybrids/local types (Table 101). Cluster I included trees with shorter stamen in relation to pistil. Cluster II and III included trees with equal length of stamen in relation to pistil (Table 102 and Table 103).

4.7.3.8 Nature of disc

Narrow, reduced or absent and swollen, broader than ovary were the nature of disc found among the hybrids/local types (Table 101). Cluster I included trees with narrow, reduced or no disc whereas cluster II and III included trees with disc which was swollen and broader than ovary (Table 102 and Table 103).

Table 101. Flowering duration, secondary/off season flowering, inflorescence position, inflorescence shape, density of flowers in the inflorescence, inflorescence colour, length of stamen in relation to pistil and nature of disc of different mango genotypes under HDP system

Sl. No	Genotypes	Flowering duration	Secondary/off season flowering	Inflorescence position	Inflorescence shape	Density of flowers in the inflorescence	Inflorescence colour	Length of stamen in relation to pistil	Nature of disc
1	Prior	Dec - Jan	Absent	Terminal	Conical	Sparse	Light green	Shorter	Narrow, reduced or absent
2	Mallika	Dec - Jan	Absent	Terminal	Pyramidal	Medium	Yellowish green	Equal	Swollen, broader than ovary
3	Vellaikolumban	Jan - Feb	Absent	Terminal	Conical	Sparse	Light greenish with red patches	Shorter	Narrow, reduced or absent
4	Ratna	Jan - Feb	Absent	Terminal	Conical	Dense	Green with red patches	Equal	Swollen, broader than ovary
5	Chandrakaran	Dec - Jan	Absent	Terminal	Conical	Dense	Light greenish with red patches	Shorter	Narrow, reduced or absent
6	Muvandan	Jan - Feb	Absent	Terminal	Conical	Dense	Light greenish with red patches	Shorter	Narrow, reduced or absent

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Table 102. Cluster wise listing of hybrids according to inflorescence characters under HDP system

Clusters		
I	II	III
Prior	Ratna	Mallika
Vellaikolumban		
Muvandan		
Chandrakaran		

Table 103. Cluster wise summary statistics of hybrids according to inflorescence characters under HDP system

Characters	Clusters		
	I	II	III
Flowering duration	Dec – Jan, Jan - Feb	Jan - Feb	Dec - Jan
Secondary/off season flowering	Absent	Absent	Absent
Inflorescence position	Terminal	Terminal	Terminal
Inflorescence shape	Conical	Conical	Pyramidal
Density of flowers in the inflorescence	Sparse, Dense	Dense	Medium
Inflorescence colour	Light greenish with red patches, Light green	Green with red patches	Yellowish green
Length of stamen in relation to pistil	Shorter	Equal	Equal
Nature of disc	Narrow, reduced or absent	Swollen, broader than ovary	Swollen, broader than ovary

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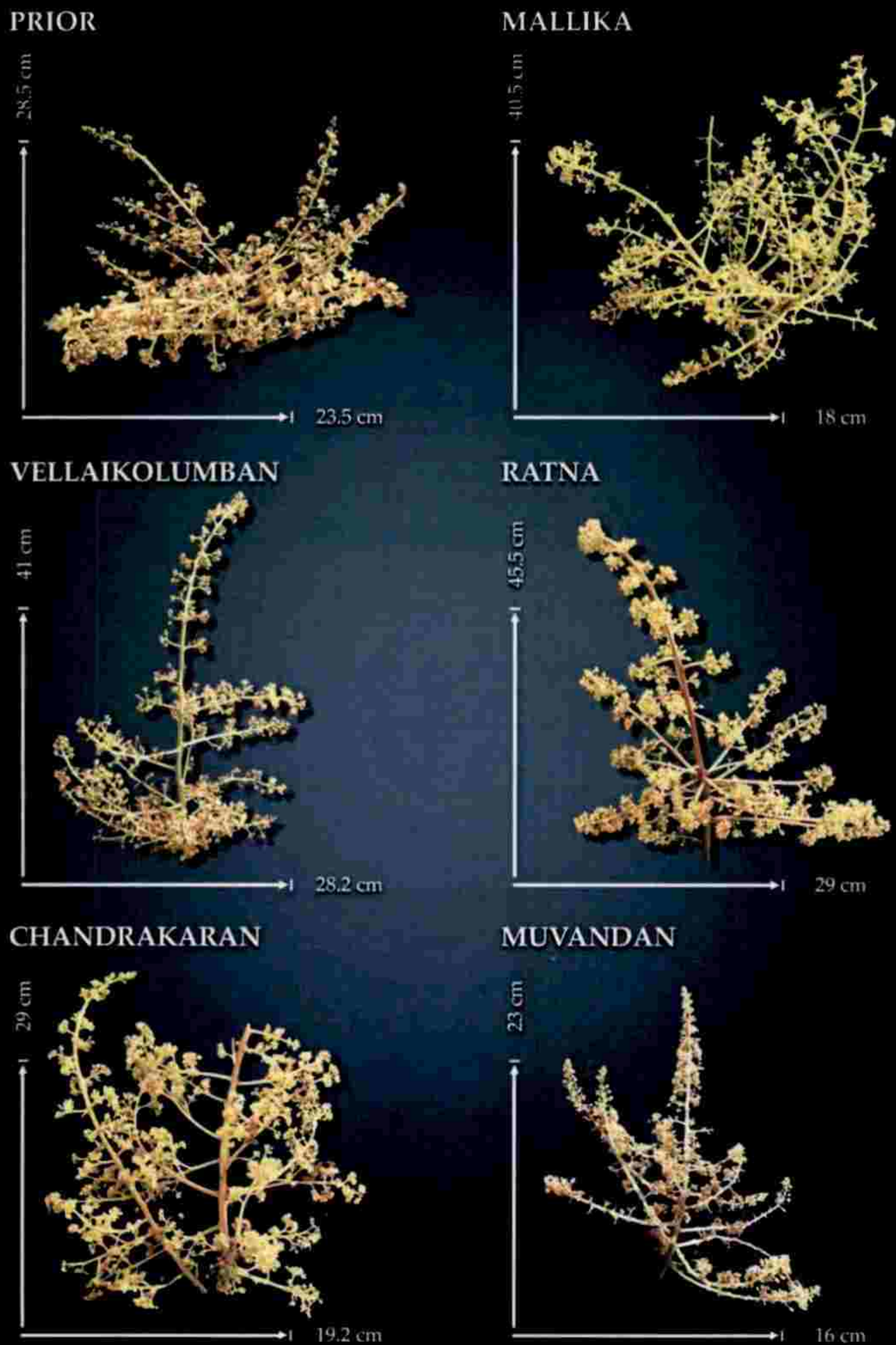
Plate 53. Variations in inflorescence characters of mango genotypes Prior, Mallika, Vellaikolumban, Ratna, Chandrakaran and Muvandan under HDP system 296



4.7.3.9 Inflorescence length

The data presented in Table 104 shows the variation in inflorescence length of different genotypes during the two seasons. Vellaikolumban (36.47 cm) recorded the highest inflorescence length which was significantly different from the rest of the hybrid/local types. Prior (22.14 cm) recorded the lowest inflorescence length which was on par with Chandrakaran (24.49 cm).

4.7.3.10 Inflorescence width

The data presented in Table 105 shows the variation in inflorescence width of different genotypes during the two seasons. Vellaikolumban (23.54 cm) recorded the highest inflorescence width which was significantly different from the rest of the hybrid/local types. Chandrakaran (12.53 cm) recorded the lowest inflorescence width.

4.7.3.11 Hermaphrodite flowers in the inflorescence

The data presented in Table 106 shows the variation in inflorescence length of different genotypes during the two seasons. Chandrakaran (85.80 cm) recorded the highest hermaphrodite flowers in the inflorescence followed by Mallika (79.70 cm) and Vellaikolumban (76.20 cm). Muvandan (36.40 cm) recorded the lowest hermaphrodite flowers in the inflorescence which was on par with Prior (54.70 cm).

4.7.3.12 Number of stamens per flower

The data presented in Table 107 shows the variation in number of stamens per flower of different genotypes during the two seasons. All the local types and the variety Mallika had 5 number of stamens per flower whereas Ratna had 5 number of stamens per flower. There was no seasonal effect on the number of stamens per flower.

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Table 104. Inflorescence length (cm) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year		
		2015-16	2016-17	Mean
1	Prior	23.40	20.88	22.14
2	Mallika	27.34	29.84	28.59
3	Vellaikolumban	33.34	39.60	36.47
4	Ratna	26.10	24.74	25.42
5	Chandrakaran	24.56	24.42	24.49
6	Muvandan	24.90	25.64	25.27
	Mean	26.61	27.52	
	Factors	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.42	1.20	0.85
	Year x Genotype	3.42	1.70	1.20

Table 105. Inflorescence width (cm) of different mango genotypes under HDP system

Sl. No.	Genotypes	Year		
		2015-16	2016-17	Mean
1	Prior	20.04	16.96	18.50
2	Mallika	15.26	18.38	16.82
3	Vellaikolumban	27.38	19.70	23.54
4	Ratna	17.58	17.50	17.54
5	Chandrakaran	11.88	13.18	12.53
6	Muvandan	14.36	14.78	14.57
	Mean	17.75	16.75	
	Factors	**C.D.**	**SE(d)**	**SE(m)**
	Genotype	1.47	0.73	0.52
	Year x Genotype	2.08	1.03	0.73

Table 106. Evaluation of mango genotypes for hermaphrodite flowers in the inflorescence (%) under HDP system

Sl. No.	Genotypes	Year		
		2015-16	2016-17	Mean
1	Prior	50.00	59.40	54.70
2	Mallika	85.20	74.20	79.70
3	Vellaikolumban	73.20	79.20	76.20
4	Ratna	56.80	71.40	64.10
5	Chandrakaran	88.40	83.20	85.80
6	Muvandan	29.60	37.20	33.40
	Mean	63.87	67.43	
	Factors	**CD**	SE(d)	SE(m)
	Genotype	13.71	6.80	4.81
	Year x Genotype	NS	9.61	6.80

Table 107. Evaluation of mango genotypes for number of stamens under HDP system

Sl. No.	Genotypes	Year		
		2015-16	2016-17	Mean
1	Prior	1	1	1
2	Mallika	3	3	3
3	Vellaikolumban	2	2	2
4	Ratna	3	3	3
5	Chandrakaran	3	3	3
6	Muvandan	2	2	2

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4.7.4 Fruit characters

4.7.4.1 Fruiting duration

All the hybrids/local types had fruiting during April-May (Table 108).

4.7.4.2 Fruit bearing intensity

Medium and high fruit bearing intensity was observed among the different hybrids/local types (Table 108). Cluster I and III included trees with medium fruit bearing intensity. Cluster II included trees with medium and high fruit bearing intensity (Table 109 and Table 110).

4.7.4.3 Fruit shape

Obovoid and roundish fruit shapes were observed among the different hybrids/local types (Table 108). Custer I and II included trees with roundish fruit shape whereas Cluster II and III included trees with obovoid fruit shape (Table 109 and Table 110).

4.7.4.4 Shape of fruit apex

Round, acute and obtuse fruit apex shapes were observed among the different hybrids/local types (Table 108). Cluster I included trees with acute fruit apex. Cluster II included trees with acute and round fruit apex. Cluster III included trees with obtuse fruit apex (Table 109 and Table 110).

4.7.4.5 Fruit attractiveness

Excellent, good and average fruit attractiveness were observed among the different hybrids/local types (Table 108). Cluster I included trees with excellent fruit attractiveness. Cluster II included trees with average fruit attractiveness and cluster III included trees with good fruit attractiveness (Table 109 and Table 110).

4.7.4.6 Skin colour of unripe fruit

All the hybrids/local types had trees with green skin colour for unripe fruits (Table 108).

4.7.4.7 Skin colour of ripe fruit

Yellow, and greenish yellow skin colours were observed for ripe fruits among the different hybrids/local types (Table 108). Cluster I and II included trees with yellow skin colour for ripe fruits. Cluster II and III included trees with greenish yellow skin colour for ripe fruit (Table 109 and Table 110).

4.7.4.8 Depth of fruit stalk cavity

Shallow and no depth for fruit stalk cavity were observed among the different hybrids/local types (Table 108). Cluster I and II had trees with no depth for fruit stalk cavity. Cluster II included trees with shallow and no depth for fruit stalk cavity (Table 109 and Table 110).

4.7.4.9 Fruit neck prominence

Slightly prominent and no fruit neck were observed among the different hybrids/local types (Table 108). Cluster I included trees with no fruit neck prominent. Cluster II included trees with slightly prominent and no fruit neck prominence and cluster III included trees with slightly prominent fruit stalk cavity (Table 109 and Table 110).

4.7.4.10 Fruit beak type

Prominent, perceptible and pointed fruit beaks were observed among the different hybrids/local types (Table 108). Cluster I included trees with perceptible fruit beak type. Cluster II include trees with pointed fruit beak type and cluster III included trees with prominent fruit beak type (Table 109 and Table 110).

4.7.4.11 Pulp colour of ripe fruit

Light yellow pulp colour of ripe fruits were observed among all the hybrids/local types (Table 108).

Table 108. Fruiting duration, fruit bearing intensity, fruit shape, shape of fruit apex, fruit attractiveness, skin colour of unripe fruit, skin colour of ripe fruit, depth of fruit stalk cavity, fruit neck prominence, fruit beak type, pulp colour of ripe fruit and aroma of ripe fruit of different mango genotypes under HDP system

Sl. No.	Genotypes	Fruiting duration	Fruit bearing intensity	Fruit shape	Shape of fruit apex	Fruit attractiveness	Skin colour of unripe fruit	Skin colour of ripe fruit	Depth of fruit stalk cavity	Fruit neck prominence	Fruit beak type	Pulp colour of ripe fruit	Aroma of ripe fruit
1	Prior	April - May	Medium	Roundish	Acute	Excellent	Green	Yellow	Absent	Absent	Perceptible	Light yellow	Mild
2	Mallika	April - May	Medium	Obovoid	Obtuse	Good	Green	Greenish yellow	Absent	Slightly prominent	Prominent	Light yellow	Intermediate
3	Vellaikolumban	April - May	Medium	Obovoid	Acute	Average	Green	Greenish yellow	Absent	Present	Pointed	Light yellow	Intermediate
4	Ratna	April - May	Medium	Obovoid	Round	Average	Green	Yellow	Absent	Absent	Pointed	Light yellow	Intermediate
5	Chandrakaran	April - May	High	Roundish	Acute	Average	Green	Greenish yellow	Shallow	Absent	Pointed	Light yellow	Strong
6	Muvandan	April - May	Medium	Obovoid	Acute	Average	Green	Greenish yellow	Absent	Slightly prominent	Perceptible	Light yellow	Strong

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Table 109. Cluster wise listing of hybrids according to fruit characters under HDP system

Clusters		
I	II	III
Prior	Vellaikolumban	Mallika
	Ratna	
	Muvandan	
	Chandrakaran	

Table 110 . Cluster wise summary statistics of hybrids according to fruit characters under HDP system

Characters	Clusters		
	I	II	III
Fruiting duration	April - May	April - May	April - May
Fruit bearing intensity	Medium	Medium, High	Medium
Fruit shape	Roundish	Obovoid, Roundish	Obovoid
Shape of fruit apex	Acute	Acute, Round	Obtuse
Fruit attractiveness	Excellent	Average	Good
Skin colour of unripe fruit	Green	Green	Green
Skin colour of ripe fruit	Yellow	Greenish yellow, Yellow	Greenish yellow
Depth of fruit stalk cavity	Absent	Absent, Shallow	Absent
Fruit neck prominence	Absent	Present, Absent, Slightly prominent	Slightly prominent
Fruit beak type	Perceptibl e	Pointed	Prominent
Pulp colour of ripe fruit	Light yellow	Light yellow	Light yellow
Aroma of ripe fruit	Mild	Intermediate, Strong	Intermediate

Plate 54. Variations in fruit characters of mango genotype Prior selected under HDP system

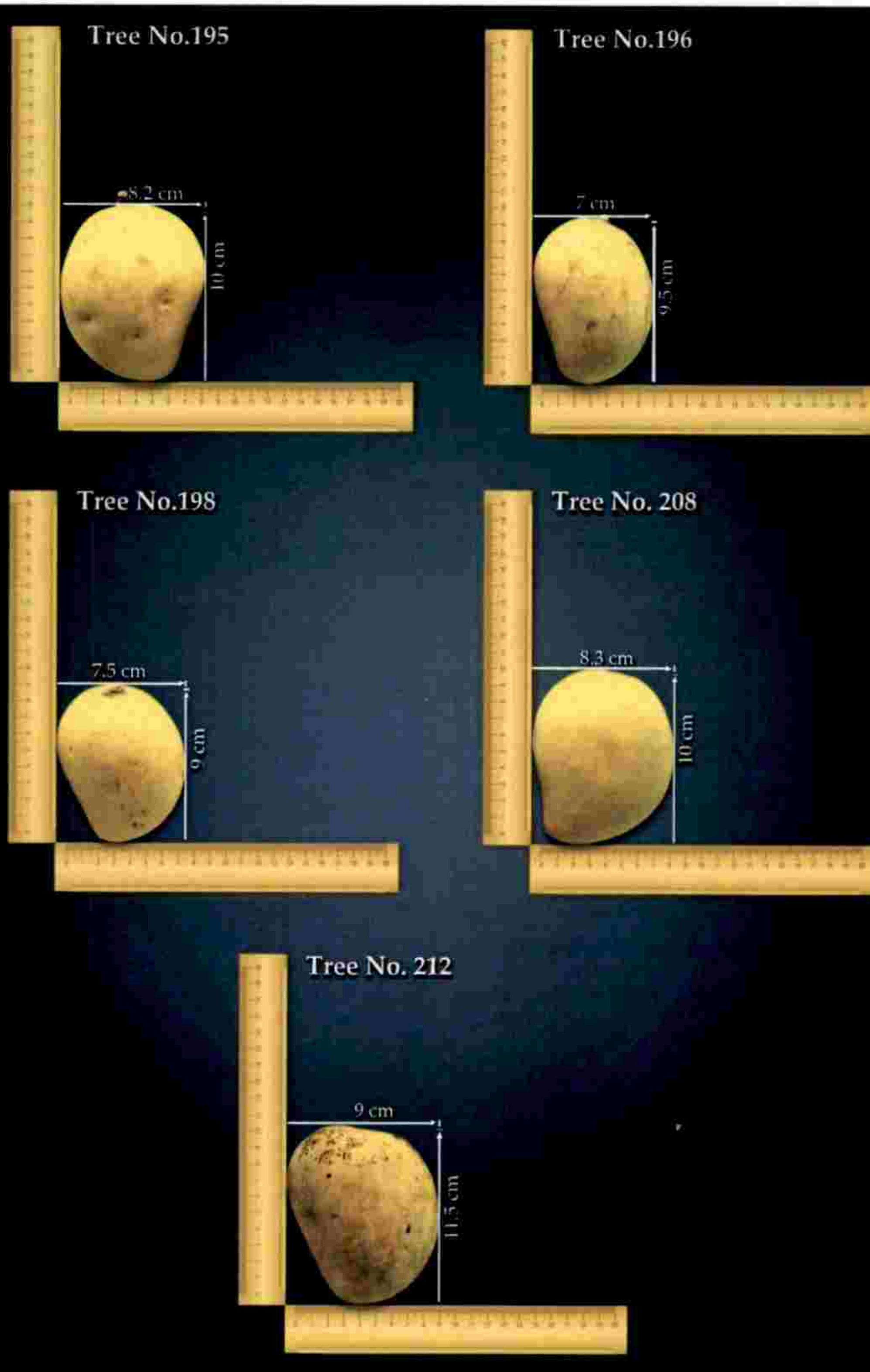


Plate 55. Variations in fruit characters of mango genotype Mallika selected under HDP system

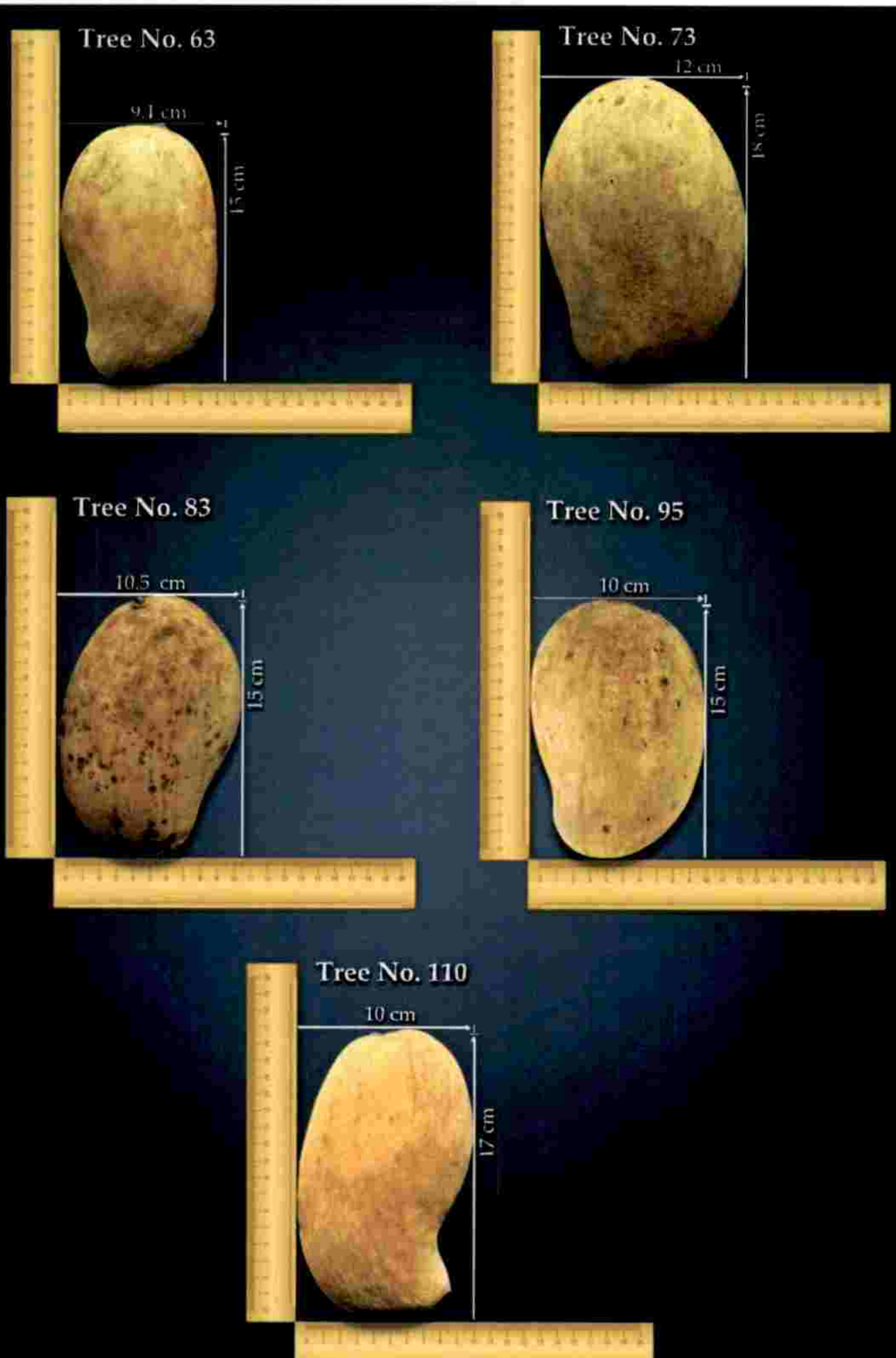


Plate 56. Variations in fruit characters of mango genotype Vellaikolumban selected under HDP system

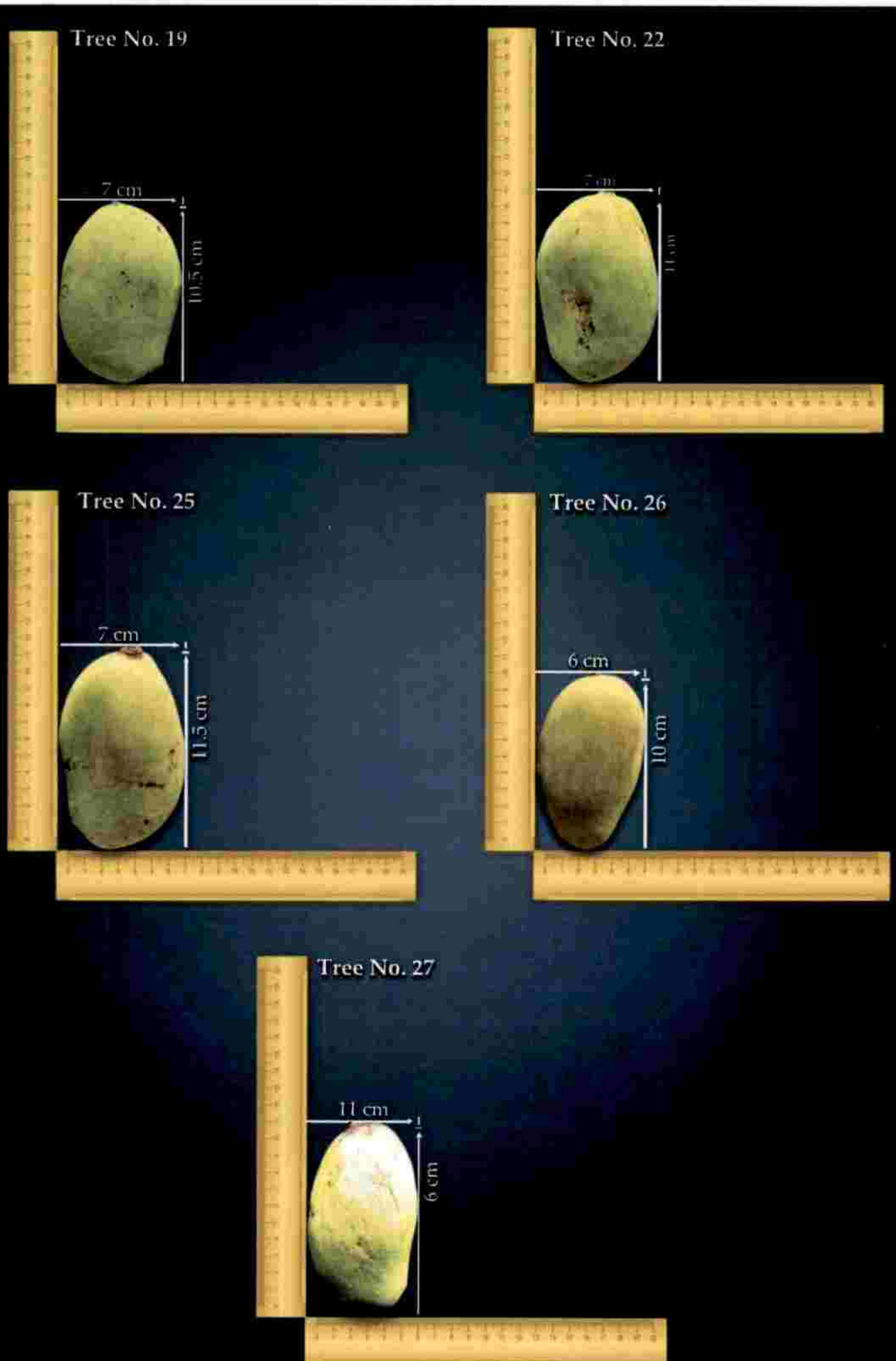


Plate 57. Variations in fruit characters of mango genotype Ratna selected under HDP system

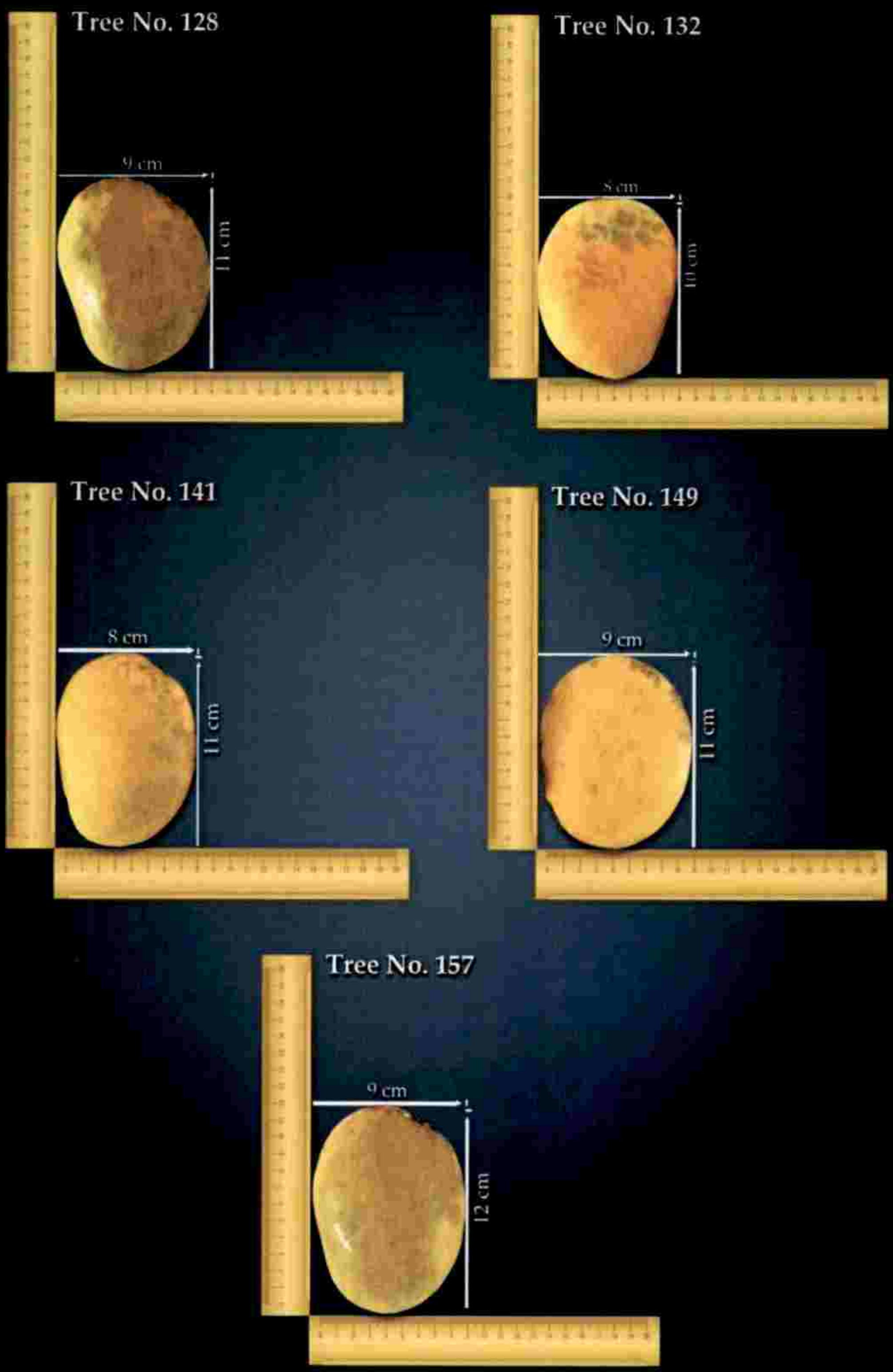


Plate 58. Variations in fruit characters of mango genotype Chandrakaran selected under HDP system

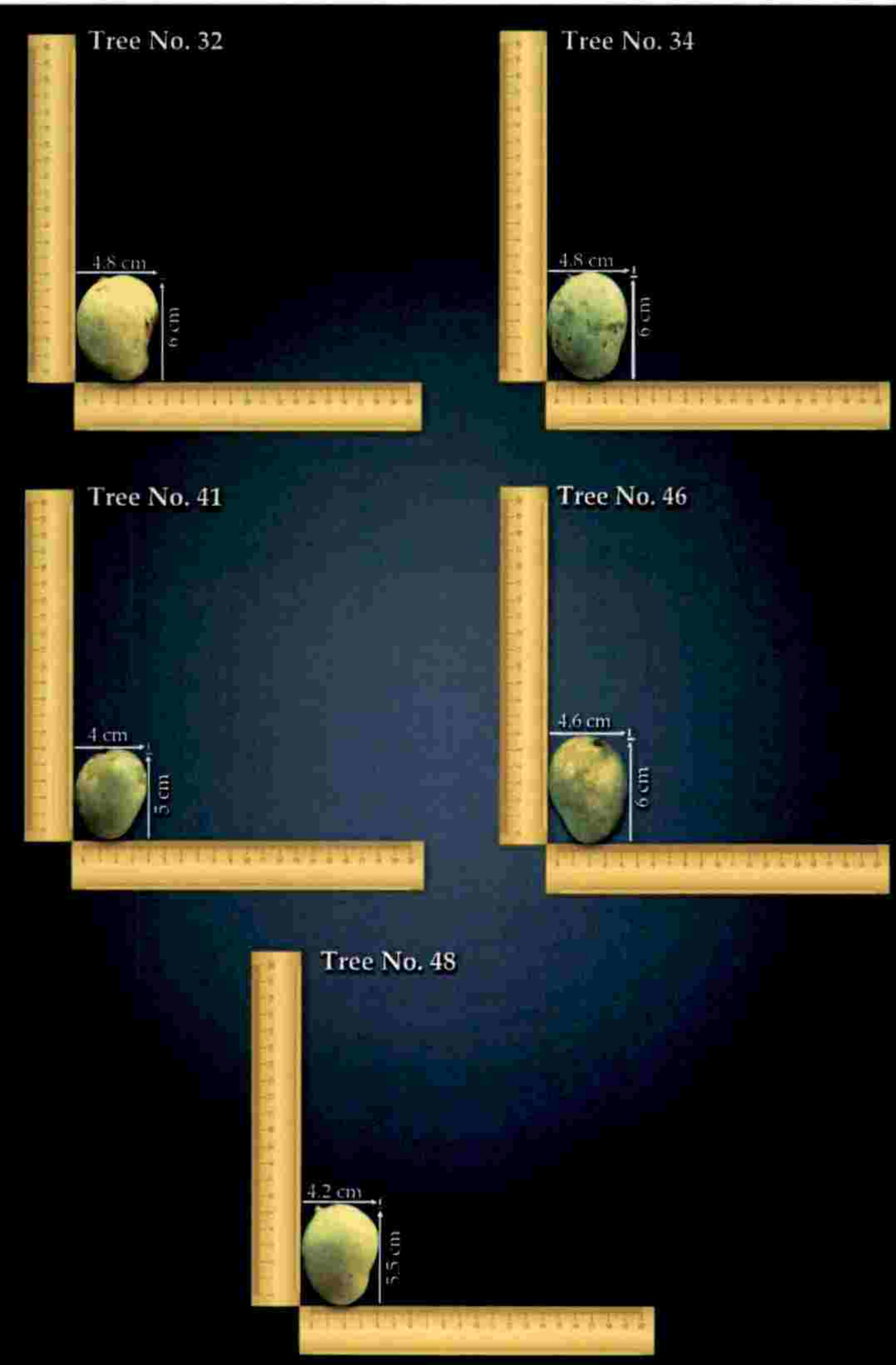
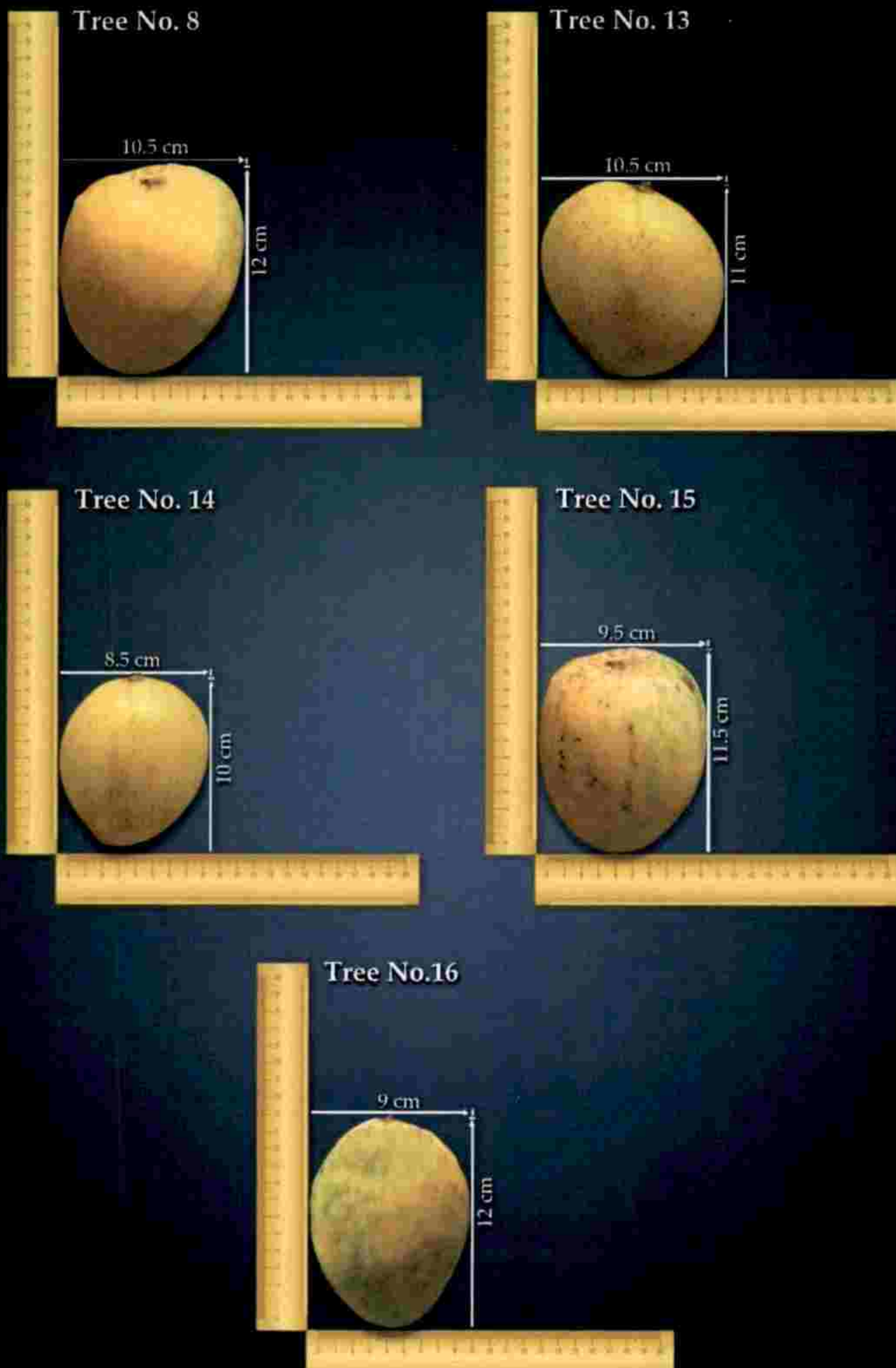


Plate 59. Variations in fruit characters of mango genotype Muvandan selected under HDP system



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4.7.4.12 Aroma of ripe fruit

Mild, intermediate and strong aroma of ripe fruits were observed among the different hybrids/local types (Table 108). Cluster I included trees with mild aroma for ripe fruits. Cluster II included trees with intermediate and strong aroma for ripe fruits. Cluster III included trees with intermediate aroma for ripe fruits (Table 109 and Table 110).

4.7.4.13 Fruit length

The data presented in Table 111 shows the variation in fruit length of different genotypes during the two seasons. Mallika (18.71 cm) recorded the highest fruit length which was significantly different from the rest of the hybrid/local types. Chandrakaran (7.49 cm) recorded the lowest fruit length.

4.7.4.14 Fruit diameter

The data presented in Table 111 shows the variation in fruit diameter of different genotypes during the two seasons. Mallika (25.25 cm) recorded the highest fruit diameter followed by Ratna (25.24 cm). Chandrakaran (13.18 cm) recorded the lowest fruit diameter.

4.7.4.15 Fruit weight

The data presented in Table 112 shows the variation in fruit weight of different genotypes during the two seasons. Mallika (482.71 g) recorded the highest fruit weight which was significantly different from the rest of the hybrid / local types. Chandrakaran (58.09 g) recorded the lowest fruit weight.

4.7.4.16 Fruit yield

The data presented in Table 112 shows the variation in fruit yield of different genotypes during the two seasons. Mallika (24.69 kg/Tree) recorded the highest fruit yield which was significantly different from the rest of the hybrid/ local types. Muvandan (8.93 kg/Tree) recorded the lowest fruit yield.

Table 111. Fruit length (cm) and fruit diameter (cm) of different mango genotypes under HDP system

Sl. No.	Genotypes	Fruit length (cm)			Fruit diameter		
		Year		Mean	Year		Mean
		2015-16	2016-17		2015-16	2016-17	
1	Prior	13.38	12.90	13.14	24.26	23.13	23.69
2	Mallika	18.21	19.20	18.71	24.43	26.06	25.25
3	Vellaikolumban	12.35	13.18	12.76	19.99	24.56	22.28
4	Ratna	13.86	12.62	13.24	25.15	25.34	25.24
5	Chandrakaran	7.52	7.46	7.49	13.34	13.02	13.18
6	Muvandan	12.02	12.12	12.07	21.04	20.94	20.99
	Mean	12.89	12.91		21.37	22.17	
	Factors	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**
	Genotype	0.75	0.37	0.26	1.33	0.66	0.47
	Year x Genotype	1.06	0.53	0.37	1.89	0.94	0.66

Table 112. Fruit weight (g), yield per tree (kg year $^{-1}$) and shelf life (days) of different mango genotypes under HDP system

Sl. No.	Genotypes	Fruit weight (g)			Yield per tree (kg year $^{-1}$)			Shelf life (days)		
		Year		Mean	Year		Mean	Year		Mean
		2015-16	2016-17		2015-16	2016-17		2015-16	2016-17	
1	Prior	296.10	274.64	285.37	13.10	23.00	18.05	6.0	6.0	6.0
2	Mallika	511.14	454.28	482.71	18.90	30.48	24.69	6.0	6.0	6.0
3	Vellaikolumban	241.45	334.34	287.89	13.10	17.88	15.49	4.0	4.0	4.0
4	Ratna	415.61	340.28	377.95	15.40	25.52	20.46	6.0	6.0	6.0
5	Chandrakaran	52.46	63.72	58.09	12.18	31.64	21.91	4.0	4.0	4.0
6	Muvandan	249.54	248.08	248.81	6.36	11.50	8.93	4.0	4.0	4.0
	Mean	294.38	285.89		13.17	23.34		5.0	5.0	
	Factors	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**
	Genotype	40.28	19.92	14.08	2.21	1.10	0.78	0.26	0.13	0.09
	Year x Genotype	56.96	28.17	19.92	3.13	1.55	1.10	NS	0.18	0.13

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4.7.4.17 Shelf life

The data presented in Table 112 shows the variation in shelf life of different genotypes during the two seasons. Prior (6.00 Days) recorded the highest shelf life followed by Mallika (6.00 Days) and Ratna (6.00 Days). Muvandan (4.00 Days) recorded the lowest shelf life which was on par with Chandrakaran (4.00 Days) and Vellaikolumban (4.00 Days).

4.7.5 Stone characters

4.7.5.1 Stone length

The data presented in Table 113 shows the variation in stone length of different genotypes during the two seasons. Mallika (11.67 cm) recorded the highest stone length which was significantly different from the rest of the hybrids/ local types. Chandrakaran 95.58 cm recorded the lowest stone length which was on par with Muvandan (5.91 cm).

4.7.5.2 Stone width

The data presented in Table 113 shows the variation in stone width of different genotypes during the two seasons. Ratna (8.67 cm) recorded the highest stone width which was significantly different from the rest of the hybrids/ local types. Chandrakaran (3.36 cm) recorded the lowest stone width.

4.7.5.3 Stone thickness

The data presented in Table 113 shows the variation in stone thickness of different genotypes during the two seasons. Vellaikolumban (2.19 cm) recorded the highest stone thickness followed by Prior (2.18 cm). Chandrakaran (1.23 cm) recorded the lowest stone thickness which was on par with Muvandan (1.32 cm) and Mallika (1.40 cm).

4.7.5.4 Stone weight

The data presented in Table 114 shows the variation in stone weight of different genotypes during the two seasons. Mallika (44.33 g) recorded the highest stone weight

Table 113. Stone length (cm), stone width (cm) and stone thickness (cm) of different mango genotypes under HDP system

Sl. No.	Genotypes	Stone length (cm)			Stone width (cm)			Stone thickness (cm)		
		Year			Year			Year		
		2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
1	Prior	10.30	11.68	10.99	4.58	5.78	5.18	2.06	2.30	2.18
2	Mallika	11.86	11.48	11.67	4.50	4.88	4.69	1.34	1.46	1.40
3	Vellaikolumban	7.22	7.78	7.50	3.58	4.40	3.99	2.20	2.18	2.19
4	Ratna	10.48	11.22	10.85	8.42	8.92	8.67	1.48	1.52	1.50
5	Chandrakaran	5.44	5.72	5.58	3.46	3.26	3.36	1.26	1.20	1.23
6	Muvandan	5.96	5.86	5.91	4.80	4.92	4.86	1.24	1.40	1.32
	Mean	8.54	8.96		4.89	5.36		1.60	1.68	
	Factors	**CD**	**SE (d)**	**SE (m)**	**CD**	**SE (d)**	**SE(m)**	**CD**	**SE (d)**	**SE (m)**
	Genotype	0.58	0.29	0.20	0.39	0.19	0.14	0.17	0.08	0.06
	Year x Genotype	NS	0.41	0.29	0.55	0.27	0.19	NS	0.12	0.08

Table 114. Stone weight (g), seed length (cm), seed width (cm) and Seed weight (g) of different mango genotypes under HDP system

Sl. No.	Genotypes	Stone weight (g)			Seed length (cm)			Seed width (cm)			Seed weight (g)		
		Year			Year			Year			Year		
		2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
1	Prior	30.50	29.50	30.00	5.34	6.16	5.75	2.70	3.44	3.07	22.52	21.92	22.22
2	Mallika	42.00	46.66	44.33	7.50	7.04	7.27	4.16	4.00	4.08	22.54	21.18	21.86
3	Vellaikolumban	17.44	18.30	17.87	5.02	4.84	4.93	3.32	3.38	3.35	8.72	10.16	9.44
4	Ratna	24.60	23.88	24.24	8.22	7.60	7.91	8.34	8.60	8.47	19.54	18.38	18.96
5	Chandrakaran	17.72	17.86	17.79	3.94	4.16	4.05	3.36	3.36	3.36	16.32	16.70	16.51
6	Muvandan	23.38	21.76	22.57	4.62	4.66	4.64	3.38	2.96	3.17	16.08	17.74	16.91
	Mean	25.94	26.33		5.77	5.74		4.21	4.29		17.62	17.68	
	Factors	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.71	1.35	0.95	2.71	1.35	0.95	0.39	0.19	0.14	1.51	0.75	0.53
	Year x Genotype	NS	1.90	1.35	NS	1.90	1.35	NS	0.27	0.19	NS	1.06	0.75

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which was significantly different from the rest of the hybrid / local types. Chandrakaran (17.79) recorded the lowest stone weight which was on par with Vellaikolumban (17.87 g).

4.7.5.5 Seed length

The data presented in Table 114 shows the variation in seed length of different genotypes during the two seasons. Ratna (7.91 cm) recorded the highest seed length which was significantly different from the rest of hybrid/local types. Chandrakaran (4.05 cm) recorded the lowest seed length.

4.7.5.6 Seed width

The data presented in Table 114 shows the variation in seed width of different genotypes during the two seasons. Ratna (8.47 cm) recorded the highest seed width which was significantly different from the rest of the hybrid/local types. Prior (3.07 cm) recorded the lowest seed width which was on par with Muvandan (3.17 cm), Vellaikolumban (3.35 cm) and Chandrakaran (3.36 cm).

4.7.5.6 Seed weight

The data presented in Table 114 shows the variation in seed weight of different genotypes during the two seasons. Prior (22.22 g) recorded the highest seed weight followed by Mallika (21.86 g). Vellaikolumban (9.44 g) recorded the lowest seed weight.

4.7.5.7 Quantity of fibre on stone

Low, intermediate and high quantity of fibre on stone were observed among the different hybrids/local types (Table 115). Cluster I included trees with low and high quantity of fibre on stone. Cluster II and III included trees with intermediate quantity of fibre on stone (Table 116 and Table 117).

Table 115. Quantity of fibre on stone, adherence of fibre to stone, texture of stone fibre and seed shape of different mango genotypes under HDP system

Sl. No.	Genotypes	Quantity of fibre on stone	Adherence of fibre to stone	Texture of stone fibre	Seed shape
1	Prior	Low	Strong	Coarse	Reniform
2	Mallika	Low	Intermediate	Coarse	Reniform
3	Vellaikolumban	Intermediate	Intermediate	Coarse	Ellipsoid
4	Ratna	Intermediate	Intermediate	Soft	Reniform
5	Chandrakaran	High	Weak	Coarse	Reniform
6	Muvandan	High	Weak	Coarse	Reniform

Table 116. Cluster wise listing of hybrids/local types according to stone characters under HDP system

Clusters		
I	II	III
Prior	Vellaikolumaban	Ratna
Mallika		
Chandrakaran		
Muvandan		

Table 117. Cluster wise summary statistics of hybrids/local types according to stone characters under HDP system

Characters	Clusters		
	I	II	III
Quantity of fibre on stone	Low, High	Intermediate	Intermediate
Adherence of fibre to stone	Strong, Intermediate, Weak	Intermediate	Intermediate
Texture of stone fibre	Coarse	Coarse	Soft
Seed shape	Reniform	Ellipsoid	Reniform

Plate 60. Variations in stone characters of mango genotypes Prior, Mallika, Vellaikolumban, Ratna, Chandrakaran and Muvandan selected under HDP system

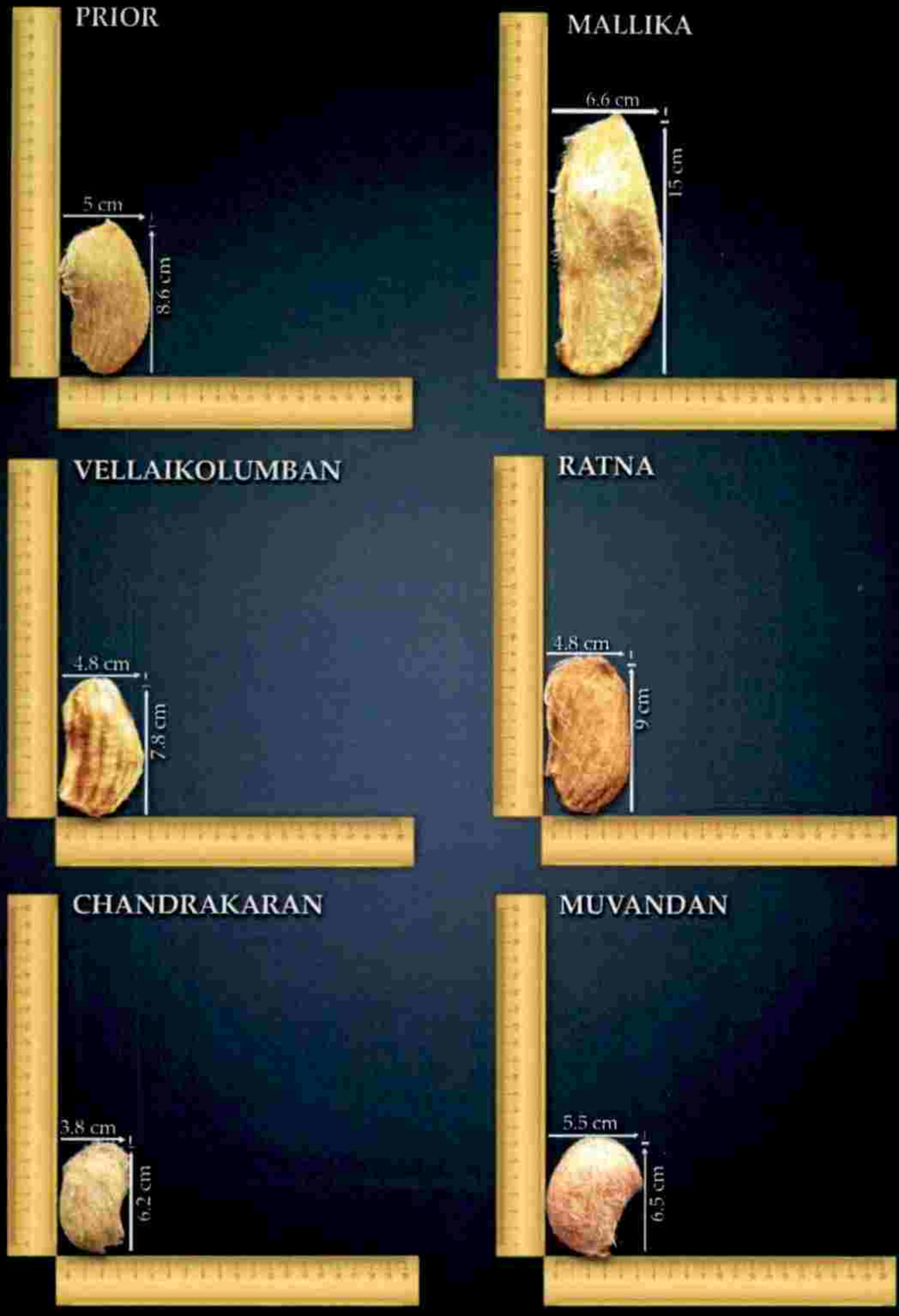

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Plate 61. Variations in seed characters of mango genotypes Prior, Mallika, Vellaikolumban, Ratna, Chandrakaran and Muvandan selected under HDP system

4.7.5.8 Adherence of fibre to stone

Weak, intermediate and strong adherence of fibre to stone were observed among the different hybrids/local types (Table 115). Cluster I included trees with weak, intermediate and strong adherence of fibre to stone. Cluster II and III included trees with intermediate adherence of fibre to stone (Table 116 and Table 117).

4.7.5.9 Texture of stone fibre

Coarse and soft texture of stone fibre were observed among the different hybrids/local types (Table 115). Cluster I and II included trees with coarse texture of stone fibre. Cluster III included trees with soft texture of stone fibre (Table 116 and Table 117).

4.7.5.10 Seed shape

Ellipsoid and reniform seed shapes were observed among the different hybrids/local types (Table 115). Cluster I and II included trees with reniform seed shape. Cluster II included trees with ellipsoid seed shape (Table 116 and Table 117).

4.8. Quality attributes

Different quality attributes like TSS (°Brix), acidity (%), ascorbic acid (mg $100g^{-1}$), total carotenoids (mg $100g^{-1}$), β carotene (mg $100g^{-1}$), total sugar (%), reducing sugar (%) and crude fibre (%) were recorded and presented from table 118 to table 119.

4.8.1 TSS

The data presented in Table 118 shows the variation in TSS of different genotypes during the two seasons. Ratna (26.77 °Brix) recorded the highest TSS followed by Chandrakaran (25.19 °Brix). Muvandan (14.78 °Brix) recorded the lowest TSS.

4.8.2 Acidity

The data presented in Table 118 shows the variation in acidity of different genotypes during the two seasons. Muvandan (0.07 %) recorded the highest acidity

Table 118. TSS content (° Brix), acidity content (%), ascorbic acid content (mg $100g^{-1}$) and total carotenoids content (mg $100g^{-1}$) of different mango genotypes under HDP system

Sl. No.	Genotypes	TSS content (° Brix)			Acidity content (%)			Ascorbic acid content (mg $100g^{-1}$)			Total carotenoids content (mg $100g^{-1}$)		
		Year			Year			Year			Year		
		2015-16	**2016-17**	**Mean**	**2015-16**	**2016-17**	**Mean**	**2015-16**	**2016-17**	**Mean**	**2015-16**	**2016-17**	**Mean**
1	Prior	19.18	19.34	19.26	0.03	0.03	0.03	31.75	33.02	32.38	2.11	2.49	2.30
2	Mallika	23.42	24.14	23.78	0.02	0.02	0.02	30.48	36.83	33.65	2.94	3.44	3.19
3	Vellaikolumban	15.74	15.16	15.45	0.02	0.03	0.03	29.21	27.30	28.26	1.34	1.46	1.40
4	Ratna	26.10	27.44	26.77	0.03	0.02	0.03	40.64	45.72	43.18	4.62	4.98	4.80
5	Chandrakaran	24.74	25.64	25.19	0.06	0.06	0.06	63.49	95.87	79.68	3.05	3.55	3.30
6	Muvandan	14.58	14.98	14.78	0.07	0.07	0.07	36.83	40.00	38.41	4.39	5.21	4.80
	Mean	20.63	21.12		0.04	0.04		38.73	46.46		3.08	3.52	
	Factors	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**
	Genotype	1.82	0.90	0.64	0.01	0.01	0.01	8.54	4.23	2.99	0.44	0.22	0.15
	Year x Genotype	NS	1.27	0.90	NS	0.01	0.01	12.07	5.99	4.23	NS	0.31	0.22

followed by Chandrakaran (0.06 %), Prior (0.03%), Vellaikolumban (0.03%) and Ratna (0.03%). Mallika (0.02%) recorded the lowest acidity.

4.8.3 Ascorbic acid

The data presented in Table 118 shows the variation in ascorbic acid of different genotypes during the two seasons. Chandrakaran (79.68 mg $100g^{-1}$) recorded the highest ascorbic acid which was significantly different from the rest of the hybrid / local types. Vellaikolumban (28.26 mg $100g^{-1}$) recorded the lowest ascorbic acid which was on par with Prior (32.38 mg $100g^{-1}$) and Mallika (33.65 mg $100g^{-1}$).

4.8.4 Total carotenoids

The data presented in Table 118 shows the variation in total carotenoids of different genotypes during the two seasons. Muvandan (4.80 mg $100g^{-1}$) recorded the highest total carotenoids followed by Ratna (4.80 mg $100g^{-1}$). Vellaikolumban (1.40 mg $100g^{-1}$) recorded the lowest total carotenoids.

4.8.5 β carotene

The data presented in Table 119 shows the variation in β carotene of different genotypes during the two seasons. Ratna (39.93 mg $100g^{-1}$) recorded the highest β carotene which was significantly different from the rest of the hybrid/local type. Vellaikolumban (13.54 mg $100g^{-1}$) recorded the lowest β carotene which was on par with Muvandan (13.66 mg $100g^{-1}$), Prior (14.29 mg $100g^{-1}$).

4.8.6 Total sugar

The data presented in Table 119 shows the variation in total sugar of different genotypes during the two seasons. The variation in total sugar was not significant among the different genotypes over the three seasons.

4.8.7 Reducing sugar

The data presented in Table 119 shows the variation in reducing sugar of different genotypes during the two seasons. The variation in reducing sugar was not significant among the different genotypes over the three seasons.

Table 119. β carotene content (mg $100g^{-1}$), total sugar content (%), reducing sugar (%) and crude fiber content (%) of different mango genotypes under HDP system

Sl. No.	Genotypes	β carotene content (mg $100g^{-1}$)			Total sugar content (%)			Reducing sugar (%)			Crude fiber content (%)		
		Year			Year			Year			Year		
		2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
1	Prior	13.49	15.10	14.29	15.94	13.52	14.73	7.96	9.39	8.67	7.96	9.39	8.67
2	Mallika	19.00	18.70	18.85	14.77	13.79	14.28	8.56	9.12	8.84	8.56	9.12	8.84
3	Vellaikolumban	14.60	12.48	13.54	15.26	13.18	14.22	8.48	10.42	9.45	8.48	10.42	9.45
4	Ratna	40.42	39.43	39.93	16.50	14.94	15.72	7.68	8.52	8.10	7.68	8.52	8.10
5	Chandrakaran	15.57	18.04	16.81	17.08	15.95	16.51	8.00	8.70	8.35	8.00	8.70	8.35
6	Muvandan	12.70	14.63	13.66	17.38	15.27	16.32	7.24	8.19	7.72	7.24	8.19	7.72
	Mean	19.30	19.73		16.15	14.44		7.99	9.06	.	7.99	9.06	
	Factors	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**
	Genotype	2.37	1.17	0.83	NS	1.43	1.01	NS	0.81	0.57	NS	0.81	0.57
	Year x Genotype	NS	1.66	1.17	NS	2.02	1.43	NS	1.14	0.81	NS	1.14	0.81

4.8.8 Crude fibre

The data presented in Table 119 shows the variation in crude fibre of different genotypes during the two seasons. Mallika (13.00%) recorded the highest crude fibre which was significantly different from the rest of the hybrid / local types. Ratna (3.56 %) recorded the lowest crude fibre.

4.9. Sensory evaluation

Among the hybrids/local types, the highest rank for appearance was given for Mallika followed by Ratna and Muvandan (Table 120). For colour highest rank was given for Ratna followed by Chandrakaran and Prior. Ratna got the highest rank for flavour followed by Chandrakaran and Mallika. Ratna recorded highest rank for sweetness followed by Mallika and Chandrakaran. Ratna also recorded highest rank for taste followed by Mallika and Chandrakaran. Ratna was given highest rank for texture followed by Mallika and Prior.

4.10 Pollen studies

Size and shape of pollen grains, pollen fertility, *in vitro* pollen germination, estimation of pollen production and pollen storage were recorded and presented in table 121.

4.10.1 Size of pollen grains

The data presented in Table 121 shows the variation in length of the pollen grains of different genotypes during the two seasons. Prior (44.00 μm) recorded the highest pollen length which was on par with Vellaikolumban (43.8 μm) and Chandrakaran (42.3 μm). Muvandan (24.8 μm) recorded the lowest pollen length.

The data presented in Table 121 shows the variation in breadth of the pollen grains of different genotypes during the two seasons. Chandrakaran (33.45 μm) recorded the highest pollen breadth followed by Vellaikolumban (32.62 μm), Ratna (32.31 μm) and prior (32.09 μm). Muvandan (22.62 μm) recorded the lowest pollen breadth which was on par with Mallika (22.72 μm).

Table 120. Sensory evaluation of mango genotypes under HDP system by Kendall's coefficient of concordance

Appearance		Colour		Flavour		Sweetness		Taste		Texture	
	Mean rank		**Mean rank**		**Mean rank**		**Mean rank**		**Mean rank**		**Mean rank**
Mallika	5.75	Ratna	4.95	Ratna	4.65	Ratna	5.20	Ratna	4.85	Ratna	4.90
Ratna	4.10	Chandrakaran	4.10	Chandrakaran	3.85	Mallika	3.60	Mallika	4.20	Mallika	3.90
Muvandan	3.40	Prior	3.40	Mallika	3.50	Chandrakaran	3.55	Chandrakaran	3.40	Prior	3.20
Prior	2.75	Mallika	3.15	Vellaikolumban	3.30	Prior	3.00	Prior	3.35	Vellaikolumban	3.15
Vellaikolumban	2.70	Vellaikolumban	2.70	Prior	2.90	Muvandan	2.85	Vellaikolumban	2.80	Chandrakaran	3.05
Chandrakaran	2.30	Muvandan	2.70	Muvandan	2.80	Vellaikolumban	2.80	Muvandan	2.40	Muvandan	2.80
Kendall's Wa	0.52	Kendall's Wa	0.32	Kendall's Wa	0.16	Kendall's Wa	0.27	Kendall's Wa	0.26	Kendall's Wa	0.21

Table 121. Pollen length (µm), pollen breadth (µm), pollen fertility (%) and pollen production of different mango genotypes under HDP system

Sl. No.	Genotypes	Pollen length (µm)			Pollen breadth (µm)			Pollen fertility (%)			Pollen production		
		Year			Year			Year			Year		
		2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean	2015-16	2016-17	Mean
1	Prior	43.5	44.5	44.0	32.75	31.44	32.09	40.55	78.38	59.47	70.00	392.80	231.40
2	Mallika	28.1	25.1	26.6	21.13	24.31	22.72	63.15	95.24	79.20	70.60	417.00	243.80
3	Vellaikolumban	43.3	44.2	43.8	31.29	33.94	32.62	47.61	85.30	66.46	79.40	532.80	306.10
4	Ratna	39.1	37.9	38.5	31.16	33.45	32.31	46.13	92.81	69.47	63.60	331.20	197.40
5	Chandrakaran	40.2	44.4	42.3	33.92	32.99	33.45	56.79	93.46	75.13	81.20	444.40	262.80
6	Muvandan	25.3	24.2	24.8	21.81	23.43	22.62	48.08	82.23	65.15	85.20	303.80	194.50
	Mean	36.6	36.7		28.68	29.92		50.39	87.91		75.00	403.67	
	Factors	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**	**CD**	**SE(d)**	**SE(m)**
	Genotype	3.37	1.67	1.18	2.84	1.41	1.00	2.74	1.36	0.96	22.73	11.27	7.97
	Year x Genotype	NS	2.36	1.67	NS	1.99	1.41	3.88	1.92	1.36	32.15	15.94	11.27

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4.10.2 Shape of pollen grains

Variation in shape of pollen grains of different genotypes were observed (Plate No. 47 to 51). Among the hybrids/local types, Mallika, Ratna and chandrakaran had oval pollen grains. Vellaikolumban, Prior and Muvandan had oblong pollen grains Tholikaippan recorded roundish pollen grains.

4.10.3 Pollen fertility

The data presented in Table 121 shows the variation in pollen fertility of different genotypes during the two seasons. Among the hybrids, Mallika (79.20%) recorded the highest pollen fertility which was significantly different from the other hybrid / local types. Prior (59.47%) recorded the lowest pollen fertility.

4.10.4 Estimation of pollen production

The data presented in Table 121 shows the variation in estimation of pollen production of different genotypes during the two seasons. Vellaikolumban (306.30) recorded the highest pollen production which was significantly different from the rest of the hybrid / local types. Muvandan (194.50) recorded the lowest pollen production which was on par with Ratna (197.40).

4.11 Physiological characters

Relative water content (%), radiation interception (μ mol m^{-2} s^{-2}), stomatal index, stomatal frequency (μ mol m^{-2} s^{-2}), stomatal conductance (μ mol m^{-2} s^{-2}), stomatal resistance (μ mol m^{-2} s^{-2}), photosynthetic rate (μ mol m^{-2} s^{-2}), transpiration (mol m^{-2} s^{-2}), leaf area index (LAI) and atmospheric pollution tolerance index (APTI) were recorded and presented from table 122 to table 124.

4.11.1 Relative water content

The data presented in Table 122 shows the variation in estimation of relative water content (%) of different genotypes during the three seasons. The variation in relative water content was not significant among the different genotypes over the three seasons.

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4.11.2 Radiation interception

The data presented in Table 122 shows the variation in estimation of radiation interception (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Ratna (0.77 μ mol m^{-2} s^{-2}) recorded the highest radiation interception followed by Chandrakaran (0.77 μ mol m^{-2} s^{-2}), Mallika (0.74 μ mol m^{-2} s^{-2}) and Vellaikolumban (0.71 μ mol m^{-2} s^{-2}). Prior (0.61 μ mol m^{-2} s^{-2}) recorded the lowest radiation interception which was on par with Muvandan (0.66 μ mol m^{-2} s^{-2}).

4.11.3 Stomatal index

The data presented in Table 122 shows the variation in estimation of stomatal index of different genotypes during the three seasons. Ratna (21.37 μ mol m^{-2} s^{-2}) recorded the highest stomatal index followed by Prior (20.68 μ mol m^{-2} s^{-2}), Vellaikolumban (19.60 μ mol m^{-2} s^{-2}) and Chandrakaran (19.02 μ mol m^{-2} s^{-2}). Mallika (17.87 μ mol m^{-2} s^{-2}) recorded the lowest stomatal index which was on par with Muvandan (18.57 μ mol m^{-2} s^{-2}).

4.11.4 Stomatal frequency

The data presented in Table 122 shows the variation in estimation of stomatal frequency of different genotypes during the three seasons. Ratna (81.40) recorded the highest stomatal frequency followed by Prior (74.13) and Vellaikolumban (74.07). Mallika (63.73) recorded the lowest stomatal frequency which was on par with Muvandan (68.07) and Chandrakaran (68.47).

4.11.5 Stomatal conductance

The data presented in Table 123 shows the variation in estimation of stomatal conductance (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Muvandan (0.19 μ mol m^{-2} s^{-2}) recorded the highest stomatal conductance followed by Mallika (0.16 μ mol m^{-2} s^{-2}). Prior (0.09 μ mol m^{-2} s^{-2}) recorded the lowest stomatal conductance which was on par with Chandrakaran (0.12 μ mol m^{-2} s^{-2}).

Table 122. Relative water content (%), radiation interception (μ mol m^{-2} s^{-2}), stomatal index and stomatal frequency of different mango genotypes under HDP system

Sl. No.	Genotypes	Relative water content (%)				Radiation interception (μ mol m^{-2} s^{-2})				Stomatal index				Stomatal frequency (μ mol m^{-2} s^{-2})			
		Year				Year				Year				Year			
		2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean
1	Prior	21.66	27.78	29.78	26.41	0.61	0.60	0.63	0.61	19.62	21.62	20.79	20.68	75.00	65.80	81.60	74.13
2	Mallika	26.71	28.40	38.88	31.33	0.74	0.77	0.70	0.74	20.57	17.35	15.70	17.87	63.20	62.00	66.00	63.73
3	Vellaikolumban	25.84	27.96	29.26	27.69	0.70	0.73	0.69	0.71	18.85	19.62	20.33	19.60	74.20	70.20	77.80	74.07
4	Ratna	27.36	25.76	30.36	27.83	0.78	0.79	0.75	0.77	18.75	19.42	25.94	21.37	74.80	74.00	95.40	81.40
5	Chandrakaran	21.66	25.56	30.21	25.81	0.74	0.86	0.70	0.77	20.26	18.40	18.41	19.02	64.60	67.60	73.20	68.47
6	Muvandan	26.71	32.54	21.11	26.79	0.73	0.52	0.73	0.66	19.38	18.85	17.49	18.57	62.60	62.20	79.40	68.07
	Mean	24.99	28.00	29.93		0.72	0.71	0.70		19.57	19.21	19.77		69.07	66.97	78.90	
	Factors	**CD**	**SE(d)**	**SE(m)**		**CD**	**SE(d)**	**SE(m)**		**CD**	**SE(d)**	**SE(m)**		**CD**	**SE(d)**	**SE(m)**	
	Genotype	NS	2.23	1.58		0.08	0.04	0.03		2.27	1.14	0.80		7.90	3.96	2.80	
	Year x Genotype	7.72	3.87	2.73		NS	0.07	0.05		3.94	1.97	1.39		NS	6.85	4.84	

4.11.6 Stomatal resistance

The data presented in Table 123 shows the variation in estimation of stomatal resistance (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Prior (19.79 μ mol m^{-2} s^{-2}) recorded the highest stomata resistance which was significantly different from the rest of the hybrids / local types. Muvandan (7.31 μ mol m^{-2} s^{-2}) recorded the lowest stomatal resistance which was on par with Vellaikolumban (8.77 μ mol m^{-2} s^{-2}) , Mallika (9.08 μ mol m^{-2} s^{-2}) and Chandrakaran (9.62 μ mol m^{-2} s^{-2}).

4.11.7 Photosynthetic rate

The data presented in Table 123 shows the variation in estimation of photosynthetic rate (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Vellaikolumban (11.68 μ mol m^{-2} s^{-2}) recorded the highest photosynthetic rate which was significantly different from the rest of hybrid / local types. Chandrakaran (3.17 μ mol m^{-2} s^{-2}) recorded the lowest photosynthetic rate which was on par with Ratna (4.89 μ mol m^{-2} s^{-2}).

4.11.8 Transpiration

The data presented in Table 124 shows the variation in estimation of transpiration (mol m^{-2} s^{-2}) of different genotypes during the three seasons. Chandrakaran (4.19 μ mol m^{-2} s^{-2}) recorded the highest transpiration rate followed by Vellaikolumban (4.00 μ mol m^{-2} s^{-2}) , Malika (3.83 μ mol m^{-2} s^{-2}) and Muvandan (3.70 μ mol m^{-2} s^{-2}). Ratna (2.44 μ mol m^{-2} s^{-2}) recorded the lowest transpiration which was on par with prior (2.65 μ mol m^{-2} s^{-2}).

4.11.9 Leaf area index (LAI)

The data presented in Table 124 shows the variation in estimation of leaf area index (LAI) of different genotypes during the three seasons. The variation in leaf area index was not significant among the different genotypes over the three seasons.

4.11.10 Atmospheric pollution tolerance index (APTI)

The data presented in Table 124 shows the variation in estimation of atmospheric pollution tolerance index (APTI) of different genotypes during the three

Table 123. Stomatal conductance (µ mol m^{-2} s^{-2}), stomatal resistance (µ mol m^{-2} s^{-2}) and photosynthetic rate (µ mol m^{-2} s^{-2}) of different mango genotypes under HDP system

Sl. No.	Genotypes	Stomatal conductance (µ mol m^{-2} s^{-2})				Stomatal resistance (µ mol m^{-2} s^{-2})				Photosynthetic rate (µ mol m^{-2} s^{-2})			
		Year				Year				Year			
		2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean
1	Prior	0.04	0.17	0.06	0.09	36.50	6.99	15.88	19.79	5.40	3.65	14.29	7.78
2	Mallika	0.15	0.26	0.07	0.16	6.82	4.19	16.24	9.08	10.70	4.23	11.33	8.75
3	Vellaikolumban	0.14	0.19	0.10	0.15	7.45	5.46	13.40	8.77	4.84	4.28	25.92	11.68
4	Ratna	0.16	0.20	0.05	0.14	6.54	5.07	21.06	10.89	4.52	4.07	6.06	4.89
5	Chandrakaran	0.18	0.12	0.07	0.12	5.70	8.33	14.83	9.62	3.36	2.66	3.48	3.17
6	Muvandan	0.25	0.22	0.10	0.19	4.01	5.97	11.94	7.31	5.86	4.17	8.42	6.15
	Mean	0.16	0.19	0.08		11.17	6.00	15.56		5.78	3.84	11.58	
	Factors	**C.D.**	**SE(d)**	**SE(m)**		**C.D.**	**SE(d)**	**SE(m)**		**C.D.**	**SE(d)**	**SE(m)**	
	Genotype	0.03	0.02	0.01		5.85	2.93	2.07		1.88	0.94	0.67	
	Year x Genotype	0.06	0.03	0.02		10.13	5.07	3.59		3.26	1.63	1.15	

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Table 124. Transpiration (mol m^{-2} s^{-2}), leaf area index (LAI) and atmospheric pollution tolerance index (APTI) of different mango genotypes under HDP system

Sl. No.	Genotypes	Transpiration (mol m^{-2} s^{-2})				Leaf area index (LAI)				Atmospheric pollution tolerance index (APTI)			
		Year				Year				Year			
		2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean
1	Prior	4.46	3.19	4.35	4.00	1.03	1.12	2.09	1.41	60.27	64.82	70.87	65.32
2	Mallika	3.45	3.96	4.07	3.83	1.24	1.46	2.57	1.76	61.63	59.82	74.16	65.20
3	Vellaikolumban	3.93	3.47	0.54	2.65	0.69	1.24	2.02	1.32	52.33	56.84	54.10	54.42
4	Ratna	4.24	3.62	3.23	3.70	0.96	1.30	1.92	1.40	55.75	64.19	85.08	68.34
5	Chandrakaran	2.75	2.55	2.03	2.44	1.13	1.70	2.30	1.71	57.69	63.82	81.28	67.60
6	Muvandan	4.36	3.92	4.29	4.19	0.84	0.86	1.67	1.12	61.63	67.89	72.44	67.32
	Mean	3.87	3.45	3.09		0.98	1.28	2.09		58.22	62.90	72.99	
	Factors	**C.D.**	**SE(d)**	**SE(m)**		**C.D.**	**SE(d)**	**SE(m)**		**C.D.**	**SE(d)**	**SE(m)**	
	Genotype	0.72	0.36	0.26		NS	0.24	0.17		4.61	2.31	1.63	
	Year x Genotype	1.25	0.63	0.44		NS	0.41	0.29		7.99	4.00	2.83	

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Plate 62. Observation recording using IRGA

seasons. Ratna (68.34) recorded the highest APTI followed by Chandrakaran (67.60) , Muvandan (67.32) and Prior (65.32). Vellaikolumban (54.42) recorded the lowest APTI.

4.12 Biochemical analysis of plants

Total phenol content (mg g^{-1}), soluble protein content (mg g^{-1}), ascorbic acid (mg 100g^{-1}), pH of the leaf and chlorophyll content (mg g^{-1}) were recorded and presented from table 125 to table 126.

4.12.1 Total phenol content

The data presented in Table 125 shows the variation in total phenol content (mg g^{-1}) of different genotypes during the three seasons. Prior (10.66 mg g^{-1}) recorded the highest total phenol followed by Chandrakaran (9.19 mg g^{-1}). Vellaikolumban (4.81 mg g^{-1}) recorded the lowest total phenol which was on par with Muvandan (5.44 mg g^{-1}), Ratna (7.00 mg g^{-1}) and Mallika (7.28 mg g^{-1}).

4.12.2 Soluble protein content

The data presented in Table 125 shows the variation soluble protein content (mg g^{-1}) of different genotypes during the three seasons. Chandrakaran (20.75 mg g^{-1}) recorded the highest soluble protein followed by Vellaikolumban (18.43 mg g^{-1}) and Mallika (17.42 mg g^{-1}). Ratna (12.72 mg g^{-1}) recorded the lowest soluble protein which was on par with Prior (14.37 mg g^{-1}) and Muvandan (15.00 mg g^{-1}).

4.12.3 Ascorbic acid

The data presented in Table 125 shows the variation in ascorbic acid (mg 100g^{-1}) of different genotypes during the three seasons. Ratna (92.34 mg g^{-1}) recorded the highest ascorbic acid which followed by Chandrakaran (89.76 mg g^{-1}) and Mallika (87.93 mg g^{-1}). Vellaikolumban (67.74 mg g^{-1}) recorded the lowest ascorbic acid content.

4.12.4 pH of the leaf

The data presented in Table 125 shows the pH of leaf of different genotypes

Table 125. Total phenol content (mg g^{-1}), soluble protein content (mg g^{-1}), ascorbic acid content (mg 100 g^{-1}) and leaf pH of different mango genotypes under HDP system

Sl. No.	Genotypes	Total phenol content (mg g^{-1})				Soluble protein content (mg g^{-1})				Ascorbic acid content (mg 100 g^{-1})				Leaf pH			
		Year				Year				Year				Year			
		2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean
1	Prior	8.25	10.52	13.20	10.66	12.27	14.16	16.68	14.37	81.98	84.25	89.10	85.11	5.81	5.61	5.81	5.74
2	Mallika	7.31	6.71	7.83	7.28	12.95	18.46	20.86	17.42	89.38	80.40	94.02	87.93	5.32	5.60	5.82	5.58
3	Vellaikolumban	1.45	6.24	6.75	4.81	15.23	18.42	21.62	18.43	67.65	68.91	66.65	67.74	6.23	6.23	5.91	6.12
4	Ratna	8.37	6.18	6.44	7.00	10.51	12.94	14.70	12.72	83.60	85.61	107.79	92.34	5.40	5.50	5.81	5.57
5	Chandrakaran	5.08	10.87	11.63	9.19	15.08	22.56	24.59	20.75	80.80	85.08	103.40	89.76	5.59	5.60	5.82	5.67
6	Muvandan	2.50	7.00	6.81	5.44	12.42	14.15	18.43	15.00	80.21	84.76	94.25	86.41	6.24	6.31	5.91	6.15
	Mean	5.50	7.92	8.78		13.08	16.78	19.48		80.61	81.50	92.53		5.77	5.81	5.85	
	Factors	**CD**	**SE(d)**	**SE(m)**		**CD**	**SE(d)**	**SE(m)**		**CD**	**SE(d)**	**SE(m)**		**CD**	**SE(d)**	**SE(m)**	
	Genotype	3.05	1.53	1.08		3.82	1.91	1.35		5.60	2.80	1.98		0.17	0.09	0.06	
	Year x Genotype	NS	2.64	1.87		NS	3.31	2.34		9.69	4.85	3.43		0.29	0.15	0.10	

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Table 126. Chlorophyll a (mg g^{-1}), chlorophyll b (mg g^{-1}) and total Chlorophyll content (mg g^{-1}) of different mango genotypes under HDP system

Sl. No.	Genotypes	Chlorophyll a (mg g^{-1})				Chlorophyll b (mg g^{-1})				Total Chlorophyll content (mg g^{-1})			
		Year				Year				Year			
		2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean	2015-16	2016-17	2107-18	Mean
1	Prior	1.12	1.42	1.31	1.29	0.16	0.30	0.34	0.27	1.28	1.72	1.65	1.55
2	Mallika	1.10	1.21	1.23	1.18	0.17	0.27	0.27	0.24	1.27	1.48	1.51	1.42
3	Vellaikolumban	1.00	1.29	1.41	1.23	0.13	0.33	0.29	0.25	1.12	1.62	1.70	1.48
4	Ratna	0.81	1.35	1.26	1.14	0.12	0.35	0.28	0.25	0.94	1.70	1.54	1.39
5	Chandrakaran	1.11	1.25	1.39	1.25	0.18	0.34	0.35	0.29	1.29	1.59	1.74	1.54
6	Muvandan	0.99	1.06	1.22	1.09	0.13	0.27	0.25	0.22	1.12	1.32	1.47	1.30
	Mean	1.02	1.26	1.30		0.15	0.31	0.30		1.17	1.57	1.60	
	Factors	**C.D.**	**SE(d)**	**SE(m)**		**C.D.**	**SE(d)**	**SE(m)**		**C.D.**	**SE(d)**	**SE(m)**	
	Genotype	0.12	0.06	0.04		0.04	0.02	0.01		0.15	0.07	0.05	
	Year x Genotype	NS	0.11	0.08		NS	0.03	0.02		NS	0.13	0.09	

during the three seasons. Muvandan (6.15 mg g^{-1}) recorded the highest pH content followed by Vellaikolumban (6.12 mg g^{-1}), Prior (5.74 mg g^{-1}) and Chandrakaran (5.67 mg g^{-1}). Ratna (5.57 mg g^{-1}) recorded the lowest pH which was on par with Mallika (5.58 mg g^{-1}).

4.12.5 Chlorophyll a content

The data presented in Table 126 shows the variation in chlorophyll a content (mg g^{-1}) of different genotypes during the three seasons. Prior (1.29 mg g^{-1}) recorded the highest chlorophyll a content followed by Chandrakaran (1.25 mg g^{-1}) , Vellaikolumban (1.23 mg g^{-1}) and Mallika (1.18 mg g^{-1}). Muvandan (1.09 mg g^{-1}) recorded the lowest chlorophyll a content which was on par with Ratna (1.14) mg g^{-1}.

4.12.6 Chlorophyll b content

The data presented in Table 126 shows the variation in chlorophyll b content (mg g^{-1}) of different genotypes during the three seasons. Chandrakaran (0.29 mg g^{-1}) recorded the highest chlorophyll b content followed by Prior (0.27 mg g^{-1}), Ratna (0.05 mg g^{-1}) and Vellaikolumban (0.05 mg g^{-1}). Muvandan (0.22 mg g^{-1}) recorded the lowest chlorophyll b content which was on par with Mallika (0.24 mg g^{-1}).

4.12.7 Total chlorophyll content

The data presented in Table 126 shows the variation in total chlorophyll content (mg g^{-1}) of different genotypes during the three seasons. Prior (1.55 mg $g^{-1)}$ recorded the highest total chlorophyll followed by Chandrakaran (1.54 mg g^{-1}), Vellaikolumban (1.48 mg g-1) and Mallika $^($1.42 mg g^{-1}). Muvandan (1.30 mg g^{-1}) recorded the lowest total chlorophyll which was on par with Ratna (1.39 mg g^{-1}).

4.13 Performance analysis of genotypes under both normal and high-density planting system

In Prior the yield under HDP (20055.56 kg/ha) was significantly higher than those planted under normal planting density (5365.16 kg/ha). In Mallika the yield under HDP (22807.41 kg/ha) was significantly higher than those planted under normal planting density (3799.73 kg/ha). In Vellaikolumban the yield under HDP (13437.04 kg/ha) was significantly higher than those planted under normal planting density (4213.99 kg/ha). In Ratna the yield under HDP (19955.56 kg/ha) was significantly higher than those planted under normal planting density (3419.75 kg/ha). In Chandrakaran the yield under HDP (20318.52 kg/ha) was significantly higher than those planted under normal planting density (1491.08 kg/ha). In Muvandan the yield under HDP (7762.96 kg/ha) was significantly higher than those planted under normal planting density (5600.82 kg/ha) (Table 127).

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Table No.127 Performance analysis of genotypes under normal and high-density planting system (Yield kg/ha)

Prior				
	Mean Yield (kg/ha)	**SE(d)**	**SE(m)**	**t value**
Normal planting	5365.16	1224.37	408.12	
High density planting	20055.56	6606.99	2089.31	6.55
Mallika				
Normal planting	3799.73	2884.79	961.60	
High density planting	22807.41	11075.54	2859.69	5.01
Vellaikolumban				
Normal planting	4213.99	1447.78	482.59	
High density planting	13437.04	7688.89	1985.26	3.53
Ratna				
Normal planting	3419.75	1007.40	335.80	
High density planting	19955.56	9886.37	2552.65	4.96
Chandrakaran				
Normal planting	1491.08	361.46	120.49	
High density planting	20318.52	14126.90	3647.55	3.96
Muvandan				
Normal planting	5600.82	1346.32	448.77	
High density planting	7762.96	5001.21	1291.31	1.260

4.14 Experiment III - Development of a crop weather model for mango and screening of genotypes for climate resilience

Development of a crop weather model for mango and screening of genotypes for climate resilience in which crop weather models was developed using primary/secondary data on growth and environmental parameters to test the performance of different genotypes under varied weather conditions. Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using ECHAM model and the performance of the various genotypes under projected climatic conditions will be evaluated using the developed model.

4.15 Phenophasis of mango

Phenology is the study of relationship between the dates of first occurrence of biological events in their annual cycle with seasonal climate change. The factors like environmental and crop genotypes shows a significant effect on developmental stages of mango.

In this current study, the phenophases of mango was divided into three developmental stages based on their morphological characters.

The phenophasis of mango include:

1. Flower initiation
2. Fruit initiation
3. Fruit maturation

4.16 Weather parameters prevailed during crop growth period

Different weather parameters prevailed during the entire crop period was recorded. The weather parameters like maximum (Max), minimum (Min) and average temperature (Avg), forenoon (RH1) and afternoon (RH2) relative humidity, sunshine hours (SS Hrs), rainfall (Rain), rainy days, evaporation (Evp) and solar radiation (SRAD) were recorded daily and converted to weekly observation. The weather parameters were averaged against standard meteorological weeks which corresponds to different phenophases of crop growth.

4.17 Weather parameters during different phenophases

4.17.1 Crop weather relationship of genotypes during flower initiation

The weather experienced during 7^{th}, 15^{th} and 30^{th} day prior to flower initiation of 24 genotypes under normal planting system were displayed in Table 128a.

It was observed that in Arka Aruna RH1 and Mean RH was found to be positively and significantly correlated with the yield whereas SS Hrs and Evp was found to be negatively and significantly correlated with the yield. In Amrapali RH1, RH2, Mean RH, SS Hrs, Rainfall and rainy days were found to be positively and significantly correlated with the yield whereas TMax was found to be negatively and significantly correlated to the yield. In Mallika TMax, TMin, RH1, Mean RH, Rainfall and Rainy days were found to be positively and significantly correlated with the yield whereas TMin and Evp was found to be negatively and significantly correlated with the yield. In Ratna RH1 and MeanRH was positively and significantly correlated with the yield whereas SS Hrs and Evp was negatively and significantly correlated. In Sindhu TMax, RH1 where found to be positively and significantly correlated to the yield whereas TMin, Average Temperature, RH2 and Evp was found to be negatively and significantly correlated to the yield. In H45 TMin, RH1, RH2, MeanRH and rainy days were found to be positively and significantly correlated to the yield whereas total rainfall, Evp and SRAD were found to be negatively and significantly correlated. In H 151 RH1, RH2, MeanRH, SS Hrs, Rainfall and Rainy days were found to be positively and significantly correlated to the yield whereas, TMin, Avg and Evp were found to be negatively and significantly correlated to the yield. In PKM1, Total rain and rainy days were found to be positively and significantly correlated to the yield whereas TMax were found to be negatively and significantly correlated. In PKM2, RH1 was found to be positively and significantly correlated whereas Evp was found to be negatively and significantly correlated to the yield. In Neelgoa RH1 was found to be positively and significantly correlated whereas, Evp was found to be negatively and significantly correlated to the yield. In Banganappalli, RH2, MeanRH and rainy days were found to be positively and significantly correlated to the yield. In Alphonso, Rainfall and Rainy days were found to be positively and significantly correlated to the yield. In Dasheri

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Table 128a. Crop weather relationship of genotypes under normal planting during flower initiation

Genotypes	Days prior to flower initiation	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
		Tem. Max. °C	Tem. Min. °C	Tem. (Average) °C	RH% I	RH% II	Mean RH %					
Arka Aruna	7				.992**		.874**	-.692*			-.949**	
	15				.745*			-.896**			-.927**	
	30				.950**		.742*				-.983**	
Amrapali	7							.759*				
	15	-.857**			.732*	.846**	.786*			.723*		
	30								.753*	.933**		
Mallika	7	.674*	-.700*		.906**		.698*				-.985**	
	15										-.728*	
	30		-.698*		.744*				.705*	.828**		
Ratna	7				.954**		.992**				-.906**	
	15				.856**		.700*	-.793*			-.959**	
	30										-.980**	
Sindhu	7	.690*	-.690*		.952**		.802**				-.995**	
	15		-.975**	-.873**		-.959**	-.756*				-.966**	
	30				.876**						-.976**	
H45	7		.696*						-.796*		-.982**	-.967**
	15				.866**	.980**	.951**				-.769*	-.758*
	30				.847**	.967**	.920**			.896**	-.766*	-.761*
H151	7			-.702*	.788*	.925**	.856**		.983**	.981**	-.963**	
	15		-.699*	-.717*	.950**	.987**	.993**	.927**			.982**	.980**
	30	-.724*			.926**	.987**	.971**				-.732*	
PKM 1	7	-.680*							.710*	.710*		
	15	-.795*							.974**	.999**		
	30							.881**	.964**	.852**		
PKM 2	7				.729*	.929**	.908**	-.890**				
	15				.755*			-.748*			-.903**	
	30				.876**						-.976**	
Neelgoa	7				.986**		.939**				-.969**	
	15				.810**			-.865**			-.961**	
	30				.917**						-.988**	
Banganapalli	7	-.718*				.840**	.754*		.952**	.994**		
	15				.867**	.930**	.890**		.998**	.999**		
	30				.892**	.969**	.933**			.685*		
Alphonso	7					.921**			.841**	.936**		
	15		.850**					.980**	.998**	.992**	-.853**	-.863**
	30		.727*					.986**	.903**	.748*	.833**	
Dashehari	7					.708*					-.952**	
	15				-.843**		-.681*					
	30				-.801**	-.858**	-.852**	-.689*	-.991**	-.991**	-.769*	
Neelum	7					.815**					-.983**	
	15					.704*						
	30								-.948**	-.948**	-.799**	
Himayuddin	7	-.775*				.800**			.905**	.929**		
	15					.854**	.687*		.891**	.962**	-.760*	-.876**
	30				.673*	.833**	.755*		.891**	.981**		
Bennet Alphonso	7				-.883**	-.686*	-.778*	.820**	-.896**	-.685*		.690*
	15	.838**			-.959**	-.769*	-.878**	.949**		.958**	.740*	.736*
	30				-.861**		-.694*	.915**		.958**		
Kalepady	7	-.794*								.670*		
	15		.893**					.955**	.985**	.898**	-.790*	-.801**
	30		.783*					.972**	.970**	.972**	.921**	.920**
Swarnarekha	7				.761*	.947**	.954**	-.852**	.977**	.977**	-.709*	
	15				.960**	.979**	.970**		.859**	.859**		
	30				.687*	.744*	.711*			.747*		
Mulgoa	7					.913**			.979**	.866**		
	15				.980**	.897**	.960**				-.993**	-.995**
	30				.941**	.972**	.961**					
Tholikippan	7								-.760*		-.973**	-.952**
	15				.687*	.976**	.859**			.707*	-.863**	-.852**
	30		.941**			.711*		1.000**	.999**	.999**		
Chandrakaran	7					.736*				.892**		
	15		-.723*		.967**	.981**	.989**	-.728*	.925**	.985**		
	30		-.915**		.793*	-.686*		-.994**	-.998**	-.999**	-.990**	
Vellaikolumban	7	.735*						.710*	.777*			.693*
	15		.859**		-.739*	-.845**	-.810**			.705*	-.695*	-.699*
	30		.907**	.819**	-.764*	-.949**	-.894**		.808**		.994**	
Prior	7	-.738*							.693*	.736*		
	15		.893**					.955**	.985**	.898**	-.790*	-.801**
	30		.783*					.972**	.970**	.972**	.887**	
Muvandan	7				.987**		.919**				-.987**	
	15		-.951**	-.817**		-.821**						
	30		-.966**	-.823**		-.959**		.846**	-.977**	-.980**		

RH1, MeanRH and Evp was negatively and significantly correlated to the yield. In Neelum Evp was negatively and significantly correlated to the yield. In Himayuddin RH2, MeanRH, Rainfall and Rainy days were found to be positively and significantly correlated to the yield. In Bennet Alphonso RH1and MeanRH was found to be negatively and significantly correlated to the yield whereas, SS Hrs was found to be positively and significantly correlated to the yield. In Kalepady SS Hrs, Total Rain and Rainy days was found to be positively and significantly correlated to the yield. In swarnarekha RH2, MeanRH, Total rain and rainy days were found to be positively and significantly correlated to the yield. In Mulgoa RH2 was found to be positively and significantly correlated to the yield. In Tholikkaipan, Evp and SRAD was found to be negatively and significantly correlated to the yield. In Chandrakaran RH1was found to be positively and signifacnrly correlated to the yield whereas TMin and SS Hrs was found to be negatively and significantly correlated to the yield. In Vellaikolumban, TMax and TMin was found to be positively and significantly correlated whereas RH1 and RH2 was found to be negatively and significantly correlated to the yield. In Muvandan, TMin and Average Temperature and RH2 was found to be negatively and significantly correlated to the yield.

4.17.2 Crop weather relationship of genotypes during fruit initiation

The weather experienced during 7^{th}, 15^{th} and 30^{th} day prior to fruit initiation of 24 genotypes under normal planting system were displayed in Table 128b.

In Arka Aruna Evp was found to be positively and significantly correlated to yield. In Amrapali RH1 showed negative and significant correlated to yield. In Mallika, Average Temperature, RH1, RH2 and MeanRH was negatively and significantly correlated to yield. In Ratna Evp was found to be positively and significantly correlated to yield. In Sindhu RH1, RH2, MeanRH, Rainfall and Rainy days were negatively and significantly correlated to yield, whereas Evp was found to be positively and significantly correlated to yield. In H45, TMin and Average Temperature was found to be negatively and significantly correlated to yield. In H151, Evp was negatively and significantly correlated to yield. In PKM1, RH1, RH2, MenaRH, Rainfall and Rainy days was found to be negatively and significantly correlated to yield. Evp was found

Table 128b. Crop weather relationship of genotypes under normal planting during fruit initiation

Genotypes	Days prior to flower initiation	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
		Tem. Max. °C	Tem. Min. °C	Tem. (Average) °C	RH% I	RH% II	Mean RH %					
Arka Aruna	7		-.698*		-.670*			.727*			.999**	
	15					-.691*		.690*	-.988**	-.919**	.862**	
	30			.669*							.961**	
Amrapali	7				-.967**		-.724*	-.840**				-.803**
	15				-.981**	-.866**			-.992**	-.992**		
	30				-.849**	-.960**	-.921**	-.855**	-.992**	-.992**	-.834**	
Mallika	7		-.730*	-.799**	-.997**	-.960**	-.987**	.971**			.923**	
	15		-.875**	-.744*	-.994**	-.997**	-.996**	.942**			.892**	
	30				.728*			-.984**	.723*	.723*	-.977**	
Ratna	7	.771*										
	15		-.700*								.837**	
	30					-.871**	-.721*				.948**	
Sindhu	7	.764*		.747*	-.987**	-.922**	-.968**	.973**	-.997**	-.997**	.995**	.867**
	15	.779*	.834**	.817**	-.959**	-.985**	-.981**	.972**	-.997**	-.997**	.944**	.820**
	30	.765*			-.947**	-.910**	-.942**		-.998**	-.904**	.982**	
H45	7		-.960**	-.903**				-.924**				-0.66
	15		-.931**	-.741*		-.926**	-.735*	.777*				
	30								.679*		-.843**	
H151	7	-.790*				.967**		-.784*				
	15							.898**	-.900**	-.900**	-.668*	
	30										-.843**	
PKM 1	7				-.976**	-.928**	-.962**	.977**	-1.000**	-.710*	.997**	.883**
	15		.883**	.788*	-.910**	-.929**	-.923**	.940**	-.972**	-.710*	.991**	.797*
	30	.682*		.795*	-.921**	-.879**	-.911**		-.818**	-.710*	.995**	
PKM 2	7							-.918**				-.813**
	15							-.893**				-.700*
	30								-.841**	-.900**		
Neelgoa	7				-.931**	-.796*	-.888**	.914**	-.957**	-.957**	.995**	.835**
	15				-.795*		-.728*	.782*	-.711*	-.711*		.721*
	30				-.818**	-.790*	-.803**	.992**				.798**
Banganapalli	7	.819**				-.908**		-.983**				-.719*
	15					-.764*		-.971**			.915**	
	30	.700*				-.982**		.754*	-.881**	-.996**	.858**	
Alphonso	7				-.761*	-.690*	-.736*	.809**			.999**	
	15				-.843**	-.955**	-.893**	.864**	-.892**	-.892**	.977**	
	30				-.831**	-.754*	-.817**		-.999**	-.836**	.994**	
Dashehari	7					-.807**	-.702*	.734*				
	15								.922**	.991**		
	30								.871**	.991**	-.969**	
Neelum	7	-.688*	-.812**	-.752*			-.718*				-.934**	
	15				-.871**			-.918**			.671*	
	30		-.713*									
Himayuddin	7	.884**			.930**	-.916**	.787*	-.942**			-.993**	
	15				.824**		.913**					
	30				.937**	.855**	.984**		.965**	.965**	-.691*	
Bennet Alphonso	7			.788*	-.908**			-.847**	-.957**	-.957**		-.763*
	15				-.953**		-.867**	-.918**	-.956**	-.956**		-.677*
	30					-.938**	-.825**	-.971**	-.956**	-.956**	-.818**	
Kalepady	7	.767*		.788*	-.908**		-0.368	-.847**	-.957**	-.957**		-.763*
	15	.694*						-.878**				
	30				.728*			-.984**	.723*	.723*	-.977**	-0.578
Swarnarekha	7		.931**	.827**	-.750*	.940**		-.816**			.995**	-.721*
	15						-.784*	-.968**	-.683*	-.683*	.986**	-.698*
	30	.776*			-.771*	-.806**	-.805**	-.964**	-.683*	-.683*		
Mulgoa	7				-.914**	.839**		-.944**				-.908**
	15				-.989**	-.820**	-.963**		-.991**	-.991**	.679*	
	30				-.823**	-.965**	-.917**	-.763*	-.991**	-.991**	-.842**	
Tholikippan	7				-.978**		-.848**					
	15	.772*			-.817**	-.932**	-.973**		-.993**	-.993**		
	30					-.962**	-.850**		-.993**	-.993**	-.960**	
Chandrakaran	7		.863**	.730*	-.695*	.862**	-0.629	-.968**			.887**	-.929**
	15		-.788*		-.700*	-.960**	-.826**		-.863**	-.863**		
	30		-.921**	-.695*		-.783*	-.700*		-.863**	-.863**	-.981**	
Vellaikolumban	7			.841**	-.684*			-.997**				-.943**
	15	.891**			-.713*			-.949**				
	30	.869**			-.877**	-.928**	-.913**	-.968**	-.943**	-.943**		
Prior	7	.889**	-.838**		-.939**	-.930**	-.966**					
	15	.743*			.836**	-.794*					-.838**	
	30	.741*							-.748*	-.748*	-.880**	
Muvandan	7		-.822**	-.714*	-.949**	-.920**	-.937**	.931**			.947**	
	15											
	30								-.682*	-.764*		

to be positively and significantly correlated to yield. In PKM 2 SS Hrs and SRAD was negatively and significantly correlated to yield. In Neelgoa RH1 and MeanRH was negatively and significantly correlated to yield. SS Hrs showed positive and significant correlation to yield. In Banganappalli RH2 was negatively and significantly correlated to the yield. In Alphonso RH, RH2 and Mean RH was negatively and significantly correlated to the yield. Evp was positively and significantly correlated to the yield. In Dasheri rainfall and rainy days were positively and significantly correlated to the yield. In Himayuddin RH1 was positively and significantly correlated to the yield. In Bennet Alphonso Mean RH, SS Hrs, rainfall and rainy days were negatively and significantly correlated to the yield whereas TMax was positively and significantly correlated to the yield. In Kalepady SS Hrs was negatively and significantly correlated to the yield. In Swarnarekha SS Hrs was negatively and significantly correlated to the yield. In Mulgoa RH1 and RH2 was negatively and significantly correlated to the yield. In Tholikkaipan Mean RH was negatively and significantly correlated to the yield. In Chandrakaran TMin and RH2 was negatively and significantly correlated to the yield. In Vellaikolumban RH1 and SS Hrs was negatively and significantly correlated to the yield. In Prior, Evp was negatively and significantly correlated to the yield.

4.17.3 Crop weather relationship of genotypes during fruit maturation

The weather experienced during 7th, 15th and 30th day prior to fruit maturation of 24 genotypes under normal planting system were displayed in Table 128c. In Mallika RH2, Mean RH and Rainy days was negatively and significantly correlated to the yield. In Neelgoa, MeanRH, RH2, Total Rainfall and Rainy days were negatively and significantly correlated to the yield. In Dashehari SS Hrs, Evp and SRAD was negatively and significantly correlated to the yield. In Neelum, SS Hrs was negatively and significantly correlated to the yield. In Bennet Alphonso Evp and SRAD was negatively and significantly correlated to the yield. In Kalepady, Total Rainfall was positively and significantly correlated to the yield. In Swarnarekha, SS Hrs and SRAD was negatively and significantly correlated to the yield, whereas Rainfall was positively and significantly correlated to the yield. In Mulgoa Evp was negatively and significantly correlated to the yield. In Vellaikolumban, SSHrs was negatively and significantly correlated to the yield.

Table 128c. Crop weather relationship of genotypes under normal planting during fruit maturation

Genotypes	Days prior to flower initiation	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
		Tem. Max. °C	Tem. Min. °C	Tem. (Average) °C	RH% I	RH% II	Mean RH %					
Amrapali	7											
	15		-.815**			-.965**	-.906**					
	30											
Mallika	7	.849**		.732*	-.770*	-.832**	-.896**	.819**	-.988**	-.988**	.768*	.778*
	15					-.951**	-.855**			-.915**		
	30										-.999*	
Ratna	7									-.676*		
	15									-.676*		
	30											
Sindhu	7											
	15		-.729*		-.891**	-.944**	-.932**					
	30											
H45	7	.763*			-.864**						.762*	
	15	.729*										
	30											
H151	7											
	15								.805**			
	30											
PKM 1	7	.860**	-.711*		-.769*						.840**	
	15		-.823**								.784*	
	30											
Neelgoa	7					-.857**	-.723*		-.729*	-.968**		
	15					-.964**	-.895**		-.694*	-.968**		
	30											
Banganapalli	7					.926**						
	15											
	30										-.998*	
Alphonso	7				-.902**						.748*	
	15		-.745*	-.668*								
	30											
Dashehari	7							-.740*			-.899**	-.889**
	15					-.847**		-.984**	-.986**		-.986**	-.978**
	30											
Neelum	7							-.769*			-.754*	-.912**
	15							-.861**			-.945**	-.906**
	30											
Himayuddin	7											
	15	.704*										
	30											
Bennet Alphonso	7							-.908**			-.807**	-.906**
	15				-.873**		-.786*				-.749*	-.741*
	30											
Kalepady	7								.669*			
	15								.669*			
	30											
Swarnarekha	7							-.688*	.763*			-.719*
	15							-.705*	.763*			-.734*
	30											
Mulgoa	7											
	15							-.754*			-.841**	-.797*
	30										-1.000*	
Tholikippan	7				-.712*		-.700*					
	15		-.702*			-.702*						
	30											-1.000**
Chandrakaran	7	.833**		.684*	-.715*	-.877**	-.846**	.803**			.736*	.792*
	15	.684*										
	30										-1.000*	
Vellaikolumban	7	-.836**				.847**		-.883**		.784*	-.909**	-.877**
	15	-.749*			-.672*			-.972**			-.969**	-.971**
	30							-.999*				
Prior	7				-.670*			-.832**			-.817**	-.814**
	15				-.738*						-.753*	
	30											-.998*
Muvandan	7	.738*										
	15											
	30											

4.18.1 Crop weather relationship of genotypes during flower initiation (combined results)

The weather experienced during 7th, 15th and 30th day (combined results) prior to flower initiation of 24 genotypes under normal planting system were displayed in Table 129a. In Arka aruna RH1 and MeanRH was positively and significantly correlated to the yield whereas Evp was negatively and significantly correlated to the yield. In Amrapali RH2 Mean RH SSHrs Rainfall and Rainy days was positively and significantly correlated to the yield, whereas TMax was negatively and significantly correlated to the yield. In Mallika TMax and RH1 was positively and significantly correlated to the yield, whereas TMin and AVG Temp was negatively and significantly correlated to the yield. In Ratna RH1 and meanRH was positively and significantly correlated to the yield. In Sindhu, TMin Avg Temp in Evp was negatively and significantly correlated to the yield, whereas TMax RH1 and Mean RH was positively and significantly correlated to the yield. In H45, RH2 was positively and significantly correlated to the yield, whereas Evp and SRAD was negatively and significantly correlated to the yield. In H151, Rh1, Rh2, Mean Rh, Rainy days, Evp and SRAD was positively and significantly correlated to the yield, whereas TMax, TMin and Avg Temp was negatively and significantly correlated to the yield. In PKM 1, TMin, SS Hrs, Rainfall and rainy days was positively and significantly correlated to the yield, whereas TMax was neagtively and significantly correlated to the yield. In PKM2, Rh1 , Rh2 and Mean Rh was positively and significantly correlated to the yield, whereas SS Hrs and Evp was negatively and significantly correlated to the yield. In Neelgoa, Rh1 and Mean Rh was positively and significantly correlated to the yield, where as Evp was negatively and significantly correlated to the yield. In Banganappalli, Rh1 Rh2, Mean Rh, Total Rainfall and rainy days was positively and significantly correlated to the yield, whereas TMin was negatively and significantly correlated to the yield. In Alphonso TMin, Mean Rh, Rainfall and rainy days was positively and significantly correlated to the yield, whereas Evp and SRAD was negatively and significantly correlated to the yield. In Dashehari, SS Hrs, Total Rainfall and Rainy days was negatively and significantly correlated to the yield. In Neelum Rh2 was positively and significantly correlated to the yield, whereas SS Hrs, Total Rainfall and Rainy Days

Table 129a. Crop weather relationship of genotypes under normal planting during flower initiation (combined results)											
Genotype	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
	Tem. Max	Tem. Min	m. (Avera	RH%	RH%	Mean RH					
	°C	°C	°C	I	II	%					
Arka Aruna											
				.666**		.474*				-.676**	
Amrapali											
	-.607**				.615**	.416*	.459*	.400*	.492**		
Mallika											
	.473*	-.604**	-.414*	.572**							
Ratna											
	.486*	-.412*		.726**		.487**					
Sindhu											
	.424*	-.662**	-.549**	.780**		.545**				-.849**	
H45											
					.610**					-.683**	-.657**
H151											
	-.495**	-.463*	-.584**	.725**	.820**	.791**			.396*	.476*	.490**
PKM 1											
	-.438*	.577**					.416*	.779**	.778**		
PKM 2											
				.683**	.521**	.656**	-.445*			-.706**	
Neelgoa											
				.792**		.611**				-.786**	
Banganapalli											
		-.423*		.765**	.729**	.773**	-0.162	.489**	.637**		
Alphonso											
		.609**					.554**	.818**	.791**	-.402*	-.406*
Dashehari											
							-.453*	-.496**	-.496**		
Neelum											
					.486*		-.506**	-.474*	-.474*		-.453*
Himayuddin											
				.427*	.756**	.612**		.508**	.670**		-.381*
Bennet Alphonso											
	.679**		.390*	-.827**	-.602**	-.713**	.834**				
Kalepady											
	-.659**							.405*	.393*		
Swarnarekha											
	-.470*		-.558**	.513**	.784**	.681**	-.442*	.588**	.683**		
Mulgoa											
				.728**	.762**	.816**			.506**		
Tholikippan											
	-.384*	.409*			.545**					-.476*	-.473*
Chandrakaran											
		-.539**		.481*		.403*			.408*		
Vellaikolumban											
	.612**		.578**	-.649**	-.640**	-.647**	.405*				
Prior											
	-.659**	.646**		-.463*						-.475*	-.503**
Muvandan											
		-.435*			-.581**	-.438*		-.519**	-.521**		

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and SRAD were negatively and significantly correlated to the yield. In Himayuddin, Rh1, Rh2, Mean Rh, Rainfall and Rainy days was positively and significantly correlated to the yield, whereas SRAD was negatively and significantly correlated to the yield. In Bennet Alphonso, TMax, Avg Temp and SS Hrs was positively and significantly correlated to the yield, whereas Rh1, Rh2 and Mean Rh was negatively and significantly correlated to the yield. In Kalepady, Rainfall and Rainy days was positively and significantly correlated to the yield, whereas TMax, was negatively and significantly correlated to the yield. In Swarnarekha, Rh1, Rh2, Mean Rh, Total Rainfall and Rainy Days was positively and significantly correlated to the yield, whereas TMax, Avg Temp and SS Hrs was negatively and significantly correlated to the yield. In Mulgoa, Rh1, Rh2, Mean Rh and Rainy days was positively and and significantly correlated to the yield. In Tholikaippan, TMin , Rh2 was positively and significantly correlated to the yield, whereas TMax, Evp and SRAD was negatively and significantly correlated to the yield. In Chandrakaran, Rh1 , Mean Rh and Total Rainfall was positively and significantly correlated to the yield, whereas TMin was negatively and significantly correlated to the yield. In Vellaikolumban, Rh1 , Rh2 and Mean Rh was negatively and significantly correlated to the yield, whereas Avg Temp and SS Hrs was positively and significantly correlated to the yield. In Prior, TMax, Rh1, Evp and SRAD was negatively and significantly correlated to the yield, whereas TMin was positively and significantly correlated to the yield. In Muvandan Tmin, Rh2, Mean Rh , Rainfall and Rainy days was negatively and significantly correlated to the yield.

4.18.2 Crop weather relationship of genotypes during fruit initiation (combined results)

The weather experienced during 7th, 15th and 30th day (combined results) prior to fruit initiation of 24 genotypes under normal planting system were displayed in Table 129 b. In Arka Aruna, RH I, RH II, Mean RH, Rain fall and rainy days were negatively and significantly correlated to the yield, whereas Evp. was positively and significantly correlated to the yield. In Amrapali RH I, Mean RH, SS Hrs, Rain Fall, Rainy Days, SRAD was negatively and significantly correlated to the yield. In Mallika TMin, Avg. Temp., RH I, RH II, Mean RH and Rainfall was negatively and significantly related to

Table 129b. Crop weather relationship of genotypes under normal planting during fruit initiation (combined results)

Genotype	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
	Tem. Max °C	Tem. Min. °C	m. (Avera °C	RH% I	RH% II	Mean RH %					
Arka Aruna				-.623**	-.483*	-.592**		-.397*	-.490**	.764**	
Amrapali				-.855**		-.801**	-.611**	-.750**	-.750**		-.520**
Mallika		-.551**	-.505**	-.957**	-.838**	-.928**	.501**	-.389*		.720**	
Ratna	.471*	-.445*			-.567**	-.472*				.409*	
Sindhu	.471*	-.445*			-.567**	-.472*				.409*	
H45		-.853**	-.683**		-.432*					-.586**	
H151	-.414*			.471*	.420*	.465*				-.612**	
PKM 1	.522**	.574**	.672**	-.855**	-.783**	-.864**	.791**	-.593**	-.605**	.856**	.689**
PKM 2							-.725**	-.453*	-.616**		-.598**
Neelgoa	.494**			-.675**	-.527**	-.655**	.709**	-.533**	-.421*	.432*	.639**
Banganapalli	.503**				-.682**		-.408*	-.438*	-.458*	.672**	
Alphonso	0.337	-0.070	0.216	-.793**	-.726**	-.790**	.559**	-.785**	-.688**	.803**	.413*
Dashehari		-.419*						.691**	.748**		
Neelum		-.675**	-.640**	-.484*							
Himayuddin	.430*		.416*			.778**	-.395*	.461*	.461*	-.764**	
Bennet Alphonso	.806**		.590**	-.681**		-.610**	-.787**	-.956**	-.956**		-.638**
Kalepady	.610**	-.484*		.551**			-.888**			-.877**	-.426*
Swarnarekha				-.588**		-.582**	-.427*	-.578**	-.578**	.391*	
Mulgoa				-.614**	-.648**	-.788**		-.669**	-.669**		
Tholikippan	.496**			-.670**		-.485*	-.585**	-.605**	-.605**		
Chandrakaran		-.501**	-.415*	-.436*	-.806**	-.624**		-.721**	-.721**		
Vellaikolumban	.746**	.393*	.672**	-.550**			-.959**	-.413*	-.413*		-.788**
Prior	.724**	-.414*			-.580**			-.477*	-.477*	-.634**	
Muvandan								-.503**	-.458*	.424*	

the yield, whereas SS Hrs and Evp. was positively and significantly correlated to the yield. In Ratna TMax and Evp. was positively and significantly correlated to the yield, whereas TMin, RH II and Mean RH was negatively and significantly correlated to the yield. In Sindhu TMax and Evp was positively and significantly correlated to the yield whereas, TMin, RH II, and Mean RH are negatively and significantly correlated to the yield. In H45 TMin, Avg Temp, RH II and Evp are negatively and significantly correlated to the yield. In H 151, RH I, RH II and Mean RH are positively and significantly correlated to the yield, whereas, TMax and Evp are negatively and significantly correlated to the yield. In PKM 1, TMax, TMin, Avg Temp, SS Hrs, Evp and SRAD are positively and significantly correlated to the yield, whereas RH I, RH II, Mean RH and Rainfall are negatively and significantly correlated to the yield. In PKM2, SS Hrs, Rainfall, Rainydays, and SRAD are negatively and significantly correlated to the yield. In Neelgoa, TMax, SS Hrs and Evp are positively and significantly correlated to the yield, whereas RH I, RH II, Mean RH, Rainfall and Rainy days were negatively and significantly correlated to the yield. In Banganappalli, TMax and Evp was positively and significantly correlated to the yield, whereas RH II, SS Hrs, Rainfall and Rainy days were negatively and significantly correlated to the yield. In Alphonso, RH I, RH II and Mean RH, Rainfall and Rainy Days were negatively and significantly correlated to the yield, whereas SS Hrs, Evp and SRAD are positively and significantly correlated to the yield. In Dasheri TMin was negatively and significantly correlated to the yield, whereas Rainfall and Rainy Days were positively and significantly correlated to the yield. In Neelum, TMin, Avg Temp and RH I are negatively and significantly correlated to the yield. In Himayuddin, TMax, Avg Temp, Mean RH, Rainfall and Rainy Days are positively and significantly correlated to the yield, whereas SS Hrs and Evp are negatively and significantly correlated to the yield. In Bennet Alphonso, TMax, Avg Temp were positively and significantly correlated to the yield, whereas, RH I, Mean RH, SS Hrs, Rainfall, Rainy Days and SRAD are negatively and significantly correlated to the yield. In Kalepady, TMax, RH I were positively and significantly correlated to the yield, whereas TMin, SS Hrs, Evp and SRAD are negatively and significantly correlated to the yield. In Swarnarekaha RHI, Mean RH SS Hrs, Rainfall and Rainy days, were negatively and significantly correlated to the yield , whereas Evp were positively and significantly correlated to the yield. In

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Table 129c. Crop weather relationship of genotypes under normal planting during fruit maturation (combined results)

Genotype	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
	Tem. Max	Tem. Min.	m. (Avera	RH%	RH%	Mean RH					
	°C	°C	°C	I	II	%					
Amrapali											
		-.603**						.419*	.422*		
Mallika											
	.527**			-.568**	-.851**	-.824**			-.574**		
Ratna											
	.433*				-.466*				-.458*		
Sindhu											
		-.520**			-.407*	-.400*	-.452*	.457*			-.421*
H45											
	.596**	-.482*		-.556**		-.493**				.448*	
H151											
							-.455*				-.486*
PKM 1											
	.565**	-.672**		-.705**	-.561**	-.650**				.752**	
PKM 2											
						.444*	-.426*	-.498**	-.441*	-.605**	
Neelgoa											
	.507**	-.424*			-.682**	-.581**			-.641**		
Banganapalli											
		.432*	.428*		.463*		-.543**				-.479*
Alphonso											
		-.507**		-.646**		-.437*				.556**	
Dashehari											
		-.434*	-.426*		-.468*		-.776**			-.891**	-.878**
Neelum											
							-.762**			-.840**	-.871**
Himayuddin											
	.569**										
Bennet Alphonso											
				-.506**			-.744**			-.534**	-.738**
Kalepady											
		-.387*							-.488**		
Swarnarekha											
							-.631**				
Mulgoa											
							-.631**				-.677**
Tholikippan											
	.396*	-.560**			-.452*	-.418*					
Chandrakaran											
	.589**		.386*		-.462*		.407*			.397*	
Vellaikolumban											
	-.468*						-.822**			-.733**	-.817**
Prior											
							-.641**			-.482*	-.607**
Muvandan											
		-.394*									

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Mulgoa, RH I, RH II, Mean RH, Rainfall and Rainy Days were negatively and significantly correlated to the yield. In Tholikkaippan, TMax were positively and significantly correlated to the yield, whereas, RH I, Mean RH, SS Hrs, Rainfall and Rainy Days were negatively and significantly correlated to the yield. In Chadrakaran, TMin, Avg Temp, RH I, RH II, Mean Rh , Rainfall and Rainy Days, were negatively and significantly correlated to the yield. In Vellaikolumban, TMax, TMin and Avg Temp were positively and significantly correlated to the yield, whereas RH I, Rainfall, SRAD and Rainy Days were negatively and significantly correlated to the yield. In Prior, TMax was postitively and significantly correlated to the yield, whereas TMin, RH II, Rainfall, Rainy Days and Evp are negatively and significantly correlated to the yield. In Muvandan, Evp was positively and significantly correlated to the yield, whereas Rainfall and Rainy Days were negatively and significantly correlated to the yield.

4.18.3 Crop weather relationship of genotypes during fruit maturation (combined results)

The weather experienced during 7th, 15th and 30th day (combined results) prior fruit maturation of 24 genotypes under normal planting system were displayed in Table 129 c. In Amrapali, Rainfall and Rainy Days were positively and significantly correlated to the yield, whereas TMin were negatively and significantly correlated to the yield. In Mallika, Tmax was positively and significantly correlated to the yield, whereas RH I, RH II, Mean RH and Rainy Days were negatively and significantly correlated to the yield. In Ratna, RH II and Rainy Days were negatively and significantly correlated to the yield, whereas TMax were positively and significantly correlated to the yield. In Sindhu, TMin, RH II, Mean RH, SS Hrs and SRAD are negatively and significantly correlated to the yield, whereas Total Rainfall were positively and significantly correlated to the yield. In H 45, TMax and Evp are positively and significantly correlated to the yield, whereas TMin, RH I and Mean RH are negatively and significantly correlated to the yield. In H 151, SS Hrs and SRAD are negatively and significantly correlated to the yield. In PKM 1, TMax and Evp are positively and significantly correlated to the yield, whereas TMin , RH I, RH II and Mean RH are negatively and significantly correlated to the yield. In PKM 2, MeanRH was positively and significantly correlated to the yield, whereas SS Hrs, Rainfall, Rainy Days and Evp are negatively and significantly correlated to the yield. In Neelgoa, TMax was positively and significantly correlated to the yield, whereas TMin, RH II, Mean RH and Rainy Days are negatively and significantly correlated to the yield. In Banganappalli, TMin, Avg Temp, RH II were positively and significantly correlated to the yield, whereas SS Hrs and SRAD are negatively and significantly correlated to the yield. In Alphonso, TMin , RH I and Mean RH are negatively and significantly correlated to the yield, whereas, Evp was positively and significantly correlated to the yield. In Dashehari, TMin, Avg Temp, RH II, SS Hrs, Evp and SRAD are negatively and significantly correlated to the yield. In Neelum SS Hrs, Evp and SRAD are negatively and significantly correlated to the yield. In Himayuddin, TMax was positively and significantly correlated to the yield. In Bennet Alphonso, RH I, SS Hrs, Evp and SRAD are negatively and significantly correlated to the yield. In Kalepady, TMin and Rainy Days are negatively and significantly correlated to the yield. In Swarnarekaha, SS Hrs and SRAD are negatively and significantly correlated to the yield. In Mulgoa, SS Hrs and SRAD are neagtively and significantly correlated to the yield. In Tholikkaipan, RH II and Mean Rh are negatively and significantly correlated to the yield. In Chandrakaran, TMax, Avg Temp, SS Hrs and Evp are positively and significantly correlated to the yield, whereas RH II was negatively and significantly correlated to the yield. In Vellaikolumban, TMax, SS Hrs, Evp and SRAD are negatively and significantly correlated to the yield. In Prior, SS Hrs, Evp and SRAD are negatively and significantly correlated to the yield. In Muvandan, TMin was negatively and significantly correlated to the yield.

4.19.1. Prediction of yield under normal planting system during flower initiation (7 days prior to flowering):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 130 a.

Table 130 a Prediction of yield under normal planting system during flower initiation (7 days prior to flowering)

Sl. no.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Mallika	y = 237.906-9.450*TMin	0.416	30.58	21.94		
	2030					23.23	18.38
	2040					23.50	15.83
	2050					23.79	13.09
2	Sindhu	y = -920.531+29.177*TMax	0.401	36.71	32.52		
	2030					36.92	156.68
	2040					37.13	162.81
	2050					37.41	170.98
3	H 151	y = 7.4+0.096*TR	0.961	9.87	25.60		
	2030					33.93	10.66
	2040					44.90	11.71
	2050					26.31	9.93
4	Banganapalli	y = 106.076-2.907*TMax	0.446	13.19	32.64		
	2030					33.35	9.13
	2040					33.68	8.17
	2050					33.96	7.35
5	Alphonso	y = 12.193+2.369*TR	0.666	20.37	1.46		
	2030					25.95	73.67
	2040					25.23	71.96
	2050					14.76	47.16
6	Himayuddin	y =13.063+0.639*TR	0.792	14.95	4.07		
	2030					22.34	27.34
	2040					19.64	25.61
	2050					13.69	21.81
7	Swarnarekha	y = 9.521+0.639*TR	0.948	8.48	3.81		
	2030					26.24	26.29
	2040					25.28	25.67
	2050					16.21	19.88
8	Mulgoa	y = 3.968+2.398*TR	0.953	13.08	2.35		
	2030					26.67	67.92
	2040					25.44	64.97
	2050					16.16	42.72
9	Tholikaippan	y =53.331-0.272*SRAD	0.893	29.95	41.55		
	2030					18.91	48.19
	2040					19.07	48.14
	2050					19.65	47.99
10	Vellaikolamban	y = -317.957+10.898*TMax	0.474	21.74	32.29		
	2030					32.23	33.29
	2040					32.66	37.97
	2050					32.74	38.84
11	Prior	y = 334.350-9.086*TMax	0.480	22.51	32.05		
	2030					33.13	33.33
	2040					33.53	29.70
	2050					33.76	27.61

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

In Mallika, as the temperature increased in the scenario the predicted yield tends to decrease. In Sindhu there was a positive increase in the predicted yield in spite of an increase in TMax. In H45, the predicted yield tend to increase in spite of a rise in TMin. In H151, the predicted yield increase due to an increase in rainfall. In Banganappalli, the predicted yield decreased due to an increase in TMax. In Alphonso, the predicted yield increased as there was in increase in rainfall. In Himayyudin, the predicted yield increased as there was an increase in rainfall. In Swarnarekaha, the predicted yield increased as there was an increase in rainfall. In Mulgoa, the predicted yield increased as there was an increase in rainfall .The increase in predicted yield in Tholikkaipan was due to the increase in SRAD. In Vellaikolumban, the predicted yield increased inspite there was an increase in TMax. In Prior, the predicted yield increased in spite of the increase in TMax.

4.19.2. Prediction of yield under normal planting system during flower initiation (15 days prior to flowering):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 130 b.

In Sindhu, the predicted yield decreased as there was an increase in TMin. In H45, the predicted yield increased in spite of the decrease in SRAD. In H151, PKM1, Banganappalli, Alphonso, Himayuddin and Swarnarekha the predicted yield increased as there was an increase in Total Rainfall. In Bennet Alphonso, the predicted yield increased in spite of the increase in TMax. In Kalepady, Vellaikoluban and Prior the predicted yield increased inspite of an increase in TMin. In Mulgoa and Tholikaippan, the predicted yield increased inspite of a decrease in SRAD. In Chandrakaran and Muvandan, the predicted yield decreased as TMin increased.

4.19.3. Prediction of yield under normal planting system during flower initiation (30 days prior to flowering):

Table 130b. Prediction of yield under normal planting system during flower initiation (15 days prior to flowering)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Sindhu	y = 205.976-8.180*TMin	0.768	36.710	21.850		
	2030					23.43	14.32
	2040					23.69	12.19
	2050					23.98	9.82
2	H45	y = 41.863-0.083*SRAD	0.514	34.390	90.090		
	2030					18.24	40.35
	2040					18.69	40.31
	2050					18.98	40.29
3	H 151	y = 5.976+0.054*TR	0.345	9.870	72.270		
	2030					118.99	12.40
	2040					129.43	12.97
	2050					113.31	12.09
4	PKM1	y = 0.307+0.475*TR	0.942	17.220	31.370		
	2030					57.31	27.53
	2040					65.08	31.22
	2050					47.53	22.88
5	Banganapalli	y = 9.547+0.368*TR	0.995	13.190	9.900		
	2030					47.89	27.17
	2040					50.89	28.27
	2050					39.47	24.07
6	Alphonso	y = 9.547+0.368*TR	0.995	20.370	31.630		
	2030					57.37	30.66
	2040					62.28	32.47
	2050					46.06	26.50
7	Himayuddin	y = 9.547+0.369*TR	0.995	14.950	13.410		
	2030					54.84	29.78
	2040					45.23	26.24
	2050					34.66	22.34
8	Bennet Alphonso	y = -240.624+8.388*TMax	0.660	28.960	32.140		
	2030					31.83	26.37
	2040					32.14	28.97
	2050					32.39	31.06
9	Kalepady	y = -354.919+16.922*Tmin	0.768	22.510	22.300		
	2030					24.15	53.75
	2040					24.34	56.96
	2050					24.70	63.05
10	Swarnarekha	y = 4.305+0.340*TR	0.701	8.480	12.260		
	2030					57.56	23.88
	2040					58.78	24.29
	2050					44.25	19.35
11	Mulgoa	y = 20.942-0.047*SRAD	0.989	13.080	166.340		
	2030					18.40	20.08
	2040					18.83	20.06
	2050					19.16	20.04
12	Tholikaippan	y = 44.869-0.078*SRAD	0.687	29.950	89.760		
	2030					18.19	43.45
	2040					18.72	43.41
	2050					18.97	43.39
13	Vellaikolamban	y =-296.617+14.273*TMin	0.700	21.740	22.300		
	2030					25.27	64.06
	2040					25.69	70.06
	2050					25.98	74.20
14	Prior	y = -354.919+16.922*TMin	0.768	22.510	22.300		
	2030					24.15	53.75
	2040					24.34	56.96
	2050					24.70	63.05

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

Table 130c. Prediction of yield under normal planting system during flower initiation (30 days prior to flowering)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Amrapalli	y = 0.648+0.565*TR	0.505	22.62	38.89		
	2030					156.35	88.99
	2040					166.72	94.84
	2050					135.43	77.17
2	H 151	y = 178.163-5.222*TMax	0.457	9.87	32.22		
	2030					31.48	13.77
	2040					31.77	12.26
	2050					31.99	11.11
3	PKM1	y = -7.736+0.532*TR	0.919	17.22	46.93.		
	2030					157.79	76.21
	2040					153.21	73.77
	2050					140.30	66.90
4	Alphonso	y = -188.894+9.408*TMin	0.462	20.37	22.24		
	2030					24.42	40.85
	2040					24.63	42.83
	2050					25.00	46.31
5	Dashehari	y = 47.693-2.017*TR	0.98	31.8	7.88		
	2030					3.00	41.64
	2040					2.59	42.47
	2050					2.15	43.36
6	Neelum	y = 17.057-0.721*TR	0.883	11.37	7.88		
	2030					2.87	14.99
	2040					2.60	15.18
	2050					2.16	15.50
7	Himayuddin	y = 6.910+0.162**TR	0.764	14.95	49.48		
	2030					139.56	29.52
	2040					140.99	29.75
	2050					128.74	27.77
8	Kalepady	y = -282.687+13.735*TMin	0.557	22.51	22.22		
	2030					24.36	51.90
	2040					24.59	55.06
	2050					24.95	60.00
9	Tholikaippan	y =-171.665+9.022*TMin	0.773	29.95	22.35		
	2030					24.28	47.39
	2040					24.51	49.46
	2050					24.89	52.89
10	Vellaikolamban	y = 13.812+0.045*TR	0.603	21.74	177.14		
	2030					307.80	27.66
	2040					288.65	26.80
	2050					286.06	26.68
11	Prior	y = -262.687+13.735*TMin	0.557	22.51	22.22		
	2030					24.37	72.03
	2040					24.59	75.06
	2050					24.95	80.00
12	Muvandan	y = 27.670-0.261*TR	0.948	15.46	46.77		
	2030					0.34	27.58
	2040					0.90	27.44
	2050					0.63	27.51

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 130 c.

In Amrapali, PKM 1, Himayuddin and Vellaikolumban the predicted yield increased due to an increase in Rainfall. In H 151, the predicted yield as the TMax decreased. In Alphonso, Kalepady, Tholikaippan and Prior the predicted yield increased inspite of an increase in TMin. In Dashehari, Neelum and Muvandan the predicted yield increased inspite of a decrease in rainfall.

4.19.4. Prediction of yield under normal planting system during fruit initiation (7 days prior to fruit initiation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 131 a.

In Arka Aruna, H45 and Chandrakaran, the predicted yield decreased as there was an increase in TMin. In Ratna, Sindhu, Neelum, Himayyudin, Bennet Alphonso, Kalepady and Prior the predicted yield increased in spite of an increase in TMax. In PKM 1 the predicted yield increased inspite of a decrease in rainfall. In Muvandan and Swarnarekha, the predicted yield increased inspite of an increase in TMin. In PKM 2 and Neelgoa, the predicted yield decreased as solar radiation increased and in Mulgoa, the yield decreased as the solar radiation decreased. In Banganappalli, the yield decreased as the TMax increased.

4.19.5. Prediction of yield under normal planting system during fruit initiation (15 days prior to fruit initiation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of

Thale 131a. Prediction of yield under normal planting system during fruit initiation (7 days prior to fruit initiation)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Arka Aruna	y =61.048-2.245*TMin	0.415	8.61	23.36		
	2030					24.56	5.91
	2040					24.90	5.15
	2050					25.26	4.34
2	Amrapalli	y =116.802-5.176*SRAD	0.594	22.62	18.2		
	2030					24.94	-12.29
	2040					24.98	-12.49
	2050					25.01	-12.65
3	Ratna	y =-248.638+7.571*TMax	0.536	27.52	36.48		
	2030					36.44	27.25
	2040					36.69	29.14
	2050					37.03	31.72
4	Sindhu	y =-775.713+22.713*TMax	0.524	36.71	35.4		
	2030					36.05	43.09
	2040					36.28	48.31
	2050					36.61	55.81
5	H45	y =232.515-8.941*TMin	0.911	34.39	21.71		
	2030					23.13	25.71
	2040					23.35	23.74
	2050					24.17	16.41
6	PKM1	y =20.279-1.787*TR	0.999	17.22	4.84		
	2030					1.85	16.97
	2040					1.40	17.78
	2050					1.82	17.03
7	PKM 2	y =53.235-1.903*SRAD	0.612	36.71	21.73		
	2030					25.77	4.19
	2040					25.85	4.04
	2050					26.13	3.51
8	Neelgoa	y =-62.221+3.442*SRAD	0.653	28.10	22.04		
	2030					25.98	27.20
	2040					26.11	27.65
	2050					26.19	27.92
9	Banganapalli	y =-61.195+2.017*TMax	0.623	13.19	35.89		
	2030					36.24	11.90
	2040					36.48	12.39
	2050					36.82	13.07
10	Neelum	y =-61.195+2.017*TMax	0.623	11.37	35.39		
	2030					36.28	11.98
	2040					36.55	12.53
	2050					36.91	13.25
11	Himayuddin	y =-147.593+4.897*TMax	0.65	14.95	33.34		
	2030					35.90	28.21
	2040					36.10	29.19
	2050					36.40	30.66
12	Bennet Alphonso	y =-292.519+9.611*TMax	0.53	28.96	33.45		
	2030					36.38	57.13
	2040					36.58	59.05
	2050					36.92	62.32
13	Kalepady	y =-828.321+25.601*TMax	0.726	22.51	33.47		
	2030					35.90	90.75
	2040					36.10	95.88
	2050					36.39	103.30
14	Swarnarekha	y =-32.870+1.917*Tmin	0.723	8.48	23.38		
	2030					23.40	11.99
	2040					23.61	12.39
	2050					23.93	13.00
15	Mulgoa	y = 28.023-0.999**SRAD	0.799	13.08	18.44		
	2030					25.06	2.99
	2040					25.11	2.94
	2050					25.13	2.92
16	Chandrakaran	y = -17.177+1.248*TMin	0.709	20.73	23.37		
	2030					23.36	11.98
	2040					23.57	12.24
	2050					23.88	12.63
17	Vellaikolamban	y =109.172-4.155*SRAD	0.873	21.74	18.11		
	2030					24.70	6.54
	2040					24.74	6.38
	2050					24.76	6.29
18	Prior	y = -263.260+9.179**TMax	0.735	22.51	33.39		
	2030					35.99	67.09
	2040					36.19	68.93
	2050					36.49	71.68
19	Muvandan	y = 305.295-11.005*TMin	0.63	15.46	23.64		
	2030					24.58	34.79
	2040					24.24	38.53
	2050					24.59	34.68

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 131 b.

In Amrapali, H 151 and Mulgoa the yield increased inspite of a decrease in total rainfall. In Ratna, Sindhu, H45 and Chandrakaran, the yield decreased as there was an increase in TMin. In PKM1, PKM 2 and Bennet Alphonso, the predicted yield decreased as SRAD decreased. In Neelgoa and Alphonso, the predicted yield increased as SRAD increased. In Dashehari, the precited yield increased as there was an increase in Rainfall. In Kalepady, Tholikkaipan, Vellaikolumban and Prior, the predicted yield increased inspite of an increase in TMax.

4.19.6. Prediction of yield under normal planting system during fruit initiation (30 days prior to fruit initiation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 131 c.

In Amrapali, Sindhu, PKM1and Banganappalli the predicted yield increased in spite of an increase in TMax. In Mallika, H45, Bennet Alphonso Kalepady, Mulgoa, Tholikkaipan, Chandrakaran and Muvandan, the predicted yield increased in spite of a decrease in rainfall. In Neelum, Vellaikolumban and Prior the predicted yield increased in spite of an increase in TMin. In H 151, PKM 2, Neelgoa and Himayuddin the predicted yield decreased as there was a decrease in rainfall. In Alphonso the yield decreased as there was an increase in TMax. In Swarnarekha thepredicted yield decreased when the rainfall increased. In Dashehari, the yield increased as the rainfall increased.

4.19.7. Prediction of yield under normal planting system during fruit maturation (7 days prior to fruit maturation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of

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Table 131b. Prediction of yield under normal planting system during fruit initiation (15 days prior to fruit initiation)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Arka Aruna	y = 10.894-0.408*TR	0.973	8.610	5.600		
	2030					6.11	8.40
	2040					3.41	9.50
	2050					1.71	10.20
2	Amrapalli	y = 33.930-1.435*TR	0.982	22.620	7.880		
	2030					2.40	30.49
	2040					1.17	32.25
	2050					1.70	31.49
3	Raina	y = 160.880-5.663*TMin	0.418	27.520	23.550		
	2030					24.78	20.55
	2040					25.14	18.51
	2050					25.55	16.19
4	Sindhu	y = 160.880-5.663*Tmin	0.418	36.710	22.600		
	2030					24.08	24.51
	2040					24.38	22.82
	2050					24.74	20.78
5	H45	y = 160.880-5.663*TMin	0.418	34.390	21.870		
	2030					23.00	30.63
	2040					23.23	29.33
	2050					24.03	24.80
6	H 151	y = 11.493-0.468**TR	0.783	9.870	7.880		
	2030					1.29	10.89
	2040					0.87	11.09
	2050					1.15	10.95
7	PKM1	y = -64.591+3.489*SRAD	0.583	17.220	21.850		
	2030					25.30	23.68
	2040					25.38	23.96
	2050					25.46	24.24
8	PKM 2	y = 60.031-2.182*SRAD	0.417	36.710	22.080		
	2030					25.94	3.43
	2040					26.08	3.12
	2050					26.24	2.78
9	Neelgoa	y = -125.985+6.586*SRAD	0.451	28.100	21.740		
	2030					25.57	42.42
	2040					25.66	43.01
	2050					25.76	43.67
10	Alphonso	y = -125.985+6.586*SRAD	0.451	20.370	22.130		
	2030					25.94	44.86
	2040					26.08	45.78
	2050					26.17	46.37
11	Dashehari	y = 6.259+4.910*TR	0.829	31.800	5.200		
	2030					16.90	89.24
	2040					17.64	92.87
	2050					19.13	100.19
12	Bennet Alphonso	y = 89.111-3.125*SRAD	0.381	28.960	19.240		
	2030					24.79	11.64
	2040					24.84	11.49
	2050					24.87	11.39
13	Kalepady	y = -594.708+18.851*TMax	0.407	22.510	33.270		
	2030					35.95	82.99
	2040					36.15	86.76
	2050					36.44	92.22
14	Mulgoa	y = 33.848-1.431*TR	0.980	13.080	7.880		
	2030					1.96	31.04
	2040					0.99	32.43
	2050					1.66	31.47
15	Tholikaippan	y = -234.316+7.986*TMax	0.539	20.730	33.520		
	2030					36.15	54.38
	2040					36.35	55.98
	2050					36.66	58.45
16	Vellaikolamban	y = -220.916+7.538**TMax	0.764	22.510	33.270		
	2030					36.12	51.36
	2040					36.33	52.94
	2050					36.63	55.20
17	Prior	y =-220.916+7.538**TMax	0.764	15.460	33.380		
	2030					35.98	50.30
	2040					36.18	51.81
	2050					36.47	53.99

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

131c. Prediction of yield under normal planting system during fruit initiation (30 days prior to fruit initiation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Amrapali	y =-220.916+7.538**TMax	0.764	22.62	33.54		
	2030					36.10	51.21
	2040					36.30	52.71
	2050					36.61	55.05
2	Mallika	y =54.825-4.409*TR	0.861	30.58	5.5		
	2030					7.80	20.43
	2040					5.07	32.47
	2050					4.84	33.49
3	Sindhu	y =-833.692+24.998*TMax	0.526	36.71	35.34		
	2030					36.20	71.24
	2040					36.42	76.74
	2050					36.74	84.73
4	H45	y =32.625+58.073*TR	0.383	34.39	13.38		
	2030					1.73	133.09
	2040					2.28	165.03
	2050					1.87	141.22
5	H 151	y =4.231+0.136*TR	0.72	9.87	25.14		
	2030					1.75	4.47
	2040					2.13	4.52
	2050					1.97	4.50
6	PKM1	y =-281.489+8.457*TMax	0.389	17.22	34.66		
	2030					36.14	24.15
	2040					36.36	26.01
	2050					36.67	28.63
7	PKM 2	y =16.152-0.321*TR	0.666	36.71	13.35		
	2030					10.96	12.63
	2040					8.55	13.41
	2050					7.37	13.79
8	Neelgoo	y =16.152-0.321*TR	0.666	28.10	13.38		
	2030					13.40	11.85
	2040					11.18	12.56
	2050					12.28	12.21
9	Banganapalli	y =-128.420+4.029*TMax	0.417	13.19	34.96		
	2030					36.20	17.43
	2040					36.42	18.32
	2050					36.75	19.65
10	Alphonso	y = -128.420+4.029*TMax	0.417	20.37	34.78		
	2030					36.18	17.35
	2040					36.42	18.32
	2050					36.74	19.61
11	Dashehari	y =9.477+3.622*TR	0.724	31.80	6.09		
	2030					27.36	108.57
	2040					27.03	107.38
	2050					29.90	117.77
12	Nochon	y =224.216-4.905*TMin	0.439	11.37	23.9		
	2030					25.47	101.73
	2040					25.84	103.07
	2050					26.29	104.70
13	Himayuddin	y =9.936+1.834*TR	0.921	14.95	1.92		
	2030					1.28	12.28
	2040					2.06	13.71
	2050					1.61	12.89
14	Bennet Alphonso	y =33.848-0.619*TR	0.902	28.96	7.88		
	2030					2.09	32.55
	2040					2.50	32.30
	2050					2.32	32.41
15	Kalepody	y =24.592+4.095*TR	0.455	22.51	1.92		
	2030					1.28	29.83
	2040					2.06	33.03
	2050					1.61	31.18
16	Swarnarekha	y =16.152-0.321*TR	0.546	8.48	7.88		
	2030					36.08	4.57
	2040					36.28	4.51
	2050					36.58	4.41
17	Mulgoa	y =33.848-1.431*TR	0.98	13.08	7.88		
	2030					2.65	30.06
	2040					2.87	29.74
	2050					2.81	29.83
18	Tholikappan	y =36.996-0.461*TR	0.984	29.95	7.88		
	2030					2.19	35.99
	2040					2.60	35.80
	2050					2.33	35.92
19	Chandrakaran	y =36.996-0.461*TR	0.984	20.73	7.88		
	2030					2.20	35.98
	2040					2.70	35.75
	2050					2.84	35.69
20	Vellaikolamban	y =52.379-1.022*TMin	0.715	21.74	22.04		
	2030					22.98	28.89
	2040					23.22	28.65
	2050					23.52	28.34
21	Prior	y =52.379-1.022*TMin	0.715	22.51	21.69		
	2030					22.92	28.95
	2040					23.16	28.71
	2050					23.45	28.41
22	Muvandan	y =32.514-1.117*TR	0.388	15.46	13.35		
	2030					9.82	21.55
	2040					4.47	27.52
	2050					3.32	28.81

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 132 a.

In Neelgoa, the predicted yield decreased as there was a decrease in rainfall. In Dashehari, Neelum, Vellaikolumban and Prior the predicted yield decreased when the solar radiation increased. In Chadrakaran, the predicted yield decreased as the TMax increased. In Kalepady and Swarnarekaha the predicted yield increased when the total rainfall increased. In Muvandan, the yield increased when SRAD increased.

4.19.8. Prediction of yield under normal planting system during fruit maturation (15 days prior to fruit maturation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 132 b.

In H45 the predicted yield increased inspite of an increase in TMax. In H 151 and Kalepady the yield increased as the total rainfall increased. In Neelgoa, the predicted yield decreased when the total rainfall increased. In Alphonso and Tholikkaipan the predicted yield as the TMin increased. In Himayuddin and Chandrakaran the predicted yield decreased as TMax increased. In Swarnarekha and Mulgoa the precited yield decreased when SRAD increased.

4.19.9. Prediction of yield under normal planting system during fruit maturation (30 days prior to fruit maturation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 132 c.

In Tholikkaipan, the predicted yield decreased when SRAD decreased.

Thale 132a. Prediction of yield under normal planting system during fruit maturation (7 days prior to fruit maturation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	H45	y=-429.161+12.796*TMax	0.522	34.39	36.56		
	2030					35.99	31.37
	2040					36.24	34.57
	2050					36.59	39.04
2	Neelgoa	y=24.221-0.674*TR	0.464	28.1	15.57		
	2030					8.60	18.42
	2040					9.72	17.67
	2050					7.06	19.46
3	Dashehari	y=249.157-10.512**SRAD	0.761	31.8	20.66		
	2030					22.50	12.64
	2040					22.57	11.90
	2050					23.30	4.23
4	Neelum	y=119.372-5.099**SRAD	0.807	11.37	21.17		
	2030					21.06	11.99
	2040					21.13	11.63
	2050					21.80	8.21
5	Kalepady	y=18.917+11.027*TR	0.369	22.51	0.89		
	2030					5.14	75.60
	2040					6.03	85.41
	2050					5.39	78.35
6	Swarnarekha	y=9.578+3.530*TR	0.522	8.48	0.7		
	2030					6.00	30.76
	2040					5.22	28.00
	2050					6.08	31.04
7	Chandrakaran	y=-56.573+1.892*TMax	0.693	20.73	36.28		
	2030					35.01	9.67
	2040					35.26	10.14
	2050					35.60	10.78
8	Vellaikolamban	y=148.827-5.737*SRAD	0.736	21.74	19.99		
	2030					25.55	2.25
	2040					25.63	1.79
	2050					25.53	2.36
9	Prior	y= 154.183-5.401*SRAD	0.615	22.51	20.5		
	2030					26.07	13.38
	2040					26.16	12.89
	2050					25.86	14.51
10	Muvandan	y=154.169-4.682*SRAD	0.79	15.46	23.24		
	2030					26.20	31.50
	2040					26.29	31.08
	2050					26.01	32.39

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

Table 132b. Prediction of yield under normal planting system during fruit maturation (15 days prior to fruit maturation)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	H45	y=-599.264+17.554*TMax	0.465	34.39	36.34		
	2030					36.27	37.42
	2040					36.51	41.63
	2050					36.85	47.60
2	H 151	y=7.499+2.722*TR	0.599	9.87	0.89		
	2030					14.47	46.89
	2040					13.43	44.06
	2050					14.44	46.80
3	Neelgoa	y=23.891-0.63*TR	0.407	28.1	16.13		
	2030					18.29	12.37
	2040					26.28	7.33
	2050					18.28	12.37
4	Alphonso	y=125.979-4.652*TMin	0.491	20.37	23.7		
	2030					25.05	9.45
	2040					25.42	7.73
	2050					25.85	5.72
5	Himayuddin	y=-137.728+4.237*TMax	0.424	14.95	36.23		
	2030					35.02	10.65
	2040					35.28	11.75
	2050					35.63	13.24
6	Kalepady	y=18.917+11.027*TR	0.369	22.51	0.89		
	2030					8.52	112.87
	2040					9.38	122.35
	2050					9.94	128.53
7	Swarnarekha	y=48.938-1.727*SRAD	0.473	8.48	21.37		
	2030					25.45	4.99
	2040					25.53	4.85
	2050					25.71	4.54
8	Mulgoa	y=46.289-1.774*SRAD	0.583	13.08	20.64		
	2030					23.00	5.49
	2040					23.08	5.35
	2050					23.66	4.32
9	Tholikaippan	y=318.638-10.945*TMin	0.42	29.95	25.25		
	2030					26.44	29.25
	2040					26.82	25.09
	2050					27.25	20.39
10	Chandrakaran	y=-93.111+2.914*TMax	0.392	20.73	36.09		
	2030					35.24	9.58
	2040					35.49	10.31
	2050					35.85	11.36

Tbale 132c. Prediction of yield under normal planting system during fruit maturation (30 days prior to fruit maturation)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield	Average parameter	Scenario	Predicted yield (kg/tree)
1	Tholikaippan	y=119.134-3.602*SRAD	0.87	29.95	21.1		
	2030					25.77	26.31
	2040					25.85	26.02
	2050					25.91	25.81

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

4.20.1 Crop weather relationship of genotypes during flower initiation under HDP

The weather experienced during 7th, 15th and 30th day prior to flower initiation of 6 genotypes under high density planting system were displayed in Table 133 a.

In Prior RH1, RH2 and MeanRH are positively and significantly correlated to yield, whereas Average Temperature is negatively and significantly correlated. In Mallika TMin, Average Temperature and Evp are positively and significantly correlated to yield and RH1, RH2, Mean RH and SRAD are positively and significantly correlated to yield. In Vellaikolumban, RH1, RH2 are positively and significantly correlated to yield. In Ratna RH1, RH2 and MeanRH are positively and significantly correlated to yield and SS Hrs are negatively and significantly correlated to yield. In Chandrakaran TMin, Average Temperature and Evp are negatively and significantly correlated to yield, whereas RH1, RH2, MeanRH and SRAD are positively and significantly correlated to yield. In Muvandan, TMin, Average Temperature, RH2 and MeanRH are positively and significantly correlated to yield, whereas SS Hrs is negatively and significantly correlated to yield.

4.20.2 Crop weather relationship of genotypes during fruit initiation under HDP

The weather experienced during 7th, 15th and 30th day prior to fruit initiation of 6 genotypes under high density planting system were displayed in Table 133 b.

In Prior TMax , TMin and Avg Temp was positively and significantly correlated to the yield. In Mallika TMax was positively and significantly correlated to the yield. In Vellaikolumban TMax, TMin, Avg Temp and RH1 was positively and significantly correlated to the yield whereas, Rainy days was negatively and significantly correlated to the yield. In Chandrakaran TMin and Avg Temp was positively and significantly correlated to the yield whereas SS Hrs was negatively and significantly correlated to the yield. In Muvandan Evp was positively and significantly correlated to the yield.

Table 133a. Crop weather relationship of genotypes under HDP system during flower initiation

Genotype	Days prior to flower initiation	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
		Tem. Max. °C	Tem. Min. °C	Tem. (Average) °C	RH% I	RH% II	Mean RH %					
Prior	7			-.642**	.749**	.981**	.947**	-.630*	.971**	.826**		
	15		-.543*	-.526*	.957**	.874**	.929**				-.539*	
	30		-.707**	-.649**	.970**	.962**	.971**				-.716**	
Mallika	7	.570*	-.887**	-.717**	.768**	.924**	.816**	-.634*			-.911**	.672**
	15		-.777**	-.543*	.551*	.951**	.755**				-.716**	.836**
	30		-.912**	-.769**	.941**	.864**	.918**		.921**	.988**	-.963**	.541*
Vellaikolumban	7			-.642**	.749**	.981**	.947**	-.630*	.971**	.826**		
	15	.750**	.715**	.904**				.955**	-.815**		.985**	.674**
	30		.755**	.673**	.570*	.921**	.853**	-.973**	.989**	.999**		-.733**
Ratna	7			.658**	.660**	.994**	.831**	-.876**				
	15		.558*	.681**	.957**	.991**	.983**	-.963**			-.837**	-.636*
	30				.865**	.929**	.904**	-.887**	.832**	.943**	-.615*	
Chandrakaran	7		-.766**	-.727**	.692**	.990**	.826**	-.775**			-.897**	.663**
	15		-.591*	-.526*	.610*	.983**	.840**				-.691**	.823**
	30		-.781**	-.724**	.979**	.962**	.980**				-.876**	.590*
Muvandan	7		.622*	.752**		.884**	.551*	-.963**				
	15		.763**	.825**	.825**	.980**	.898**	-.880**			-.658**	-.650**
	30		.527*	.520*	.720**	.770**	.882**	-.870**	.911**	.950**		

Table 133b. Crop weather relationship of genotypes under HDP system during fruit initiation

Genotypes	Days prior to flower initiation	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
		Tem. Max. °C	Tem. Min. °C	Tem. (Average) °C	RH% I	RH% II	Mean RH %					
Prior	7	.702**	.974**	.948**	-.623*	.988**	.562*	-.891**			.710**	-.810**
	15	.872**	.968**	.964**				-.997**				-.888**
	30	.817**	.831**	.926**	-.934**	-.992**	-.972**			-.823**	.659**	
Mallika	7	.598*				-.733**	-.604*	.801**			.565*	
	15	.818**						.811**			-.908**	
	30	.613*		.623*	.953**		.866**	-.695**			-.722**	
Vellaikolumban	7	.682**	.781**	.888**	.731**			-.670**	-.926**	-.926**		-.548*
	15	.673**	.953**	.884**	.812**	-.732**	.732**	-.858**	-.926**	-.926**	.692**	
	30	.729**	.919**	.935**	.672**	-.637*				-.789**	.895**	
Ratna	7							-.516*			-.939**	-.558*
	15											
	30		.731**					-.681**	-.725**	-.982**		-.667**
Chandrakaran	7		.973**	.966**		.529*		-.978**			.977**	-.950**
	15	.521*	.873**	.943**				-.935**			.874**	-.892**
	30	.706**	.614*	.857**				-.779**				-.688**
Muvandan	7				-.914**	-.896**	-.898**				.937**	
	15				-.941**	-.993**	-.945**	.668**	-.795**	-.795**	.994**	
	30		.972**	.812**		-.532*		-.769**		-.922**	.960**	

Table 133c. Crop weather relationship of genotypes under HDP system during fruit maturation

Genotype	Days prior to fruit maturation	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
		Tem. Max. °C	Tem. Min. °C	Tem. (Average) °C	RH% I	RH% II	Mean RH %					
Prior	7		.552*	.848**			.761**					
	15		.753**	.859**	-.797**				-.772**			
	30		.887**	.535*	-.526*	.812**		-.979**	-.993**	-.996**	-.883**	-.655**
Mallika	7	.883**	.777**	.923**	-.920**	-.797**	-.882**	.954**	-.929**	-.626*	.979**	.616*
	15		.952**	.794**		.988**	.922**	.992**	-.913**	1.000**	.990**	.708**
	30				.661**		.530*	.570*	-.917**	-.987**	-.919**	
Vellaikolumban	7	.787**	.820**	.951**	-.858**		-.561*	.898**	-.784**		.984**	.795**
	15	.750**	.715**	.904**				.955**	-.815**		.985**	.674**
	30				.661**		.530*	.570*	-.917**	-.987**	-.919**	
Ratna	7		.879**	.767**	-.887**		-.641*	-.730**	-.981**	-.759**	.565*	
	15	.847**	.687**	.861**	-.736**		-.549*	.851**	-.981**	-.759**	.911**	.523*
	30								-.834**	-.942**	-.631*	
Chandrakaran	7	.881**	.569*	.790**	-.763**	-.913**	-.847**	.619*	-.542*	-.542*	.764**	.574*
	15	.843**						.595*	-.538*	-.542*	.691**	
	30				.543*	.605*	.580*	-.641**			-.948**	
Muvandan	7	.927**	.863**	.946**	-.912**	-.827**	-.894**	.998**	-.920**	-.606*	.983**	.881**
	15	.880**	.626*	.879**				.867**	-.996**	-.922**	.969**	.585*
	30				.719**	.631*	.673**		-.912**	-.991**	-.969**	

4.20.3 Crop weather relationship of genotypes during fruit maturation under HDP

The weather experienced during 7th, 15th and 30th day prior to fruit maturation of 6 genotypes under high density planting system were displayed in Table 133 c. In Prior, TMin and Avg Temp was positively and significantly correlated to yield. In Mallika and Vellaikolumban, SS Hrs was positively and significantly correlated to yield and Total Rainfall was negatively and significantly correlated to yield. In Ratna, Chandrakaran and Muvandan, Total Rainfall and Rainy Days was negatively and significantly correlated to yield.

4.21.1 Crop weather relationship of genotypes during flower initiation (combined results) under HDP

The weather experienced during 7th, 15th and 30th day (combined results) prior to flower initiation of 6 genotypes under high density planting system were displayed in Table 134 a. In Prior, Rh1, Rh2, meanRh and Rainy days were positively and significantly correlated to the yield, whereas TMin, Avg Temp, SS Hrs and Evp was negatively and and significantly correlated to the yield. In Mallika TMax, Rh1, Rh2, Mean Rh, Rainfall and SRAD was positively and significantly correlated to the yield, whereas TMin, Avg Temp, SS Hrs and Evp was negatively and significantly correlated to the yield. In vellaikolumban, TMin, Avg Temp, Rh2, Mean Rh, Total Rainfall and Rainy days was positively and significantly correlated to the yield, whereas SS Hrs and SRAD was negatively and and significantly correlated to the yield. In Ratna TMin, Avg Temp, Rh1, Rh2 and MeanRh was positively and significantly correlated to the yield. Whereas, SS Hrs and Evp were negatively and significantly correlated to the yield. In Chandrakaran, Rh1, Rh2 and Mean Rh was positively and significantly correlated to the yield, whereas TMin, Avg Temp, SS Hrs, Rainfall and Evp was negatively and significantly correlated to the yield. In Muvandan TMin , Avg Temp, Rh1 , Rh2, Mean Rh, Rainfall and Rainy days was positively and significantly correlated to the yield, whereas SSHrs and SRAD was negatively and significantly correlated to the yield.

Table 134a. Crop weather relationship of genotypes under HDP system during flower initiation (Combined result)

Genotype	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
	Tem. Max.	Tem. Min.	m. (Avera	RH%	RH%	Mean RH					
	°C	°C	°C	I	II	%					
Prior		-.575**	-.584**	.746**	.883**	.898**	-.460**		.331*	-.429**	
Mallika	.314*	-.846**	-.603**	.705**	.839**	.786**	-.347*	.301*		-.813**	.534**
Vellaikolumabn		.782**	.782**		.515**	.410**	-.516**	.380*	.390**		-.486**
Ratna		.461**	.569**	.634**	.476**	.588**	-.492**			-.481**	-.321*
Chandrakaran		-.701**	-.610**	.657**	.933**	.809**	-.312*			-.770**	
Muvandan		.611**	.701**	.466**	.427**	.471**	-.459**	.349*	.370*		-.326*

Table 134b. Crop weather relationship of genotypes under HDP system during fruit initiation (Combined result)

Genotype	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
	Tem. Max.	Tem. Min.	m. (Avera	RH%	RH%	Mean RH					
	°C	°C	°C	I	II	%					
Prior	.766**	.868**	.889**	-.602**		-.367*	-.730**			.481**	-.579**
Mallika					-.358*					-.451**	0.188
Vellaikolumaban	.634**	.769**	.789**	.541**	-.399**	.311*	-.498**		-.835**	.346*	-.315*
Ratna							-.385**	-.366*	-.438**	-.523**	-.452**
Chandrakaran	.482**	.794**	.867**				-.752**	-.457**	-.457**	.621**	-.745**
Muvandan		.518**	.434**	-.537**	-.613**	-.617**			-.572**	.783**	

Table 134c. Crop weather relationship of genotypes under HDP system during fruit maturation (Combined result)

Genotype	Temperature			Relative humidity			Sun shine hours	Total rainfall	Total rainfall	Evaporation	Solar radiation
	Tem. Max.	Tem. Min.	m. (Avera	RH%	RH%	Mean RH					
	°C	°C	°C	I	II	%					
Prior		.635**	.640**		.344*			-.516**	-.368*		
Mallika	.611**	.536**	.674**				.712**	-.757**	-.533**	.439**	.441**
Vellaikolumaban	.560**	.662**	.768**				.733**	-.764**	-.503**	.509**	.592**
Ratna	.531**	.547**	.648**					-.792**	-.710**	.395**	
Chandrakaran	.616**		.462**				.347*	-.419**	-.367*	.312*	.296*
Muvandan	.684**	.562**	.725**				.729**	-.861**	-.758**	.523**	.565**

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4.21.2 Crop weather relationship of genotypes during fruit initiation (combined results)

The weather experienced during 7th, 15th and 30th day (combined results) prior to fruit initiation of 6 genotypes under high density planting system were displayed in Table 134 b . In Prior, TMax, TMin, Avg Temp and Evp are positively and significantly correlated to the yield, whereas RH I, Mean RH, SS Hrs and SRAD are negatively and significantly correlated to the yield. In Mallika, RH II and Evp are negatively and significantly correlated to the yield, whereas SRAD was positively and significantly correlated to the yield. In Vellaikolumban, TMax, TMin and Avg Temp, RH I, Mean RH, Evp and SRAD are positively and significantly correlated to the yield, whereas RH II, SS Hrs, Rainy Days and SRAD are negatively and significantly correlated to the yield. In Ratna SS Hrs, Rainfall, Rainy Days, Evp and SRAD are negatively and significantly correlated to the yield. In Chandrakaran, TMax, TMin, Avg Temp and Evp are positively and significantly correlated to the yield, whereas SS Hrs, Total Rainfall, Rainy Days and SRAD are negatively and significantly correlated to the yield. In Muvandan, TMin, Avg Temp and Evp are positively and significantly correlated to the yield.

4.21.3 Crop weather relationship of genotypes during fruit maturation (combined results)

The weather experienced during 7th, 15th and 30th day (combined results) prior to fruit maturation of 6 genotypes under high density planting system were displayed in Table 134 c. In all the varieties and local types TMax, TMin and Avg Temp was positively and significantly correlated to the yield, whereas Total Rainfall and Rainy Days were neagtively and significantly correlated to the yield.

4.22.1 Prediction of yield under HDP system during flower initiation (7 days prior to flowering):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of

observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 135 a.

In Prior, the predicted yield increased as the total rainfall increased. In Chandrakaran, the predicted yield decreased as the TMin increased. In Muvandan the predicted yield increased inspite of an increase in TMin.

4.22.2 Prediction of yield under HDP system during flower initiation (15 days prior to flowering):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 135 b.

In Prior and Chandrakaran the predicted yield decreased as the TMin increased. In Vellaikolumban the predicted yield increased inspite of an increase in TMax. In ratna and Muvandan the yield increased inspite of an increase in TMin.

4.22.3 Prediction of yield under HDP system during flower initiation (30 days prior to flowering):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 135 c.

In Prior, the predicted yield decreases as TMin increased. In Ratna and Muvandan the predicted yield decreased as the rainfall decreased. In Vellaikolumban the predicted yield decreased inspite of an increase in TMin. In Chandrakaran the yield increased as SRAD increased.

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Table 135a. Prediction of yield under high density planting system flower initiation (7 days prior to flowering)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=10.977+1.019*TR	0.938	16.06	4.99		
	2030					20.33	31.69
	2040					16.09	27.37
	2050					12.82	24.04
2	Moovandan	y=-21.552+1.323*TMin	0.34	6.97	21.56		
	2030					23.39	52.50
	2040					23.65	52.84
	2050					23.95	53.24

Table 135b Prediction of yield under high density planting system flower initiation (15 days prior to flowering)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=100.754-3.783*TMin	0.241	16.06	22.39		
	2030					23.80	10.72
	2040					23.96	10.11
	2050					24.30	8.83
2	Vellaikolumban	y=-50.465+1.908*TMax		12.06	32.77		
	2030					36.69	19.54
	2040					36.90	19.94
	2050					37.18	20.47
3	Ratna	y=-50.639+3.129*TMin	0.259	17.91	21.9		
	2030					23.15	21.80
	2040					23.42	22.64
	2050					23.72	23.58
4	Chandrakaran	y=172.881-6.963*TMin	0.299	18.24	22.21		
	2030					23.55	8.90
	2040					23.72	7.72
	2050					24.07	5.28
5	Moovandan	y=-49.355+2.586*TMin	0.551	6.97	21.78		
	2030					23.39	11.13
	2040					23.65	11.80
	2050					23.95	12.58

Table 135c. Prediction of yield under high density planting system flower initiation (30 days prior to flowering)

Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=120.265-4.672*TMin	0.461	16.06	22.31		
	2030					24.18	7.30
	2040					24.38	6.36
	2050					24.64	5.15
2	Vellaikolumban	y=-71.436+3.781**TMin	0.537	12.06	22.08		
	2030					23.23	16.40
	2040					23.50	17.42
	2050					23.80	18.55
3	Ratna	y=9.851+0.243*TR	0.669	17.91	33.15		
	2030					0.42	9.95
	2040					1.01	10.10
	2050					0.70	10.02
4	Chandrakaran	y=-121.141+8.619*SRAD	0.298	18.24	16.17		
	2030					18.65	39.60
	2040					19.07	43.22
	2050					19.17	44.09
5	Moovandan	y=2.640+0.142*TR	0.816	6.97	30.59		
	2030					0.43	2.70
	2040					0.95	2.77
	2050					0.83	2.76

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

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4.23.1 Prediction of yield under HDP system during fruit initiation (7 days prior to fruit initiation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 136 a.

In Prior and Mallika the predicted yield increased inspite of an increase in TMax. In Chandrakaran, the predicted yield increased inspite of an increase in TMin. In vellaikolumban and Ratna, the predicted yield increased as the rainfall decreased.

4.23.2 Prediction of yield under HDP system during fruit initiation (15 days prior to fruit initiation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 136 b.

In Prior, the yield decreased as the TMin increased. In Vellaikolumban and Muvandan the yield decreased as the rainfall decreased. In Mallika, the predicted yield increased as the SRAD increased.

4.23.3 Prediction of yield under HDP system during fruit initiation (30 days prior to fruit initiation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 136 c.

In Prior and Muvandan, the predicted yield increased inspite of an increase in TMin. In Mallika, Vellaikolumban, Ratna and Chandrakaran the predicted yield increased inspite of an increase in TMax.

Table 136a. Prediction of yield under high density planting system during fruit initiation (7 days prior to fruit initiation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=-377.241+11.589*TMax	0.454	16.06	33.59		
	2030					36.26	42.98
	2040					36.48	45.53
	2050					36.62	47.15
2	Mallika	y= -230.405+7.432*TMax	0.308	20.47	33.76		
	2030					36.33	39.60
	2040					36.53	41.09
	2050					36.83	43.32
3	Vellaikolumban	y=15.449-1.959*TR	0.847	12.06	1.73		
	2030					4.21	7.20
	2040					2.14	11.26
	2050					2.06	11.41
4	Ratna	y= 15.449-1.959*TR	0.847	17.91	0		
	2030					3.15	9.28
	2040					1.72	12.08
	2050					1.94	11.65
5	Chandrakaran	y=-100.397+5.143*TMin	0.943	18.24	23.07		
	2030					23.46	20.26
	2040					23.67	21.34
	2050					23.97	22.88

Table 136b. Prediction of yield under high density planting system during fruit initiation (15 days prior to fruit initiation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=-122.390+5.928*TMin	0.933	16.06	22.67		
	2030					23.12	14.67
	2040					23.35	16.03
	2050					23.65	17.81
2	Mallika	y=-67.963+4.613*SRAD	0.103	20.47	19.17		
	2030					24.64	45.70
	2040					24.68	45.89
	2050					24.70	45.98
3	Vellaikolumban	y=15.449-1.959*TR	0.847	12.06	1.73		
	2030					6.52	2.68
	2040					3.70	8.20
	2050					2.78	10.00
4	Moovandan	y=8.907-1.121*TR	0.603	6.97	1.73		
	2030					2.91	5.64
	2040					2.85	5.71
	2050					1.74	6.96

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

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Table 136c. Prediction of yield under high density planting system during fruit initiation (30 days prior to fruit initiation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=-165.343+7.971*TMin	0.667	16.06	22.25		
	2030					22.95	17.59
	2040					23.22	19.74
	2050					23.51	22.06
2	Mallika	y=-359.796+11.458*TMax	0.328	20.47	33.19		
	2030					36.07	53.49
	2040					36.27	55.79
	2050					36.56	59.11
3	Vellaikolumban	y=-359.769+11.458*TMax	0.328	12.06	34.8		
	2030					36.20	55.01
	2040					36.37	56.96
	2050					36.74	61.20
4	Ratna	y=-359.796+11.458*TMax	0.328	17.91	34.83		
	2030					36.19	54.87
	2040					36.41	57.39
	2050					36.73	61.06
5	Chandrakaran	y=-359.796+11.458*TMax	0.328	18.24	33.33		
	2030					36.12	54.07
	2040					36.33	56.47
	2050					36.58	59.34
6	Moovandan	y=-84.542+4.034*TMin	0.94	6.97	22.69		
	2030					23.44	10.01
	2040					23.86	11.71
	2050					24.19	13.04

Table 137a. Prediction of yield under high density planting system during fruit maturation (7 days prior to fruit maturation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=-111.946+4.893*TMin	0.119	16.06	25.33		
	2030					27.70	23.59
	2040					27.99	25.01
	2050					28.42	27.11
2	Mallika	y=30.368-0.633*TR	0.852	20.47	15.63		
	2030					8.10	25.24
	2040					11.26	23.24
	2050					6.56	26.22
3	Vellaikolumban	y=17.798-0.367**TR	0.823	12.06	15.63		
	2030					9.56	14.29
	2040					8.14	14.81
	2050					8.37	14.73
4	Ratna	y=25.441-0.482*TR	0.765	17.91	15.63		
	2030					9.55	20.84
	2040					12.03	19.64
	2050					7.38	21.88
5	Chandrakaran	y=-211.928+9.150*TMin	0.272	18.24	25.15		
	2030					26.54	30.91
	2040					26.98	34.94
	2050					27.34	38.23
6	Moovandan	y=-211.928+9.150*TMin	0.272	6.97	25.14		
	2030					27.14	36.40
	2040					27.52	39.88
	2050					27.89	43.27

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

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4.24.1 Prediction of yield under HDP system during fruit maturation (7 days prior to fruit maturation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 137 a.

In Prior, Chandrakaran and Muvandan, the yield increased inspite of an increase in TMin. In Mallika, vellaikolumban and Ratna the predicted yield increased inspite of a decrease in rainfall.

4.24.2 Prediction of yield under HDP system during fruit maturation (15 days prior to fruit maturation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 137 b.

In Mallika and Ratna. The predicted yield increased inspite of an increase in TMin and in Muvandan the yield increases inspite of a decrease in rainfall. In Prior and Vellaikolumban, the yield decreased as the rainfall pattern differed.

4.24.3 Prediction of yield under HDP system during fruit maturation (30 days prior to fruit maturation):

The regression equation, adjusted R^2 value, average yield during the years of observation and average of the parameter responsible for the yield during the years of observation, the change in the parameter during the scenario responsible for the yield and the predicted yield are tabulated in the Table No: 137 c.

In Prior, Mallika, Vellaikolumban, Ratna and Muvandan, the predicted yield decreased when the rainfall increased.

Table 137b. Prediction of yield under high density planting system during fruit maturation (15 days prior to fruit maturation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=22.228-0.625**TR	0.565	16.06	16.36		
	2030					22.79	7.98
	2040					25.38	6.37
	2050					20.72	9.28
2	Mallika	y=-99.080+4.560*TMin	0.899	20.47	25.38		
	2030					26.78	23.04
	2040					27.19	24.91
	2050					27.56	26.59
3	Vellaikolumban	y=18.126-0.375*TR	0.638	12.06	16.19		
	2030					16.89	11.79
	2040					22.92	9.53
	2050					18.83	11.06
4	Ratna	y=-141.753+6.292*TMin	0.431	17.91	25.38		
	2030					26.93	27.69
	2040					27.33	30.21
	2050					27.70	32.54
5	Chandrakaran	y=21.857-0.194*TR	0.235	18.24	18.62		
	2030					15.66	18.82
	2040					23.86	17.23
	2050					18.48	18.27
6	Moovandan	y=21.857-0.194*TR	0.235	6.97	22.41		
	2030					17.69	18.43
	2040					24.98	17.01
	2050					19.43	18.09

Table 137c. Prediction of yield under high density planting system during fruit maturation (30 days prior to fruit maturation)							
Sl. No.	Genotypes	Equations	Adjusted r^2	Average yield (kg/tree)	Average parameter	Scenario	Predicted yield (kg/tree)
1	Prior	y=27.078-0.488*TR	0.986	16.06	30.89		
	2030					39.19	7.95
	2040					46.26	4.50
	2050					39.05	8.02
2	Mallika	y=31.432-0.361*TR	0.829	20.47	30.36		
	2030					34.82	18.86
	2040					44.69	15.30
	2050					38.39	17.57
3	Vellaikolumban	y=20.656-0.277*TR	0.973	12.06	31.05		
	2030					35.21	10.90
	2040					40.36	9.48
	2050					38.70	9.94
4	Ratna	y=24.965-0.234*TR	0.671	17.91	30.16		
	2030					35.96	16.55
	2040					42.99	14.91
	2050					38.01	16.07
5	Moovandan	y=12.263-0.170*TR	0.819	6.97	31.05		
	2030					34.94	6.32
	2040					41.60	5.19
	2050					40.05	5.45

Higher temp.
Higher rainfall
Lower rainfall
Lower solar radiation

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Discussion

5. DISCUSSION

In this chapter an attempt has been made to elucidate the findings of the present investigation entitled "Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes" have been discussed critically in the light of recent review of literature. The whole findings have been discussed in the appropriate headings *viz.* morphological characters, fruit characters, stone characters, quality attributes, sensory evaluation, pollen studies, physiological characters, biochemical characters and development of a crop weather model for mango and screening of genotypes for climate resilience.

5.1 Morphological Characters

Various observations on morphological characters *viz.*, tree characters, leaf characters, inflorescence characters, fruit characters and seed characters were recorded.

The trees of same age group (25 years) were selected for the study. Wide variation was observed among the plant height of different mango genotypes. Among the hybrids Sindhu recorded the highest plant height (11.93m) and H 151 recorded the lowest plant height. Kalepady recorded the highest tree height (12.31m) among the parents involved in breeding and Bennet Alphonso recorded the lowest plant height (8.36m). Chandrakaran recorded the highest plant height (12.49m) followed by Muvandan (11.95m) among the local types and Vellaikolumban recorded the lowest plant height (9.29m). The tree characters namely height and girth are influenced by age of the plant, nutritional and climatic factors.

Wide variation was observed among the trunk circumference of different mango genotypes. The maximum trunk circumference was recorded for Mallika (168.13 cm) and H 151 has registered the least trunk circumference (95.17 cm). Swarnarekha (196.53cm) recorded the highest trunk circumference among the parents involved in breeding and Neelum recorded the lowest value of 103.79 cm. Prior recorded the highest trunk circumference of 153.53 cm among the local types and lowest trunk circumference was recorded for Muvandan (91.63 cm). Variability in trunk circumference amongst the mango varieties might be due to variation in genetic makeup Murti and Upreti (2004).

The crown diameter (North –South) and (East-West) of mango was measured. The variety H 45 recorded the highest crown diameter (North –South) and the lowest crown diameter (North –South) was recorded by H 151 (7.07 m). Mulgoa (13.40 m) recorded the highest value among the parents involved in breeding and the lowest value was recorded by Alphonso (8.23 m). Prior (11.72 m) recorded the highest crown diameter (North-South) among the local types and Muvandan (7.26 m) recorded the lowest value.

The crown diameter (East-West) of mango hybrids were measured and the highest value was registered by Ratna and H 151(5.57 m) recorded the lowest value from all other hybrids. Kalepady (10.27 m) recorded the highest value of 10.27 m which was significantly different from the rest of the cultivars, among the parents involved in breeding, whereas the lowest value was registered by Bennet Alphonso (6.74 m). Prior (11.59 m) recorded the highest crown diameter (East – West) which was significantly different from the other types among the local types, and Tholikaippan recorded the lowest value of 5.94 m. The variability in crown diameter amongst the mango varieties might be due to variation in genetic makeup Murti and Upreti (2004).

Different crown shapes like oblong, semi-circular, spreading, broadly pyramidal and spherical were noticed among the varieties/cultivars (Table 5). Grouping the hybrids, cluster I included trees with oblong crown shape (Fig.14). Cluster II had trees with broadly pyramidal crown shape and cluster III included trees with spherical and broadly pyramidal crown shape (Table 6 and Table 7). Grouping the parents involved in breeding, cluster I included trees with semicircular, oblong and broadly pyramidal crown shape (Fig.15). Cluster II had trees with drooping crown shape. Cluster III had trees with spherical and oblong crown shape while cluster IV included trees with oblong crown shape (Table 8 and Table 9). Grouping the local types, cluster I had trees with spherical and oblong crown shape (Fig.16). Cluster II had tree with broadly pyramidal crown shape and cluster III included tree with semicircular crown shape (Table 10 and Table 11). Crown shape and branching pattern are mainly decided by genetic make-up but still environmental parameters and shade also play a role (Simi, 2006).

Fig.14 Dendrogram of tree characters - Hybrids

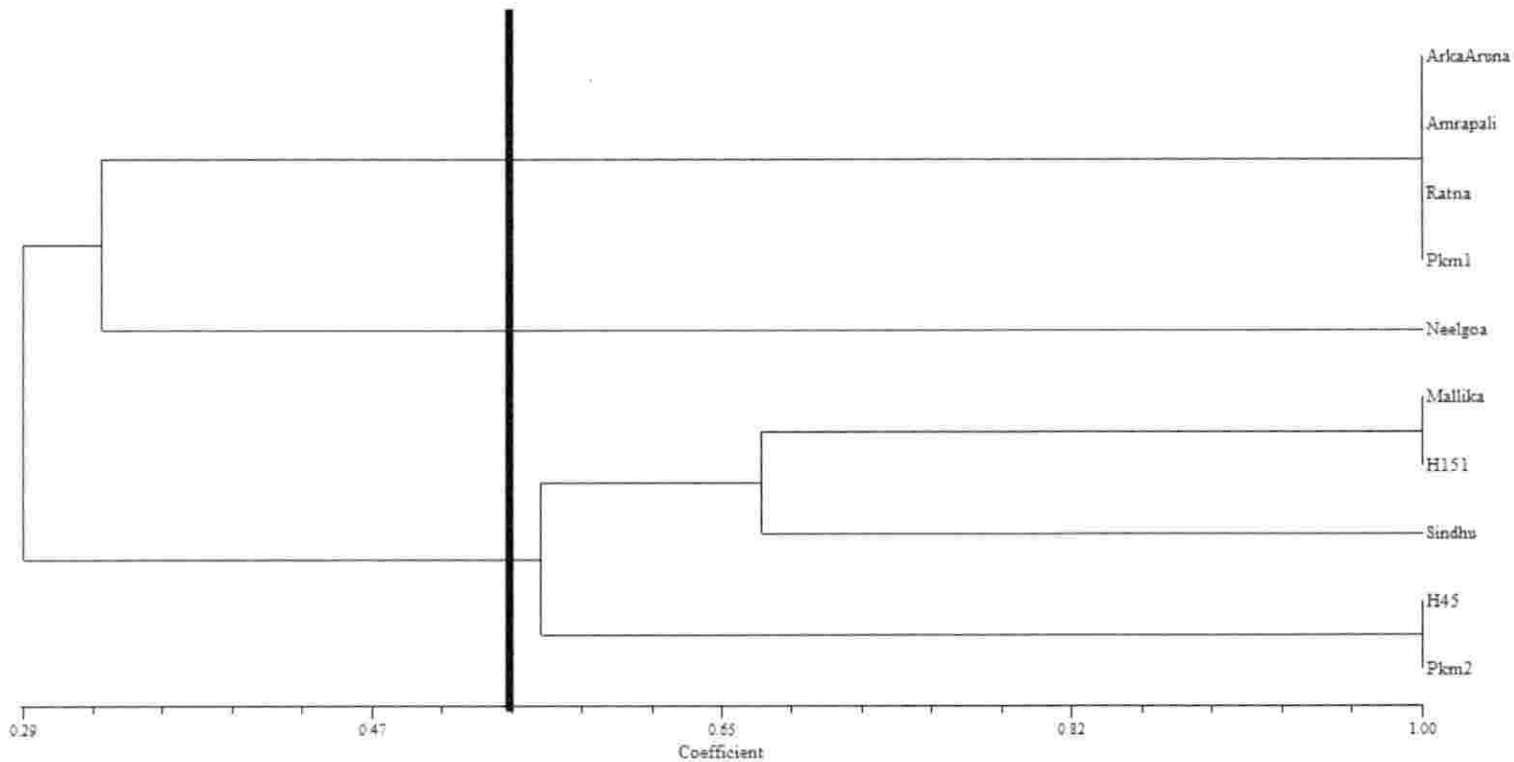


Fig.15 Dendrogram of tree characters - Parents involved in crossing

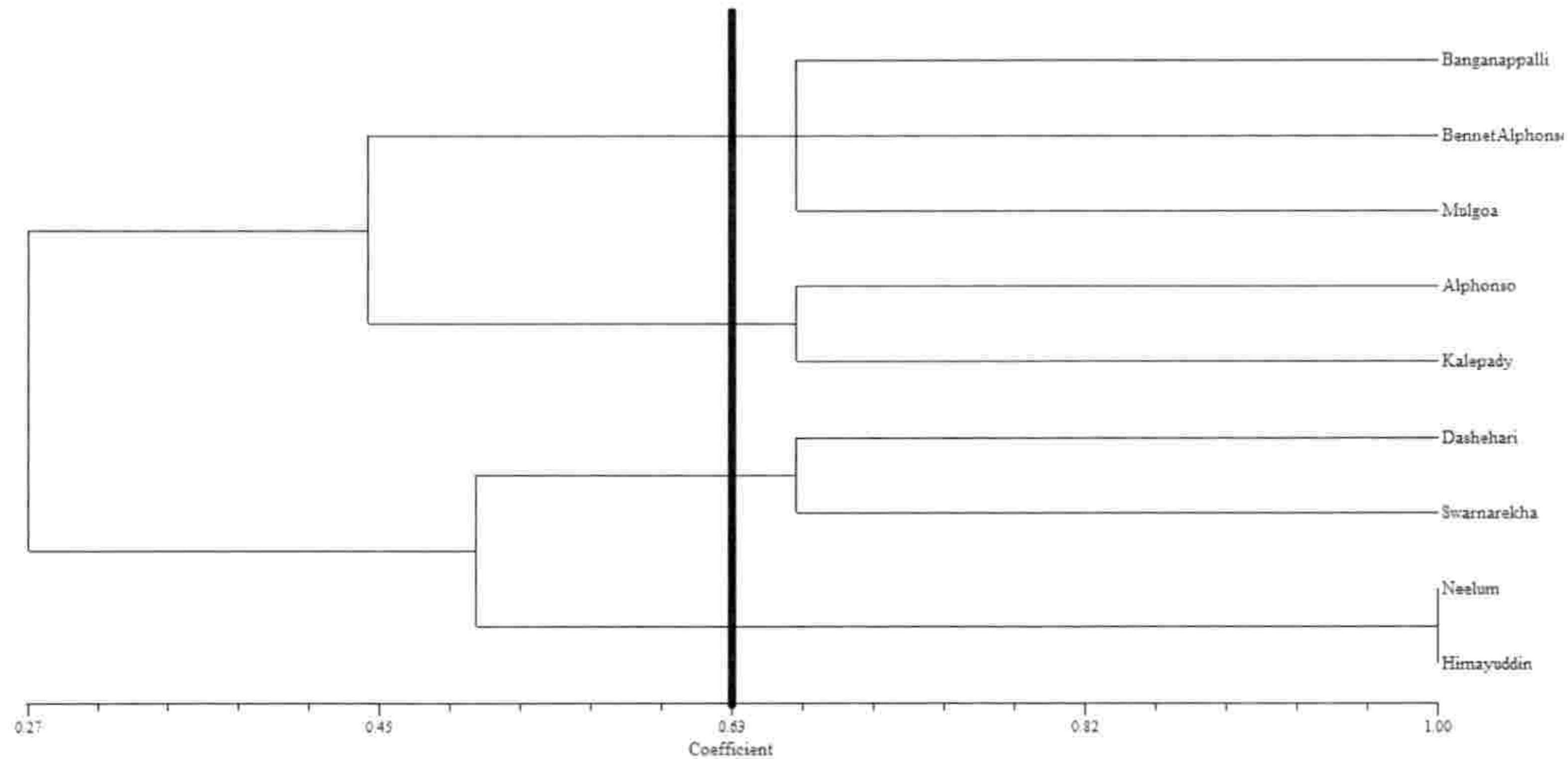
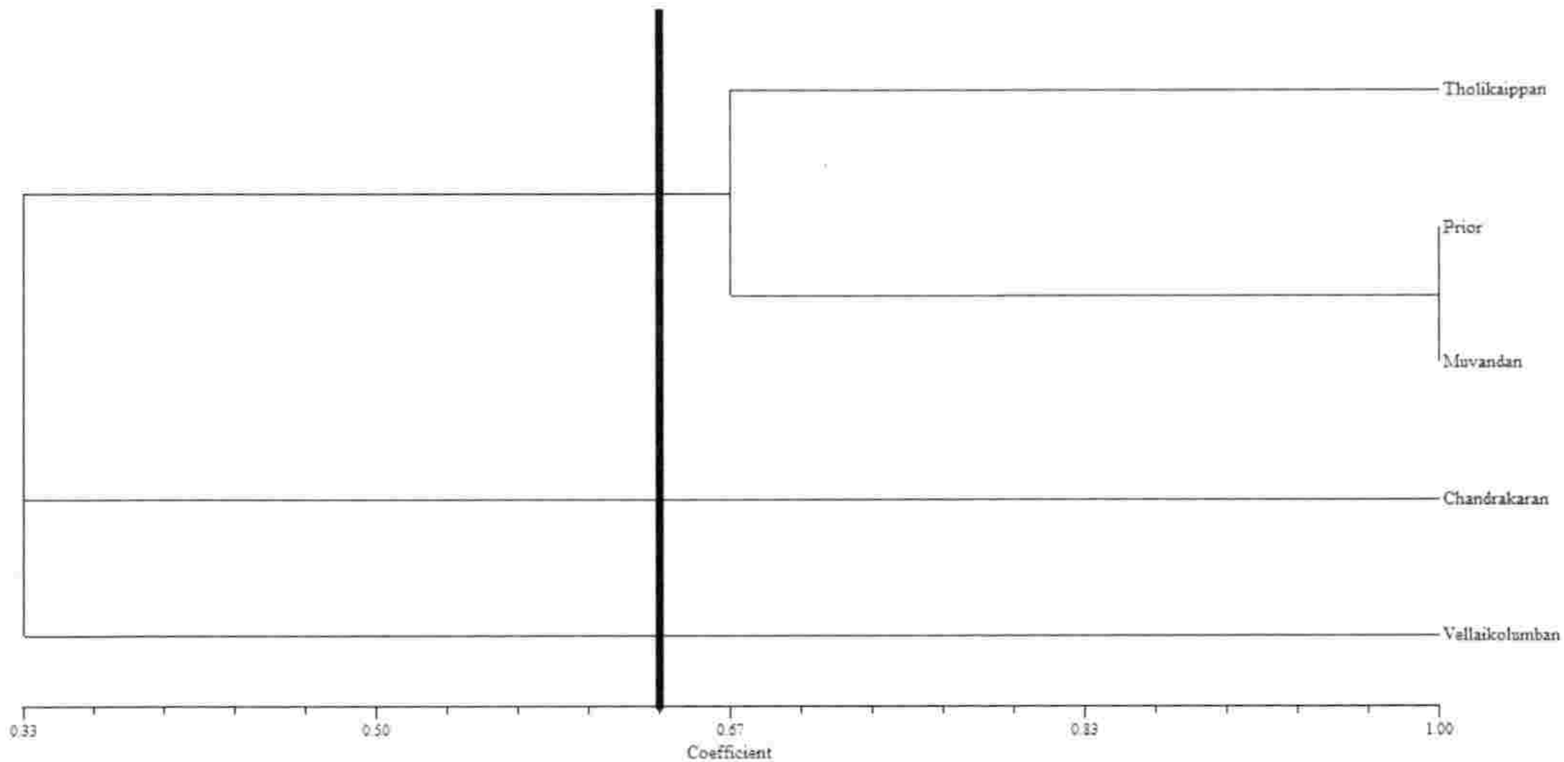


Fig.16 Dendrogram of tree characters - Local types



Different tree growth habit like erect, drooping and spreading were noticed among the varieties/cultivars (Table 5). Grouping the hybrids, cluster I and Cluster II had trees with erect growth habit. Cluster III included trees with spreading and drooping growth habit (Table 6 and Table 7). Grouping the parents involved in breeding, cluster I included trees with spreading growth habit. Cluster II had trees with drooping growth habit. Cluster III and cluster IV included trees with erect growth habit (Table 8 and Table 9). Grouping the local types, cluster I had trees with erect growth habit. Cluster II had tree with drooping growth habit and cluster III included tree with spreading growth habit (Table 10 and Table 11). This was in accordance with the findings of Riberio *et al.,* (2013).

Dense and erect foliage density were noticed among the varieties/cultivars (Table 5). Elliptic, obovate, ovate, lanceolate and oblong leaf blade shape were noticed among the varieties/cultivars (Table 12). Obtuse, acuminate and acute leaf apex shape were noticed among the varieties/cultivars (Table 12). Round, acute and obtuse leaf base shape were noticed among the varieties/cultivars (Table 12). Wavy and entire leaf margin were noticed among the varieties/cultivars (Table 12). Leaf pubescence was absent among all the varieties/cultivars (Table 12). Coppery red, light brick red, reddish brown, light green and coppery tan colour of young leaf were noticed among the varieties/cultivars (Table 12). All the hybrids had green colour for fully developed leaves (Table 12). All the hybrids and parents involved in breeding had mild leaf fragrance (Table 12) (Fig.17, 18 and 19).

The data presented in Table 19 shows the variation in leaf lade length of different genotypes during three seasons. Among the hybrids, Amrapali (29.32 cm) gave significantly higher leaf blade length compared to other hybrids. Neelam (25.08 cm) recorded significantly higher leaf blade length among the parents involved in breeding. Vellaikolumban (26.28 cm) gave significantly higher leaf blade length among the local types.

The data presented in Table 20 shows the variation in leaf lade width of different genotypes during three seasons. Amrapali (6.70 cm) recorded significantly higher leaf blade width. Neelum (7.13 cm) gave significantly higher leaf blade than all other

Fig.17 Dendrogram of leaf characters - Hybrids

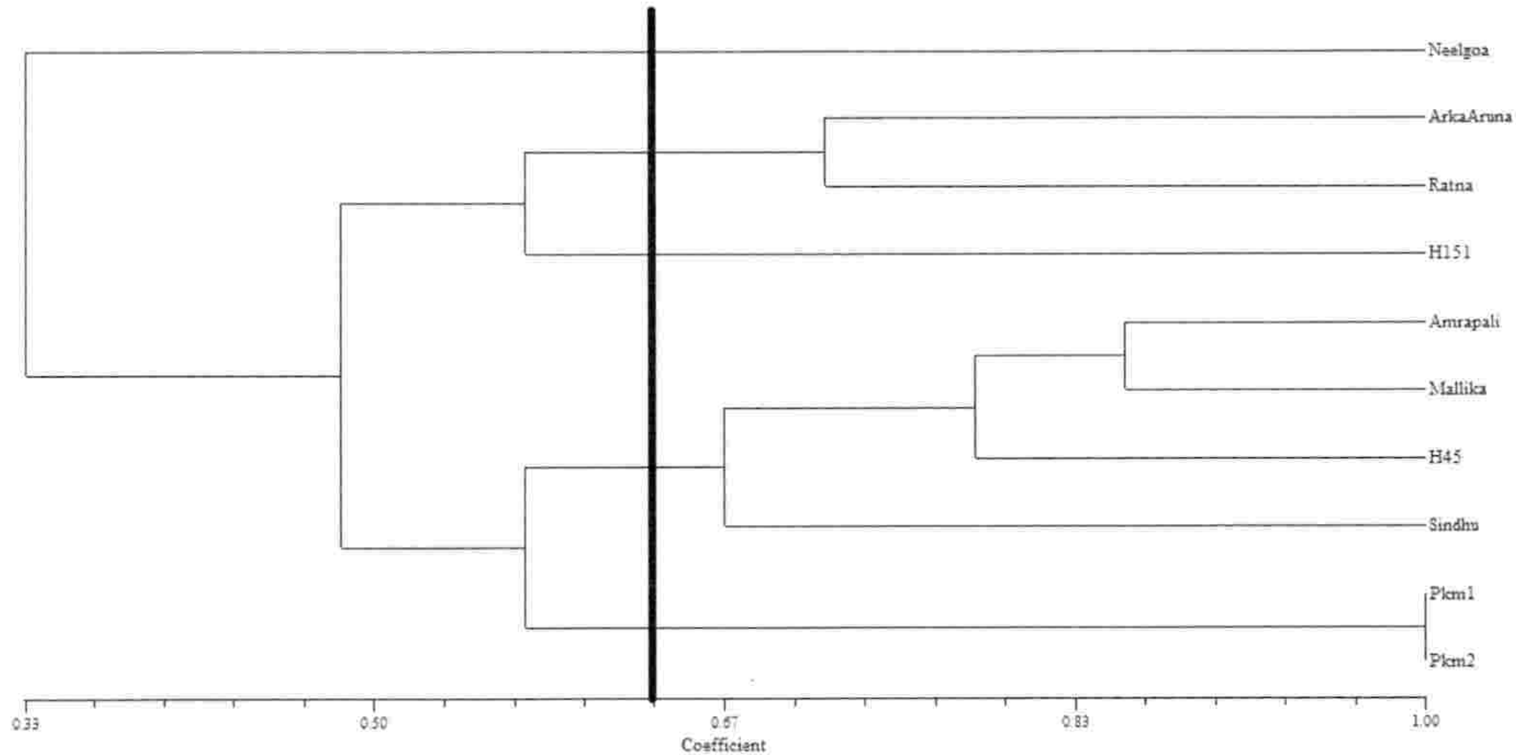


Fig.18 Dendrogram of leaf characters - Parents involved in crossing

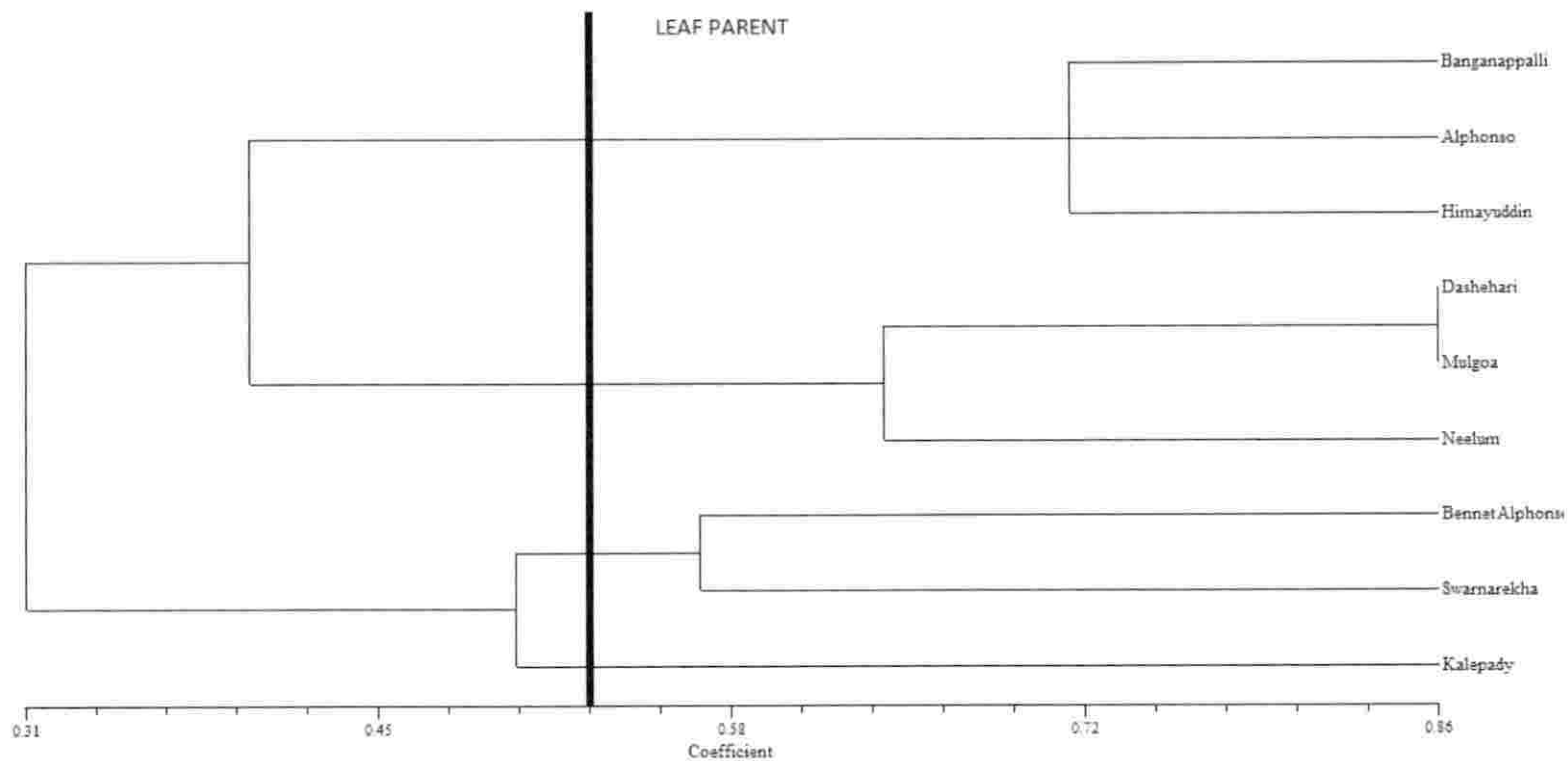
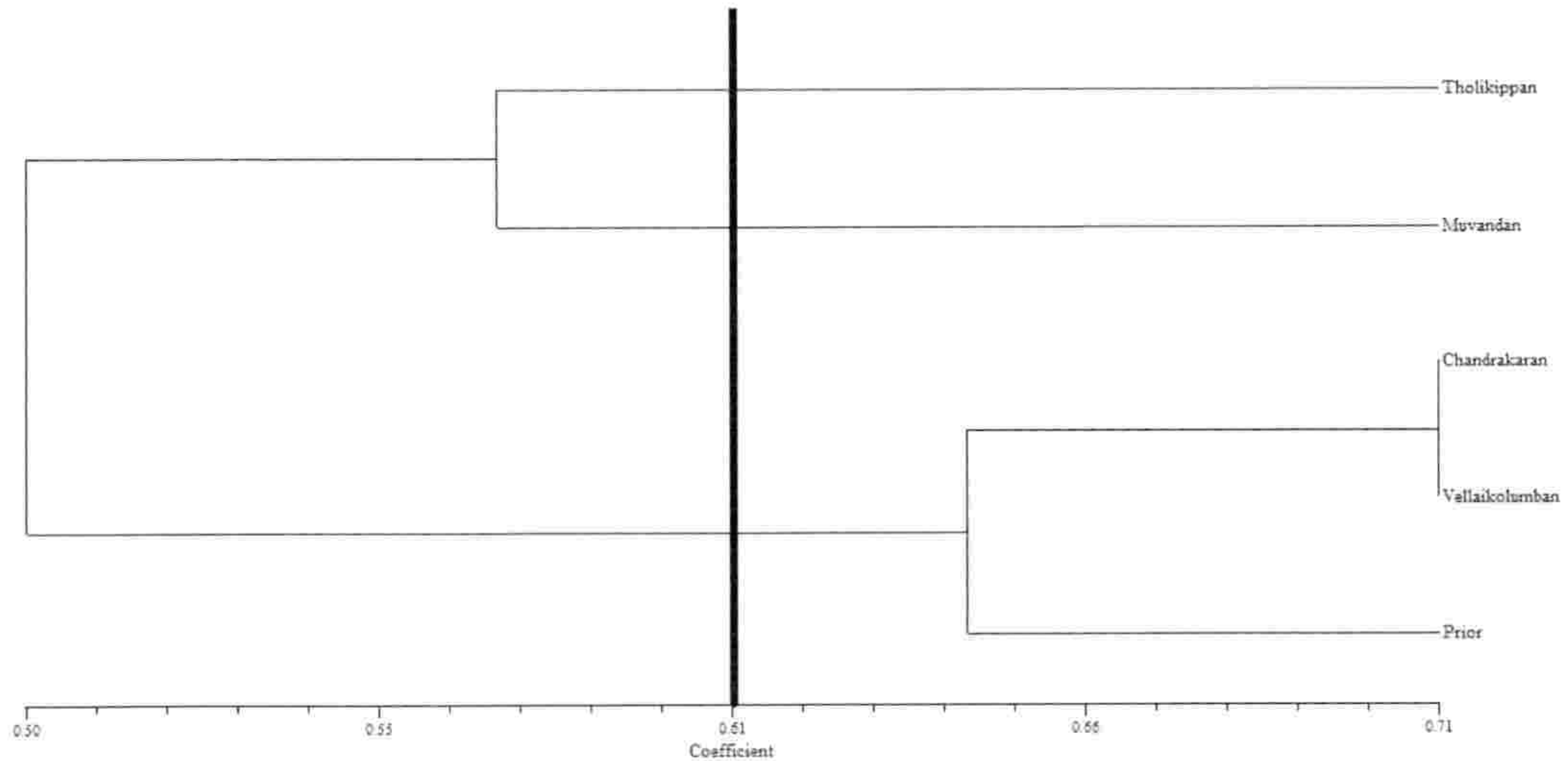


Fig.19 Dendrogram of leaf characters - Local types



parents. Vellaikolumban (8.12 cm) recorded the highest leaf blade width followed by Tholikaippan (7.04 cm) among the local types.

The data presented in Table 21 shows the variation in petiole length of different genotypes during three seasons. Amrapali (3.70 cm) recorded the highest petiole length among the hybrids.

Dashehari (3.16) recorded the highest petiole length followed by Alphonso (3.11 cm) among the parents. Tholikaippan recorded the highest petiole length among the local types.

Different flowering durations like January – February, December – February, December – January, November to January and February – March were noticed among the varieties/cultivars (Table 22). Grouping the hybrids, cluster I and cluster II included trees with flowering duration from January – February (Fig.20). Cluster III and IV included trees with flowering duration from December - February (Table 23 and Table 24). Grouping the parents involved in breeding, cluster I had trees with flowering duration from December to February, December to January and November to January (Fig.21). Cluster II included the trees with flowering duration from December-February. Cluster III included the trees with flowering duration from February to March. (Table 25 and Table 26). Grouping the local types, Cluster I included trees with flowering duration from December to January (Fig.22). . Cluster II had trees with flowering duration from January- February. Cluster III had trees with flowering duration from November – January and December – January (Table 27 and Table 28).

Secondary/off season flowering were absent among all the varieties/cultivars (Table 22). All the hybrids trees had terminal inflorescence position (Table 22). Broadly pyramidal, pyramidal and conical inflorescence shape were noticed among the varieties/cultivars (Table 22). Sparse, medium and dense flowers were observed among the inflorescence of different varieties/cultivars (Table 22). Yellowish green, yellow, light green and greenish with red patches were the inflorescence colour observed among the different varieties/cultivars (Table 22). All the hybrids/parents involved in breeding had equal length of stamen in relation to pistil (Table 22).

The data presented in Table 29a shows the variation in inflorescence length of different genotypes during the two seasons. Sindhu (33.45cm) recorded the highest

Fig.20 Dendrogram of inflorescence characters - Hybrids

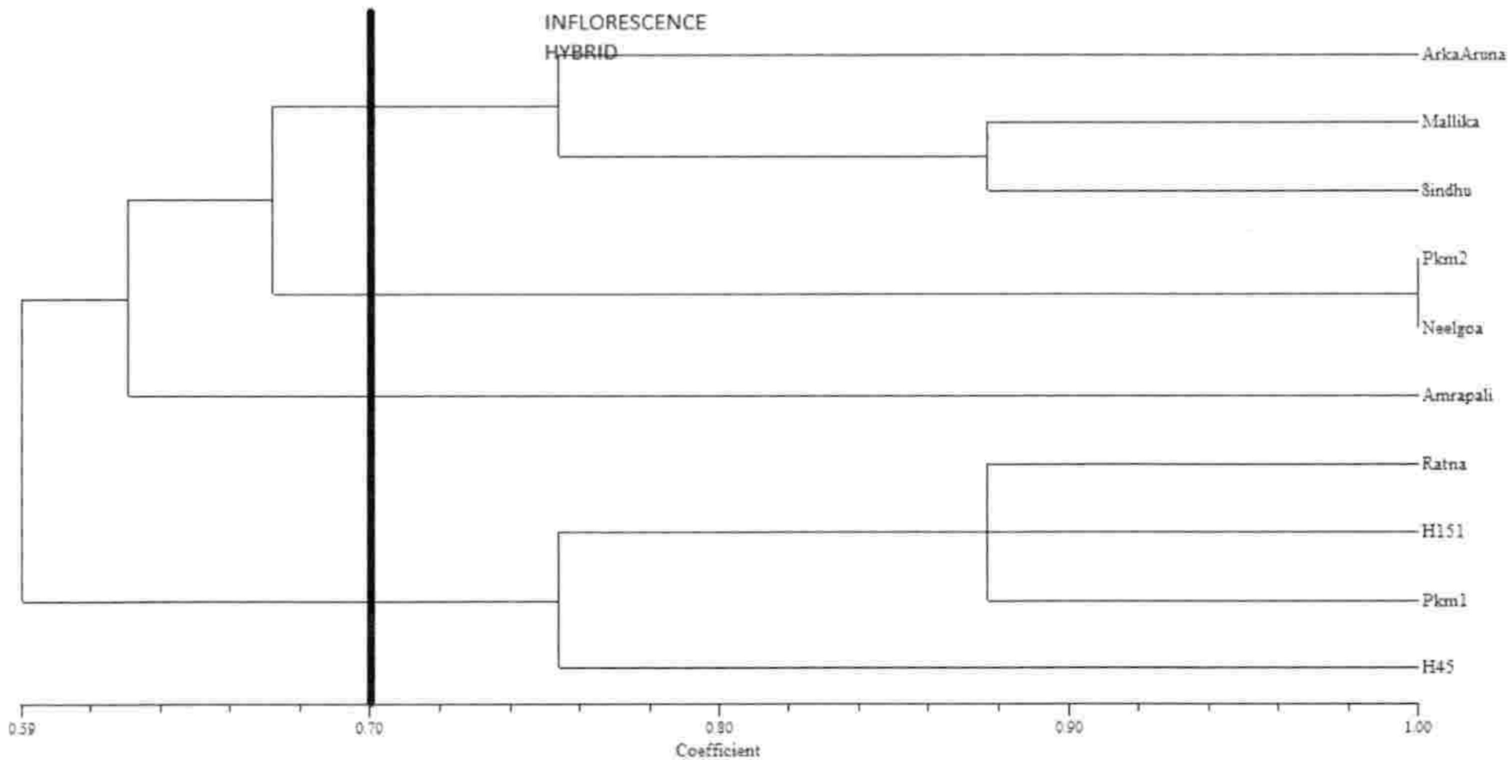


Fig.21 Dendrogram of inflorescence characters - Parents involved in crossing

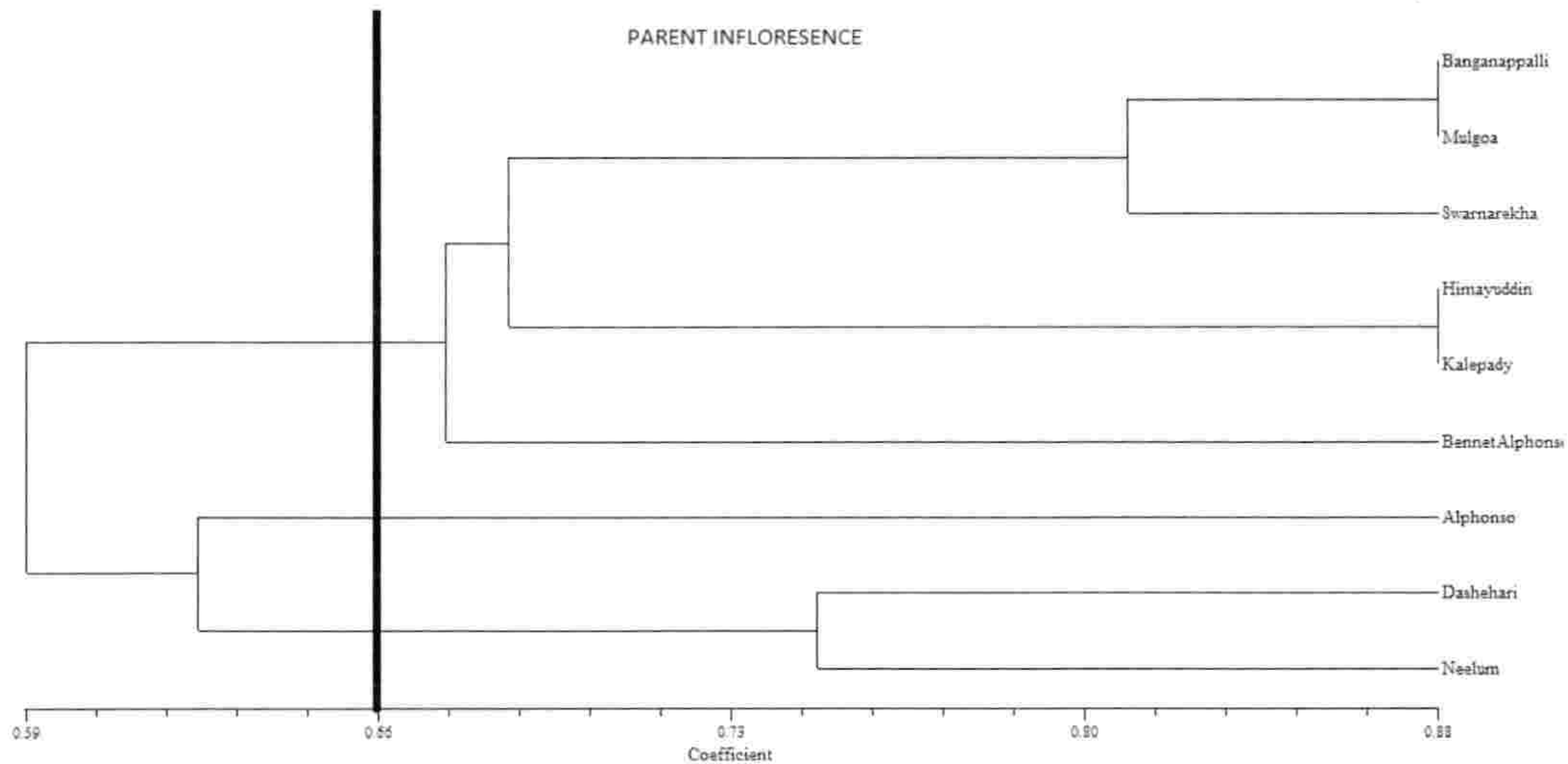
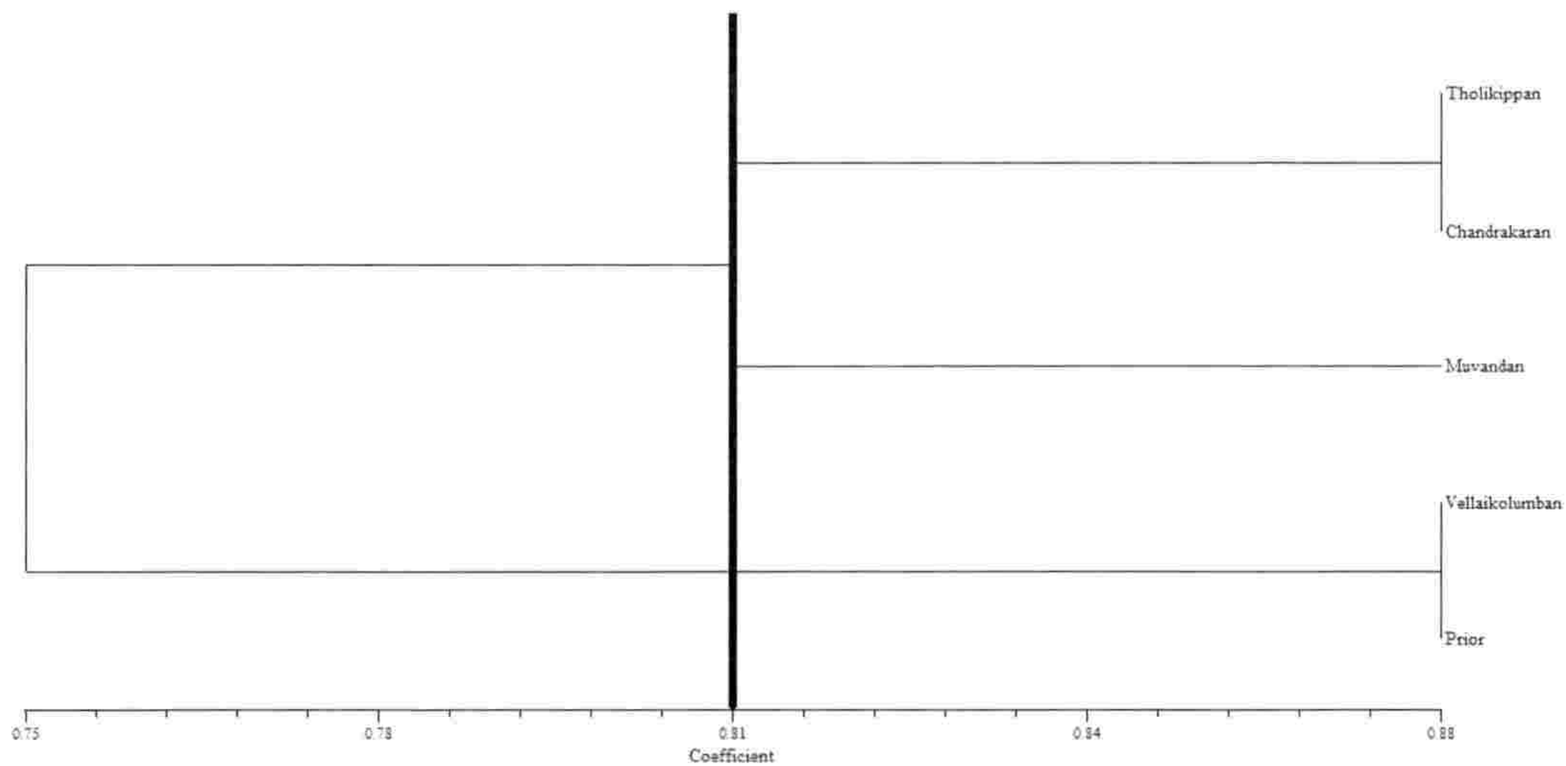


Fig. 22 Dendrogram of inflorescence characters – local types



inflorescence length. among the hybrids. Bennet Alphonso (42.42 cm) recorded the highest inflorescence length among the parents. Vellaikolumban (36.87 cm) recorded the highest inflorescence among the local types.

The data presented in Table 29b shows the variation in inflorescence length of different genotypes during the three seasons. H 151 recorded the highest inflorescence length followed by among the hybrids. Mulgoa (34.71 cm) recorded the highest inflorescence length among the parents involved in breeding. Chandrakaran (28.14 cm) recorded the highest inflorescence length among the local types.

The data presented in Table 30a shows the variation in inflorescence width of different genotypes during the two seasons. Ratna (25.33 cm) recorded the highest inflorescence width. Bennet Alphonso (20.83 cm) recorded the highest inflorescence width among the parents involved in breeding. Vellaikolumban (30.40 cm) recorded the highest inflorescence width which was significantly different from the rest of the local types. The data presented in Table 30b shows the variation in inflorescence width of different genotypes during the three seasons. Ratna (23.57 cm) recorded the highest inflorescence width which was significantly different from the other hybrids. Bennet Alphonso (20.56 cm) recorded the highest inflorescence among the parents involved in breeding. Prior (19.99 cm) recorded the highest inflorescence width among the local types.

The data presented in Table 31a shows the variation in inflorescence length of different genotypes during the two seasons. Among the hybrids, PKM 1 (66.67 %) recorded the highest hermaphrodite flowers and H 151 (37.00 %) recorded the lowest hermaphrodite flowers in the inflorescence. Neelam (67.83%) recorded the highest hermaphrodite flowers in the inflorescence among the parents involved in breeding and Mulgoa (14.00%) recorded the lowest hermaphrodite flowers in the inflorescence. Prior (67.00%) recorded the highest hermaphrodite flowers in the inflorescence among the local types and Muvandan (20.83%) recorded the lowest hermaphrodite flowers in the inflorescence.

The data presented in Table 31b shows the variation in inflorescence width of different genotypes during the three seasons. Among the hybrids, H 45 (55.33%) recorded the highest hermaphrodite flowers in the inflorescence and H 151 (34.56%)

recorded the lowest hermaphrodite flowers in the inflorescence. Bennet Alphonso (65.89%) recorded the highest number of hermaphrodite flowers in the inflorescence among the parents involved in breeding. And Mulgoa (12.44%) recorded the lowest hermaphrodite flowers in the inflorescence. Prior (62.22%) recorded the highest hermaphrodite flowers in the inflorescence and Chandrakaran (51.56%) recorded the lowest hermaphrodite flowers in the inflorescence among the local types.

The data presented in Table 32 shows the variation in number of stamens per flower. All the hybrids had 5 number of stamens of which 1 or 2 may be fertile whereas Ratna, H 45 and H 151 recorded 4 number of stamens per flower. All the parents involved in breeding had 5 number of stamens per flower except Himayuddin with 4 number of stamens per flower. All the local types had 5 number of stamens per flower. There was no seasonal effect on the number of stamens per flower.

Morphological characters can be used as an efficient tool for proper identification of different mango cultivars (Joshi, 2013). The growth and development of a variety having a definite genetic character in particular set of environmental conditions shows positive relation. The variation in vegetative growth characters among mango varieties might be due to variation in genetic makeup. High variability in vegetative growth amongst the mango varieties have also been reported by Davenport and Nunez-Elizea (1977), Radha and Manjula (2000), Murti and Upreti (2004), Simi (2006), Jyothi *et al.* (2009) and Riberio *et al.*, (2013).

5.2 Fruit Characters

Wide variation was observed in fruit characters of different mango genotypes.

Different fruiting durations like March – May, April-May, and May- June were noticed among the varieties/cultivars (Table 33). Fruiting duration of all the hybrids in Cluster I, II and III were from March, April and May (Tables 34 and 35) (Fig.23). Among the parents, Dashehari, Neelum and Mulgoa were having a fruiting duration from May – June (Tables 36 and 37) (Fig.24). All the local types had a fruiting duration from April to May (Tables 38 and 39) (Fig.25).

Low, medium and high fruit bearing intensity was observed among the different varieties/cultivars (Table 33). The findings showed that among the hybrids Ratna, PKM

Fig.23 Dendrogram of fruit characters - Hybrids

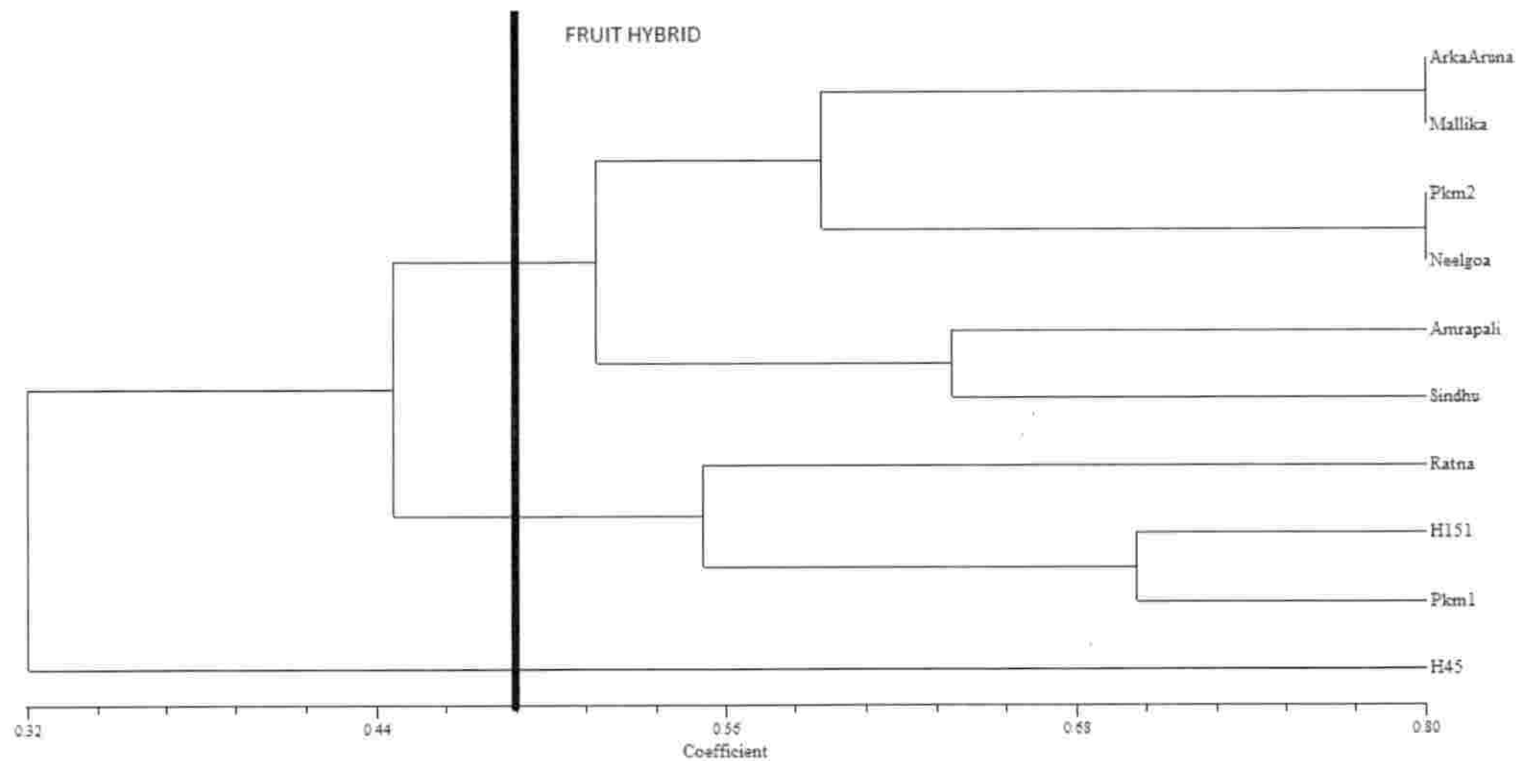


Fig.24 Dendrogram of fruit characters - Parents involved in crossing

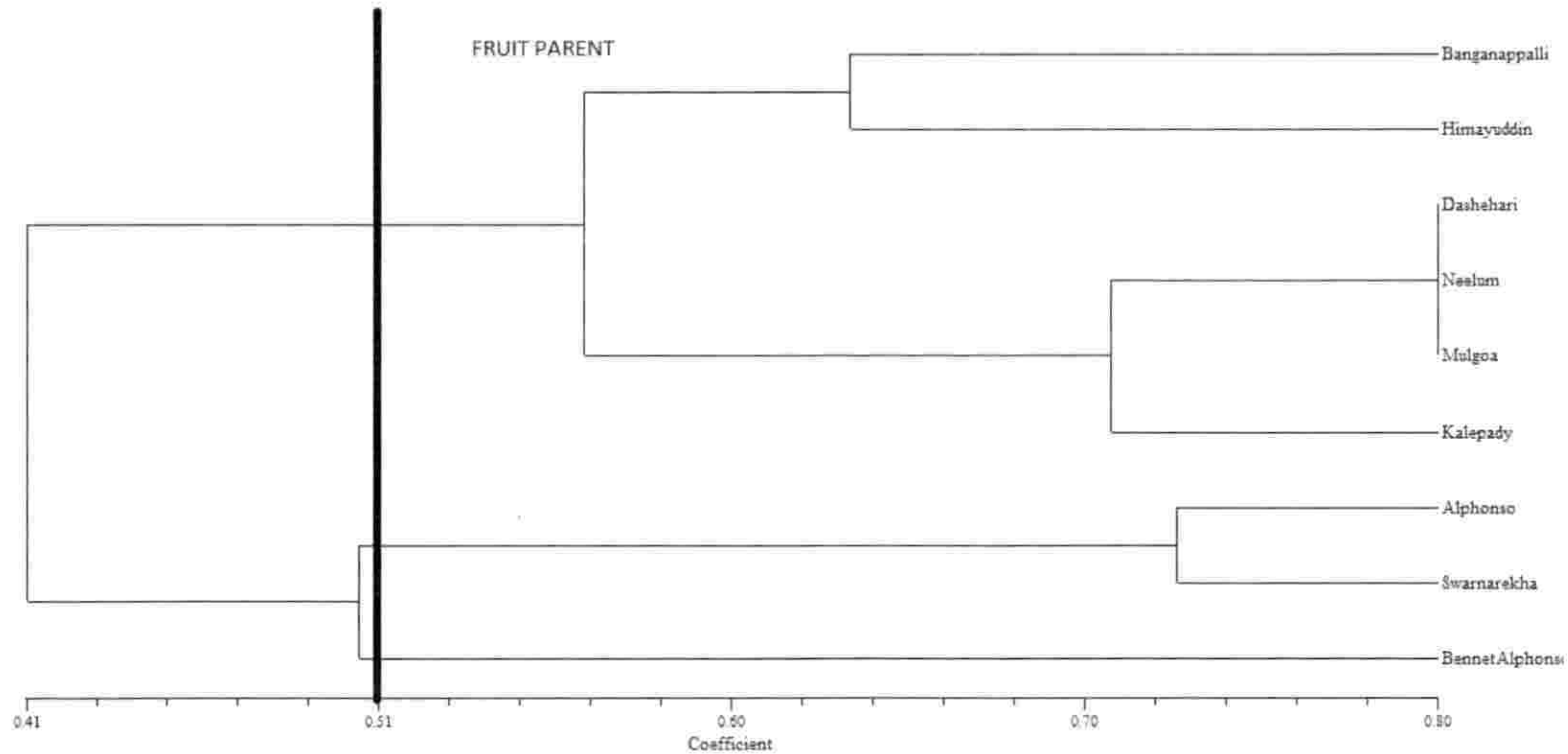
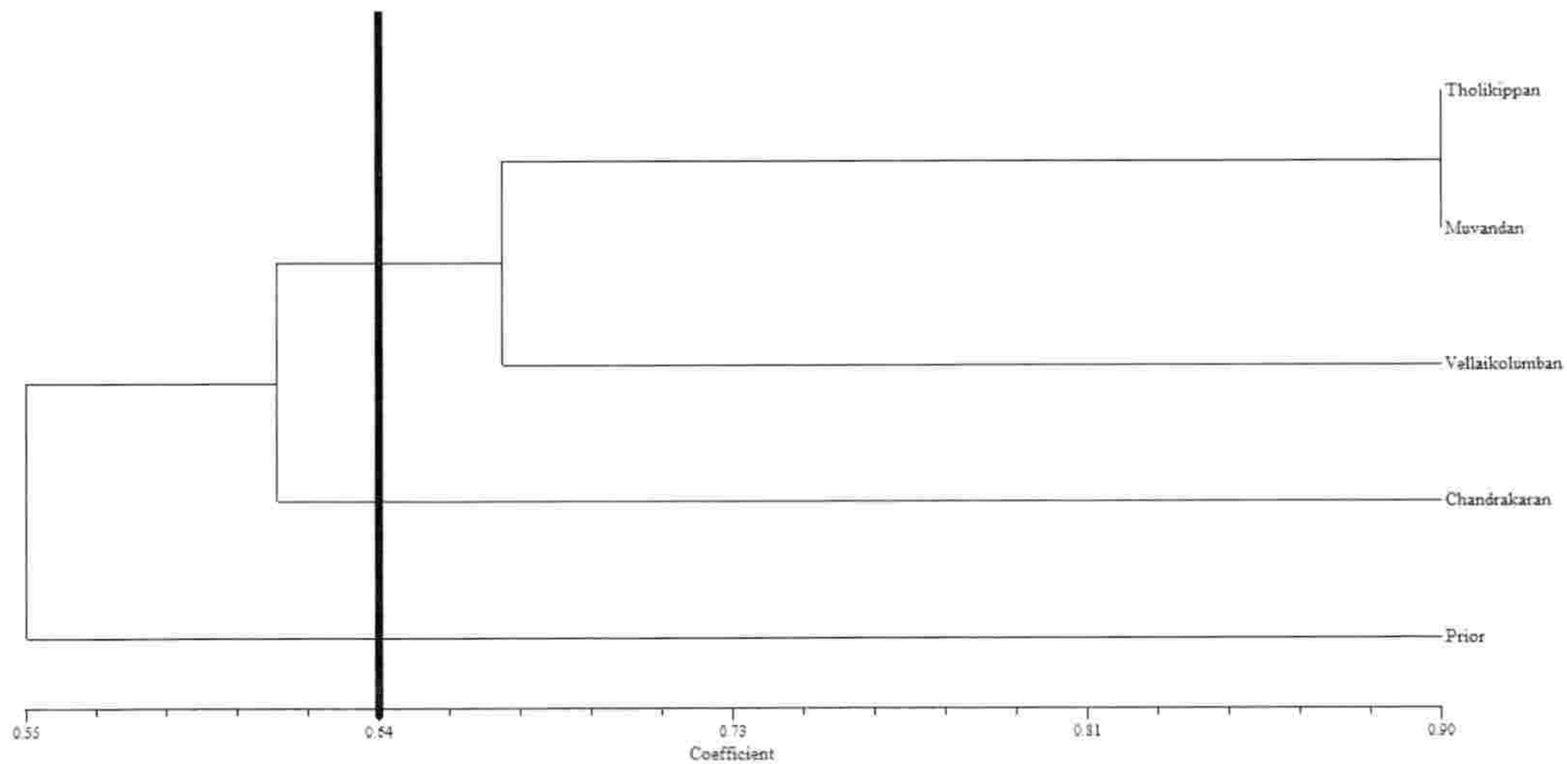


Fig.25 Dendrogram of fruit characters – local types



1, H 45 and H 151 were having high fruit bearing intensity (Tables 34 and 35), Amrapali, Himayuddin, Dashehari, Neelum, Mulgoa and Kalepady were also having high fruit bearing intensity (Tables 36 and 37). Among the local types Chandrakaran was having the high fruit bearing intensity.

Oblong, elliptic and roundish fruit shapes were observed among the different varieties/cultivars. Round, acute and obtuse fruit apex shapes were observed among the different varieties/cultivars. Excellent, good and average fruit attractiveness were observed among the different varieties/cultivars. Shallow, medium and no depth for fruit stalk cavity were observed among the different varieties/cultivars. Slightly prominent and no fruit neck were observed among the different varieties/cultivars. Prominent, perceptible, pointed and mammiform fruit beaks were observed among the different varieties/cultivars. Mild, intermediate and strong aroma of ripe fruits were observed among the different varieties/cultivars. Yellow, orange and shallow yellow with blush skin colours were observed for ripe fruits among the different varieties/cultivars. Golden yellow, light yellow, yellow and yellow orange pulp colour of ripe fruits were observed among the different varieties/cultivars (Table 33).

Fruits were obtained only during two seasons in Arka Aruna, Amrapali, Mallika, Ratna, Sindhu, H 45, H 151, PKM 1, PKM 2 and Neelgoa among the hybrids. Among the local types, Banganapalli, Alphonso, Dashehari, Neelum, Himayuddin, Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa had fruiting during two seasons, while Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan showed fruiting during two seasons. The results in the present study revealed that there was no flowering during the first season.

Fruits were obtained only during three seasons in Arka Aruna, Ratna, H 45, H 151 and PKM 2 among the hybrids. Among the local types, Banganapalli, Alphonso, Himayuddin, Bennet Alphonso, Swarnarekha and Mulgoa had fruiting during three seasons, while Chandrakaran, and Prior showed fruiting during three seasons.

The data presented in Table 40a shows the variation in fruit length of different genotypes during the two seasons. Among the hybrids, Mallika (17.97 cm) recorded the highest fruit length and H 151 (10.27 cm) recorded the lowest fruit length. Mulgoa (20.08 cm) recorded the highest fruit length the parents involved in breeding and

Bennet Alphonso (10.47 cm) recorded the lowest fruit length. Prior (13.77 cm) recorded the highest fruit length and Chandrakaran (7.60 cm) recorded the lowest fruit length. The data presented in Table 40b shows the variation in fruit length of different genotypes during the three seasons. Among the hybrids Arka Aruna (16.56 cm) recorded the highest fruit and H 151 (9.11 cm) recorded the lowest fruit length. Mulgoa (19.99 cm) recorded the highest fruit among the parents involved in breeding. and Bennet Alphonso (10.47 cm) recorded the lowest fruit length. Prior (13.67 cm) recorded the highest fruit length whereas Chandrakaran (7.47 cm) recorded the lowest fruit length among the local types.

The data presented in Table 41a shows the variation in fruit diameter of different genotypes during the two seasons. Among the hybrids Arka Aruna (32.50 cm) recorded the highest fruit and H 151 (17.05 cm) recorded the lowest fruit diameter and Mulgoa (28.02 cm) recorded the highest fruit diameter among the parents involved in breeding. and Neelum (18.78 cm) recorded the lowest fruit diameter. Prior (26.83 cm) recorded the highest fruit diameter which was significantly different from the rest of the local types and Chandrakaran (17.13 cm) recorded the lowest fruit diameter. The data presented in Table 41b shows the variation in fruit diameter of different genotypes during the three seasons. Among the hybrids Arka Aruna (32.87 cm) recorded the highest diameter which was significantly different from the rest of the hybrids and H 151 (18.26 cm) recorded the lowest fruit diameter. Mulgoa (27.08 cm) recorded the highest fruit diameter which was significantly different from the rest of the parents involved in breeding and Bennet Alphonso (19.07 cm) recorded the lowest fruit diameter. Prior (26.57 cm) recorded the highest fruit diameter and Chandrakaran (16.96 cm) recorded the lowest fruit diameter among the local types.

The data presented in Table 42a shows the variation in fruit weight of different genotypes during the two seasons. Among the hybrids Arka Aruna (631.40g) recorded the highest fruit weight which was significantly different from the rest of the hybrids and H 151 (131.25g) recorded the lowest fruit weight. Mulgoa (738.97g) recorded the highest fruit weight which was significantly different from the other parents involved in breeding and Alphonso (145.83g) recorded the lowest fruit weight. Prior recorded the highest fruit weight among the local types and Chandrakaran (123.10g) recorded the lowest fruit weight. The data presented in Table 42b shows the variation in fruit weight of different genotypes during the three seasons. Among the hybrids Arka Aruna (660.01 g) recorded the highest fruit weight and H 151 (145.99 g) recorded the lowest fruit weight. Mulgoa (707.69 g) recorded the highest fruit weight which was significantly different from the rest of the parents involved in breeding and Alphonso (147.76 g) recorded the lowest fruit weight. Prior (350.69 g) recorded the highest fruit weight and Chandrakaran (120.49 g) recorded the lowest fruit weight among the local types.

The data presented in Table 43a shows the variation in fruit yield of different genotypes during the two seasons. Among the hybrids H45 (46.92 kg/tree) recorded the highest yield and Arka Aruna (9.75 kg/tree) recorded the lowest yield. Dashehari (48.00 kg/tree) recorded the highest fruit yield which was significantly different from the rest of the parents involved in breeding and Mulgoa (11.42 kg/tree) recorded the lowest fruit yield. Muvandan (52.13 kg/tree) recorded the highest fruit yield and Prior (48.84 kg/tree). Chandrakaran (12.87 kg/tree) recorded the lowest fruit yield among the local types. The data presented in Table 43b shows the variation in fruit yield of different genotypes during the three seasons. Among the hybrids H 45 (38.61 kg/tree) recorded the highest fruit yield and Arka Aruna (8.67 kg/tree) recorded the lowest fruit yield. Prior (43.46 kg/tree) recorded the highest fruit yield and Chandrakaran (12.08 kg/tree) recorded the lowest fruit yield among the local types.

The data presented in Table 44a shows the variation in shelf life of different genotypes during the two seasons. Among the hybrids H 151 (7.00 Days) recorded the highest shelf life and PKM 1 (3.83 Days) recorded the lowest shelf life which was on par with PKM 2 (4.00 Days). Dashehari (6.67 Days) recorded the highest shelf life which was significantly different from the rest of the parents involved in breeding and Himayuddin (4.00 Days) recorded the lowest shelf life. Chandrakaran (4.17 Days) recorded the highest shelf life which followed by the rest of the local types and Tholikaippan (4.00 Days) recorded the lowest shelf life. The data presented in Table 44b shows the variation in shelf life of different genotypes during the three seasons. Among the hybrids H 151 (7.00 Days) recorded the highest shelf life and PKM 2 (4 Days) recorded the lowest shelf life. Alphonso (6.00 Days) recorded the highest shelf life and Himayuddin (4 Days) recorded the lowest shelf life. Chandrakaran (4.11 Days) and Prior (4.11 Days) recorded the same shelf life among the local types both.

The variations observed in fruiting behaviors may be attributed to the genetic nature of varieties and weather parameter. These observations were in accordance with the results of Kumar and Singh (2005), Abdullah *et al.* (2013), Riberio *et al.* (2013) and Navprem *et al.*, (2014). 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 is important for studying variability in mango germplasm. The variation in length and width of the fruit in mango was observed by Ram and Rajan, (2003), Simi (2006), Toili *et al.*, (2013) and Navprem (2014). Prasad and Nalini (1988) have studied the fruit size of mango and reported that mango cultivars differed in fruit length and width according to their genetic makeup.

5.3 Stone characters

The data presented in Table 45a shows the variation in stone length of different genotypes during the two seasons. Among the hybrids, PKM 2 (11.83 cm) recorded the highest fruit stone and Sindhu (6.53 cm) recorded the lowest stone length. Mulgoa (14.05 cm) recorded the highest stone length among the parents involved in breeding and Neelum (5.60 cm) recorded the lowest stone length. Prior (12.07 cm) recorded the highest stone length among the local types and Muvandan (5.60 cm) recorded the lowest stone length. The data presented in Table 45b shows the variation in stone length of different genotypes during the three seasons. Among the hybrids, PKM 2 (11.23 cm) recorded the highest stone length which was significantly different from the rest of the hybrids and H 151 (7.70 cm) recorded the lowest stone length. Mulgoa (13.94 cm) recorded the highest stone length which was significantly different from the rest of the parents involved in breeding and Bennet Alphonso (6.66 cm) recorded the lowest stone length. Prior (11.60 cm) recorded the highest stone length and Chandrakaran (5.76 cm) recorded the lowest stone length among the local types.

The data presented in Table 46a shows the variation in stone width of different genotypes during the two seasons. Among the hybrids, H 45 (12.07 cm) recorded the highest stone width which was significantly different from the rest of the hybrids and Sindhu (3.28 cm) recorded the lowest stone width. Banganapalli (8.68 cm) recorded the highest stone and Dashehari (4.18 cm) recorded the lowest stone width. Prior (5.85 cm) recorded the highest stone width which was significantly different from the rest of the local types and Muvandan (3.17 cm) recorded the lowest stone width. The data presented in Table 46b shows the variation in stone width of different genotypes during the three seasons. Among the hybrids, H 45 (12.45 cm) recorded the highest stone width which was significantly different from the rest of the hybrids and H 151 (7 cm) recorded the lowest stone width. Banganapalli (8.88 cm) recorded the highest stone width and Bennet Alphonso (5.11 cm) recorded the lowest stone width. Prior (5.66cm) recorded the highest stone width and Chandrakaran (3.78 cm) recorded the lowest stone width among the local types.

The data presented in Table 47a shows the variation in stone thickness of different genotypes during the two seasons. Among the hybrids, Neelgoa (3.15 cm) recorded the highest stone thickness and PKM 1 (1.22 cm) recorded the lowest stone thickness. Alphonso (2.37 cm) recorded the highest stone thickness and Banganapalli (1.23 cm) recorded the lowest stone thickness. Using (2.17cm) recorded the highest stone thickness among the local types and Muvandan (1.20 cm) recorded the lowest stone thickness. The data presented in Table 47b shows the variation in stone thickness of different genotypes during the three seasons. Among the hybrids, Arka Aruna (2.45 cm) recorded the highest stone thickness and H 151 (1.34 cm) recorded the lowest stone thickness. Alphonso (2.42 cm) recorded the highest stone thickness and Mulgoa (1.24 cm) recorded the lowest stone thickness. Prior (2.00 cm) recorded the highest stone thickness and Chandrakaran (1.67 cm) recorded the lowest stone thickness among the local types.

The data presented in Table 48a shows the variation in stone weight of different genotypes during the two seasons. Among the hybrids, Mallika (45.50 g) recorded the highest stone weight and Sindhu (20.15 g) recorded the lowest stone weight. Mulgoa (47.73 g) recorded the highest stone weight which was significantly different from the rest of the parents involved in breeding and Bennet Alphonso (15.93 g) recorded the lowest stone weight. Prior (29.43 g) recorded the highest stone weight which is significantly different from rest of the local types and Vellaikolumban (17.17 g) recorded the lowest stone weight. The data presented in Table 48b shows the variation in stone weight of different genotypes during the three seasons. Among the hybrids, Arka Aruna (47.67 g) recorded the highest stone weight and H 151 (22.60 g) recorded the lowest stone weight. Mulgoa (47.46 g) recorded the highest stone weight which was significantly different from the rest of the parents involved in breeding and Bennet Alphonso (16.05 g) recorded the lowest stone weight. Prior (29.07 g) recorded the highest stone weight and Chandrakaran (18.49 g) recorded the lowest stone weight among the local types.

The data presented in Table 49a shows the variation in seed length of different genotypes during the two seasons. Among the hybrids, Amrapali (7.38 cm) recorded the highest seed length and H 151 (6.05 cm) recorded the lowest seed length. Mulgoa (11.22 cm) recorded the highest seed length among the parents involved in breeding and Bennet Alphonso (4.28 cm) recorded the lowest seed length. Tholikaippan (6.25 cm) recorded the highest seed length and Chandrakaran (4.45 cm) recorded the lowest seed length. The data presented in Table 49b shows the variation in seed length of different genotypes during the three seasons. Among the hybrids, PKM 2 (7.55 cm) recorded the highest seed length and H 151 (5.92 cm) recorded the lowest seed length. Mulgoa (10.89 cm) recorded the highest seed length among the parents involved in breeding and Bennet Alphonso (4.31 cm) recorded the lowest seed length. Prior (6.00 cm) recorded the highest seed length and Chandrakaran (4.26 cm) recorded the lowest seed length among the local types.

The data presented in Table 50a shows the variation in seed width of different genotypes during the two seasons. Among the hybrids, Ratna (8.45 cm) recorded the highest seed width and Sindhu (2.25 cm) recorded the lowest seed width. Banganapalli (8.88 cm) recorded the highest seed width among the parents involved in breeding and Dashehari (3.37 cm) recorded the lowest seed width. Tholikaippan (3.45 cm) recorded the highest seed width among the local types and Muvandan (2.31 cm) recorded the lowest seed width. The data presented in Table 50b shows the variation in seed width of different genotypes during the three seasons. Among the hybrids, Ratna (8.51 cm) recorded the highest seed width and PKM 2 (3.13 cm) recorded the lowest seed width. Banganapalli (8.93 cm) recorded the highest seed width which was significantly different from the rest of the parents involved in breeding and Mulgoa (4.93 cm) recorded the lowest seed width. Prior (3.01 cm) recorded the highest stone width and Chandrakaran (2.86 cm) recorded the lowest stone width among the local types.

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The data presented in Table 51a shows the variation in seed weight of different genotypes during the two seasons. Among the hybrids, Neelgoa (24.17 g) recorded the highest seed weight and Sindhu (12.80 g) recorded the lowest seed weight. Mulgoa (28.98 g) recorded the highest seed weight among the parents involved in breeding and Bennet Alphonso (11.03 g) recorded the lowest seed weight. Tholikaippan (18.45 g) recorded the highest seed weight among the local types and Vellaikolumban (8.58 g) recorded the lowest seed weight. The data presented in Table 51b shows the variation in seed weight of different genotypes during the three seasons. Among the hybrids, PKM 2 (23.71 g) recorded the highest seed weight and H 151 (15.13 g) recorded the lowest seed weight. Mulgoa (26.49 g) recorded the highest seed weight which was significantly different from the rest of the parents involved in breeding and Bennet Alphonso (11.55 g) recorded the lowest seed weight. Prior (18.31 g) recorded the highest seed weight and Chandrakaran (14.82 g) recorded the lowest seed weight among the local types.

Low, intermediate and high quantity of fibre on stone were observed among the different varieties/cultivars (Table 52). Weak, intermediate and strong adherence of fibre to stone were observed among the different varieties/cultivars (Table 52). Coarse and soft texture of stone fibre were observed among the different varieties/cultivars (Table 52). Ellipsoid, reniform and oblong seed shapes were observed among the different varieties/cultivars (Table 52) (Fig.26, 27 and 28).

Wide variation was observed among the stone characters, all these variations observed in stone characters may be attributed to the genetic nature of varieties. The results in the present study was parallel with the findings of Prasad and Nalini (1988) and Bains and Dhillon (1999).

5.4 Quality attributes

Wide variation was observed among the different quality attributes like acidity (%), ascorbic acid (mg $100g^{-1}$), total carotenoids (mg $100g^{-1}$), β carotene (mg $100g^{-1}$), total sugar (%), reducing sugar (%), crude fibre (%) and TSS (^{o}Brix).

The data presented in Table 59 shows the variation in acidity of different genotypes during the two seasons. Among the hybrids, PKM 1 (0.06 %) recorded the highest acidity and H 151 (0.02%) recorded the lowest acidity. Himayuddin (0.12%)

Fig.26 Dendrogram of stone characters - Hybrids

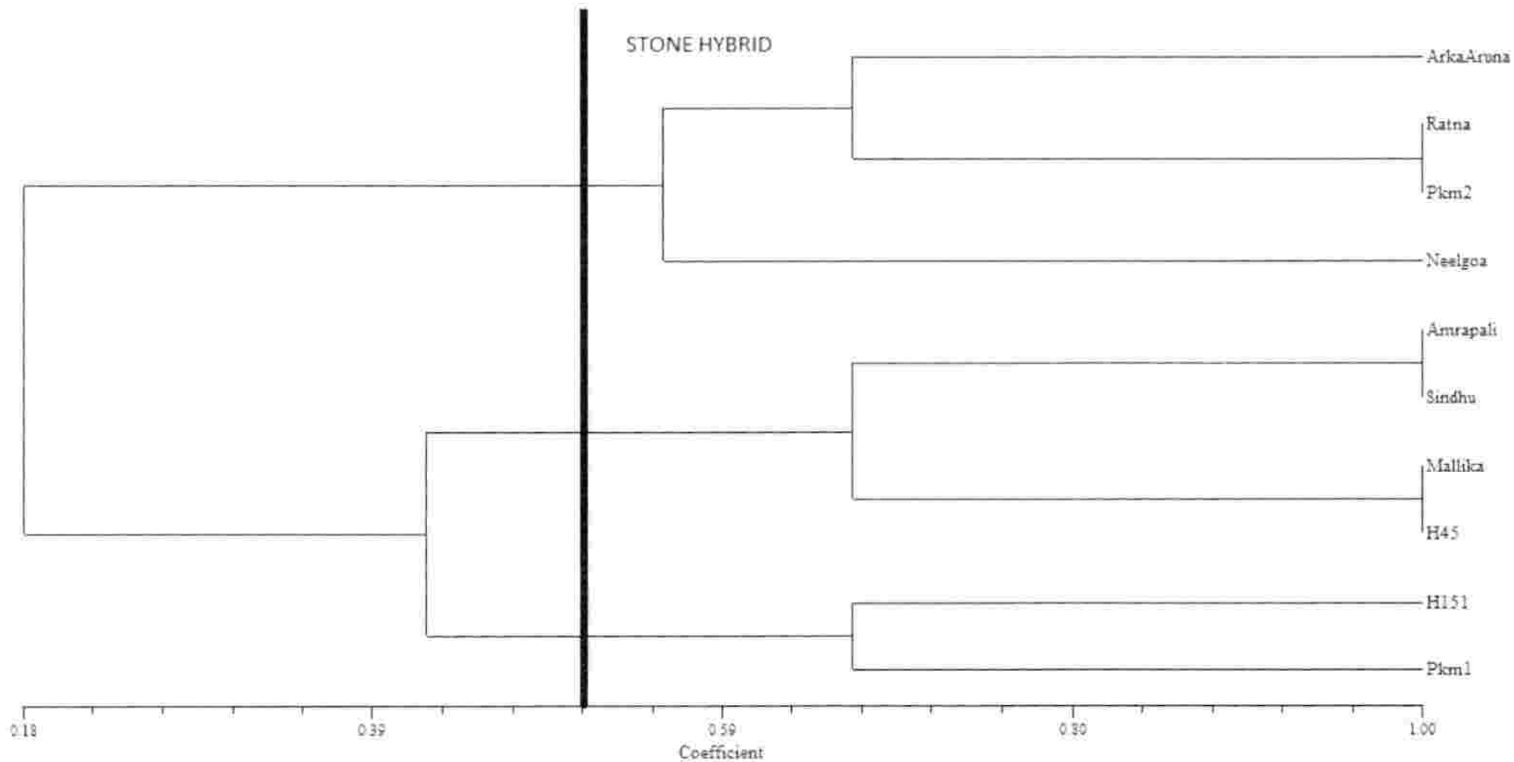


Fig.27 Dendrogram of stone characters - Parents involved in crossing

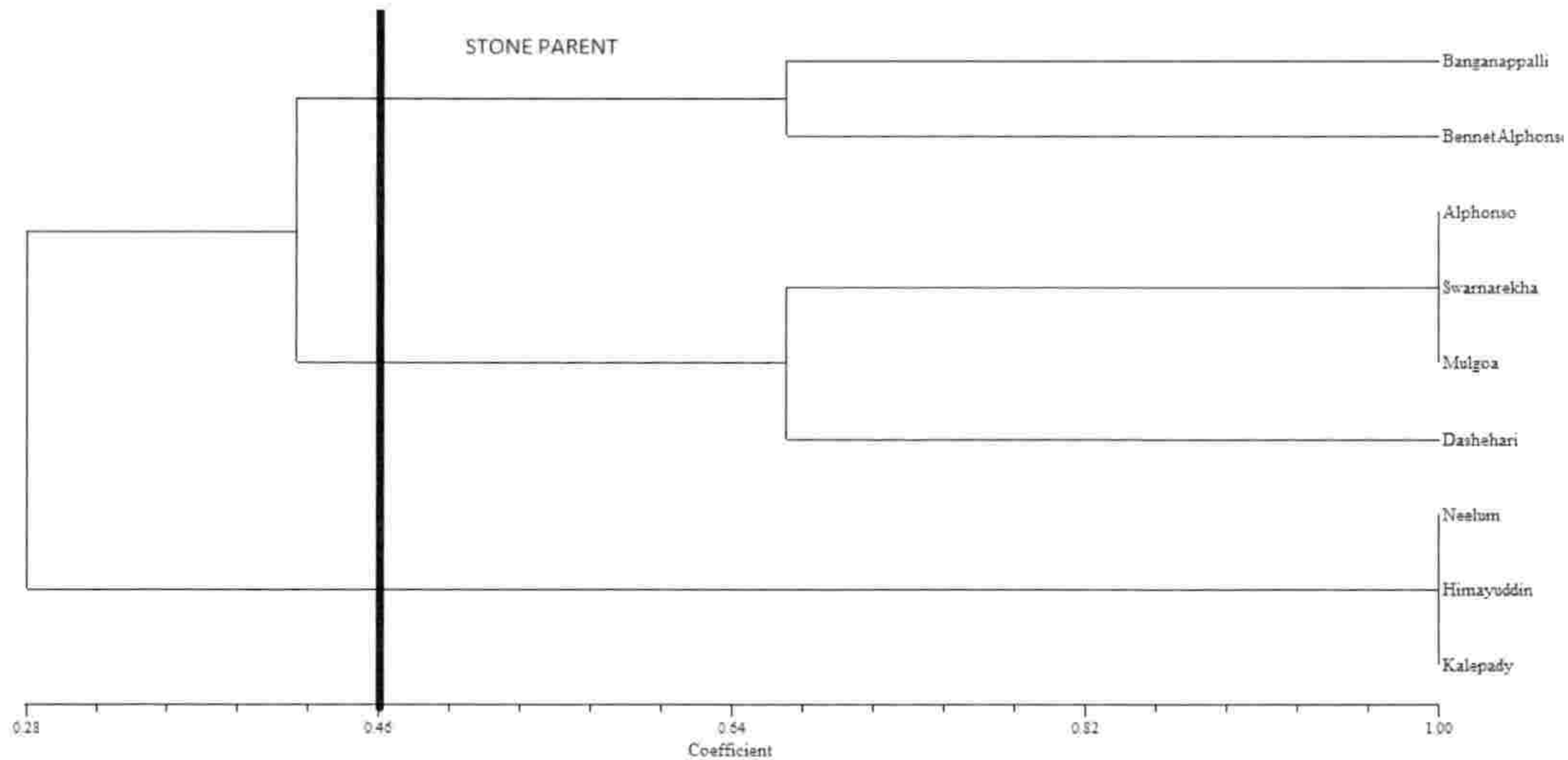
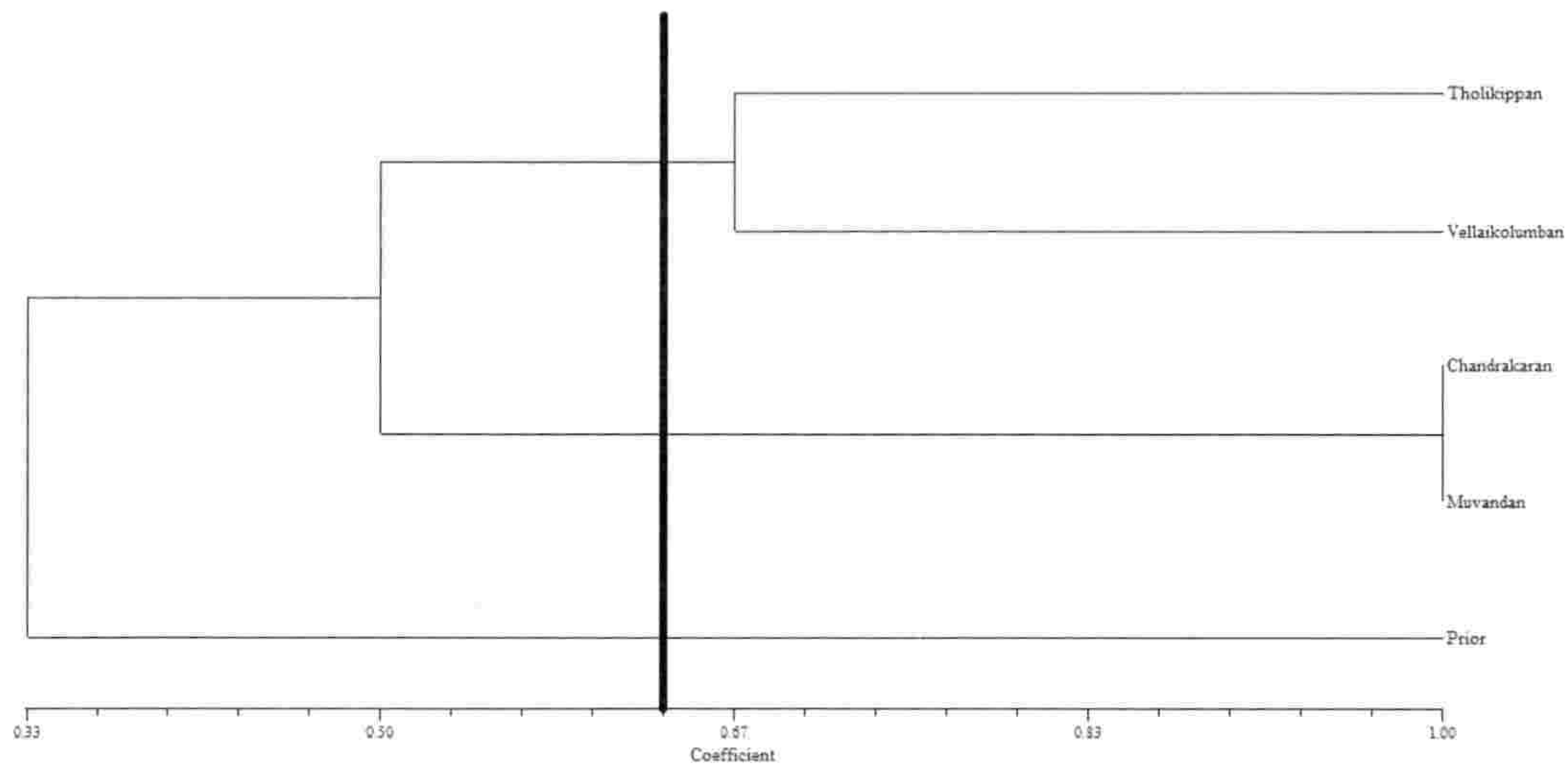


Fig.28 Dendrogram of stone characters – local types



recorded the highest acidity among the parents involved in breeding and Kalepady (0.02%) recorded the lowest acidity. Muvandan (0.09 %) recorded the highest acidity and Chandrakaran (0.04 %) recorded the lowest acidity. The data presented in Table 59b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, Arka Aruna (0.05%) recorded the highest acidity and H 151 (0.02%) recorded the lowest acidity. Among the parents involved in breeding Himayuddin (0.09 %) recorded the highest acidity and Mulgoa (0.03 %), recorded the lowest acidity. Prior (0.05%) recorded the highest acidity and Chandrakaran (0.04%) recorded the lowest acidity among the local types.

The data presented in Table 60a shows the variation in ascorbic acid of different genotypes during the two seasons. Among the hybrids, H 151 (66.67 mg 100g$_{-1}$) recorded the highest ascorbic acid and Arka Aruna (12.17 mg 100g$_{-1}$) recorded the lowest ascorbic acid. Neelum (59.26 mg 100g$_{-1}$) recorded the highest Ascorbic acid) among the parents involved in breeding and Swarnarekha (20.11 mg 100g$_{-1}$) recorded the lowest ascorbic acid. Muvandan (72.49 mg 100g$_{-1}$) recorded the highest ascorbic acid among the local types and Vellaikolumban (16.93 mg 100g$_{-1}$) recorded the lowest ascorbic acid. The data presented in Table 60b shows the variation in ascorbic acid of different genotypes during the three seasons. Among the hybrids, H 151 (56.79 mg 100g$_{-1}$) recorded the highest ascorbic acid and Arka Aruna (10.93 mg 100g$_{-1}$) recorded the lowest ascorbic acid. Alphonso (60.95 mg 100g$_{-1}$) recorded the highest ascorbic acid among the parents involved in breeding and Swarnarekha (18.69 mg 100g$_{-1}$) recorded the lowest ascorbic acid. Chandrakaran (50.37 mg 100g$_{-1}$) recorded the highest ascorbic acid and Prior (33.86 mg 100g$_{-1}$) recorded the lowest ascorbic acid among the local types.

The data presented in Table 61a shows the variation in total carotenoids of different genotypes during the two seasons. Among the hybrids, H 151 (5.79 mg 100g$_{-1}$) recorded the highest total carotenoids and Arka Aruna (0.86 mg 100g$_{-1}$) recorded the lowest total carotenoids. Alphonso (8.47 mg 100g$_{-1}$) recorded the highest total carotenoids among the parents involved in breeding and Neelum (0.16 mg 100g$_{-1}$) recorded the lowest total carotenoids. Tholikaippan (5.34 mg 100g$_{-1}$) recorded the highest total carotenoids which was significantly different from the rest of the local types and Vellaikolumban (1.28 mg 100g$_{-1}$) recorded the lowest total carotenoids. The data presented in Table 61b shows the variation in total carotenoids of different genotypes during the three seasons. Among the hybrids, H 151 (5.32 mg 100g$_{-1}$) recorded the highest total carotenoids which was significantly different from the rest of the hybrids and Arka Aruna (0.86 mg 100g$_{-1}$) recorded the lowest total carotenoids. Alphonso (8.49 mg 100g$_{-1}$) recorded the highest total carotenoids which was significant different from the rest of the parents involved in breeding and Himayuddin (1.78 mg 100g$_{-1}$) recorded the lowest carotenoids which was on par with Banganapalli (2.33 mg 100g$_{-1}$). Chandrakaran (3.21 mg 100g$_{-1}$) recorded the highest total carotenoids and Prior (1.78 mg 100g$_{-1}$) recorded the lowest total carotenoids among the local types.

The data presented in Table 62a shows the variation in β carotene of different genotypes during the two seasons. Among the hybrids, Sindhu (32.57 mg 100g$_{-1}$) recorded the highest β carotene which was significantly different from the rest of the hybrids and Arka Aruna (10.60 mg 100g$_{-1}$) recorded the lowest β carotene. Dashehari (45.06 mg 100g$_{-1}$) recorded the highest β carotene which was significantly different from the rest of the parents involved in breeding and Mulgoa (9.75 mg 100g$_{-1}$) recorded the lowest β carotene. Tholikaippan (20.08 mg 100g$_{-1}$) recorded the highest β carotene which was significantly different form the rest of the local types and Prior (11.16 mg 100g$_{-1}$) recorded the lowest β carotene. The data presented in Table 62b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, H151 (25.28 mg 100g$_{-1}$) recorded the highest β carotene which was significantly different from the rest of the hybrids and Arka Aruna (10.88 mg 100g$_{-1}$) recorded the lowest β carotene. Among the parents involved in breeding Alphonso (39.08 mg 100g$_{-1}$) recorded the highest β carotene which was significantly different from the rest of the parents involved in breeding and Mulgoa (9.59 mg 100g$_{-1}$) recorded the lowest β carotene. Chandrakaran (15.73 mg 100g$_{-1}$) recorded the highest β carotene and Prior (11.26 mg 100g$_{-1}$) recorded the lowest β carotene among the local types.

The data presented in Table 63a shows the variation in total sugar of different genotypes during the two seasons. Among the hybrids, PKM 1 (22.43%) recorded the highest total sugar and H 151 (13.85) recorded the lowest total sugar. Swarnarekha (27.81 %) recorded the highest total sugar which was significantly different from the rest of the parents involved in breeding and Kalepady (13.14 %) recorded the lowest total sugar. Vellaikolumban (17.29 %) recorded the highest total sugar which was significantly different from the rest of the local types and Tholikaippan (12.55 %) recorded the lowest total sugar. The data presented in Table 63b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, PKM 2 (20.95%) recorded the highest total sugar and Arka Aruna (14.68%) recorded the lowest total sugar. Swarnarekha (25.01%) recorded the highest total sugar which was significantly different from the rest of the parents involved in breeding and Banganapalli (15.10%) recorded the lowest total sugar. Chandrakaran (17.79%) recorded the highest total sugar and Prior (16.34%) recorded the lowest total sugar among the local types.

The data presented in Table 64a shows the variation in reducing sugar of different genotypes during the two seasons. Among the hybrids, H 151 (9.18%) recorded the highest reducing sugar and PKM 1 (5.58%) recorded the lowest reducing sugar. Kalepady (9.55%) recorded the highest reducing sugar among the parents involved in breeding and Swarnarekha (5.37%) recorded the lowest reducing sugar. Tholikaippan (10.38%) recorded the highest reducing sugar which was significantly different from the rest from the rest of the local types and Vellaikolumban (7.41%) recorded the lowest reducing sugar. The data presented in Table 64b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, Arka Aruna (8.81%) recorded the highest reducing sugar and PKM 2 (5.98%) recorded the lowest reducing sugar which was on par with H 45 (6.40%).Banganapalli (8.31%) recorded the highest reducing sugar and Swarnarekha (5.72%) recorded the lowest reducing sugar. Prior (7.90%) recorded the highest reducing sugar and Chandrakaran (7.34%) recorded the lowest reducing sugar among the local types.

The data presented in Table 65a shows the variation in crude fibre of different genotypes during the two seasons. Among the hybrids, Arka Aruna (16.50 %) recorded the highest crude fibre which was significantly different from the rest of the hybrids and PKM 2 (2.85%) recorded the lowest crude fibre. Swarnarekha (12.02%) recorded the highest crude fibre which was significantly different from the rest of the parents involved in breeding and Alphonso (2.67%) recorded the lowest crude fibre. Among the local types Chandrakaran (10.98%) recorded the highest crude fibre which was significantly different from the rest of the local types and Vellaikolumban (7.75%) recorded the lowest crude fibre. The data presented in Table 65b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, Arka Aruna (15.53 %) recorded the highest crude fibre which was significantly different from the rest of the hybrids and PKM 2 (2.74%) recorded the lowest crude fibre. Swarnarekha (11.75%) recorded the highest crude fibre among the parents involved in breeding and Alphonso (2.69%) recorded the lowest crude fibre. Chandrakaran (10.83 %) recorded the highest crude fibre and Prior (8.65 %) recorded the lowest crude fibre among the local types.

The data presented in Table 66a shows the variation in TSS of different genotypes during the two seasons. Among the hybrids, Neelgoa (26.65 $_{o}$Brix) recorded the highest TSS which was significantly different from the rest of the hybrids and Arka Aruna (16.53 $_{o}$Brix) recorded the lowest TSS which was on par with PKM 2 (17.10 $_{o}$Brix). Himayuddin (27.68 $_{o}$Brix) recorded the highest TSS which was significantly different from the rest of the parents involved in breeding and Kalepady (16.18 $_{o}$Brix) recorded the lowest TSS. Tholikaippan (23.80 $_{o}$Brix) recorded the highest TSS followed and Muvandan (16.95 $_{o}$Brix) recorded the lowest TSS. The data presented in Table 66b shows the variation in TSS of different genotypes during the three seasons. Among the hybrids, H 151 (23.78 $_{o}$Brix) recorded the highest TSS and Arka Aruna (16.28 $_{o}$Brix) recorded the lowest TSS. Himayuddin (27.02 $_{o}$Brix) recorded the highest TSS which was significantly different from the rest of the parents involved in breeding and Swarnarekha (17.76 $_{o}$Brix) recorded the lowest TSS. Chandrakaran (21.71 $_{o}$Brix) recorded the highest TSS and Prior (17.52 $_{o}$Brix) recorded the lowest TSS among the local types.

In general, among the hybrids H 151 recorded high ascorbic acid, total carotenoids, reducing sugar and lowest acidity. Highest beta carotene, total sugar, crude fibre and TSS were recorded for Sindhu, PKM 1, Arka Aruna and Neelgoa respectively. However, among the parents involved in breeding, highest reducing sugar and lowest acidity was recorded in Kalepady. Highest total sugar and crude fibre was recoded in Swarnarekha. The highest ascorbic acid, total carotenoid, beta carotene and TSS were noticed in Neelum, Alphonso, Dashehari and Himayuddin respectively. Among the local types, Tholikaippan recorded the highest total carotenoid, beta carotene, reducing sugar and TSS. Chandrakaran recorded lowest acidity, highest ascorbic acid was recorded for Muvandan, highest total sugar content was recorded for Vellaikolumban and highest crude fiber was recorded for Chandrakaran. The variability in the quality characters could be attributed to the nature and extent of genetic variability present in the experimental material. Similar findings have been reported by Mann *et al.* (1974), Gangwar and Tripathi (1973), Singh *et al.* (1976), Singh *et al.* (1988), Kumar and Singh (2005) and (Simi and Mohan, 2013).

5.5 Sensory evaluation

Sensory evaluation was conducted using ripe fruits and the ranking on the sensory evaluations are given in Table 67. Among the hybrids, the highest rank for appearance, flavor, sweetness and texture was given for Mallika. For colour and taste highest rank was given for Ratna (Table 67a). Among the parents involved in breeding, the highest rank for flavor, sweetness and texture was given for Neelum. Himayuddin recorded highest rank for taste, Kalepady for appearance and colour for Swarnarekha. (Table 67b). Among the local types, the highest rank for appearance was given for Muvandan. For colour highest rank was given for Chandrakaran. Prior got the highest rank for flavor, sweetness, and texture (Table 67c).

5.6 Pollen studies

Size and shape of pollen grains, pollen fertility, *in vitro* pollen germination, estimation of pollen production and pollen storage were recorded and presented in table 68a to table 72.

The data presented in Table 68 a show the variation in pollen length of different genotypes during the two seasons. Among the hybrids, Arka Aruna (41.92 μm) recorded the highest pollen and Neelgoa (26.40 μm) recorded the lowest pollen length. Himayuddin (45.72 μm) recorded the highest pollen length among the parents involved in breeding and Swarnarekha (27.11 μm) recorded the lowest pollen length. Chandrakaran (45.22 μm) recorded the highest pollen length and Muvandan (30.10 μm) recorded the lowest pollen length among the local types. The data presented in Table 68b shows the variation in pollen length of different genotypes during the three seasons. Among the hybrids, Ratna (43.17 μm) recorded the highest pollen length and H 151 (35.61 μm) recorded the lowest pollen length. Bennet Alphonso (46.53 μm)

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recorded the highest pollen length among the parents involved in breeding and Banganapalli (22.31 μm) recorded the lowest pollen length . Prior (44.29 μm) recorded the highest pollen length and Chandrakaran (41.84 μm) recorded the lowest pollen length among the local types.

The data presented in Table 68c shows the variation in pollen width of different genotypes during the two seasons. Among the hybrids, Arka Aruna (38.34 μm) recorded the highest pollen width and Mallika (24.79 μm) recorded the lowest pollen width. Neelam (35.32 μm) recorded the highest pollen width and Banganapalli (25.99 μm) recorded the lowest pollen width which was on par with Mulgoa (26.96 μm) and Kalepady (27.84 μm). Tholikaippan (35.11 μm) recorded the highest pollen width which was significantly different from rest of the local types and Muvandan (22.92 μm) recorded the lowest pollen width. The data presented in Table 68d shows the variation in pollen width of different genotypes during the three seasons. Among the hybrids, Arka Aruna (37.09 μm) recorded the highest pollen and H 151 (31.79 μm) recorded the lowest pollen width. Alphonso (35.10 μm) recorded the highest pollen and Banganapalli (25.23 μm) recorded the lowest pollen width. Prior (30.36 μm) recorded the highest pollen width and Chandrakaran (28.67 μm) recorded the lowest pollen width among the local types.

The data presented in Table 69 shows the variation in shape of pollen grains of different genotypes during. Among the hybrids, Arka Aruna, Amrapali, Sindhu, H 45, H 151, PKM 1, PKM 2 and Neelgoa had oblong pollen whereas Mallika and Ratna had oval pollen grains. All the parents involved in breeding had oblong pollen grains except Swarnarekha and Mulgoa. Swarnarekha had round pollen grains whereas Mulgoa had oval pollen grains. Vellaikolumban, Prior and Muvandan had oblong pollen grains among the local types whereas Chandrakaran recorded oval pollen grains and Tholikaippan recorded roundish pollen grains.

The data presented in Table 70a shows the variation in pollen fertility of different genotypes during the two seasons. Among the hybrids, Ratna (93.54 %) recorded the highest fertility and Neelgoa (87.16%) recorded the lowest fertility. Dashehari (92.18%) recorded the highest fertility among the and Mulgoa (82.70%)

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recorded the lowest pollen fertility. Tholikaippan (93.60%) recorded the highest pollen fertility and Prior (86.22%) recorded the lowest pollen fertility which was on par with Muvandan (87.63%) and Vellaikolumban (87.69%).The data presented in Table 70b shows the variation in pollen fertility of different genotypes during the three seasons. Among the hybrids, Ratna (78.79%) recorded the highest pollen fertility and Arka Aruna (71.93%) recorded the lowest pollen fertility. Swarnarekha (80.45%) recorded the highest pollen fertility among the parents involved in breeding and Himayuddin (74.89%) recorded the lowest pollen fertility. Chandrakaran (80.47%) recorded the highest pollen fertility and Prior (73.85%) recorded the lowest pollen fertility among the local types.

The data presented in Table 71a shows the variation in estimation of pollen production of different genotypes during the two seasons. Among the hybrids, Amrapali (438.17) recorded the highest pollen production and H 151 (299.00) recorded the lowest pollen production. Banganapalli (489.00) recorded the highest pollen production among the parents involved in breeding and Neelum (315.83) recorded the lowest pollen production. Prior (541.83) recorded the highest pollen production which was significantly different from rest of the local types and Muvandan (347.33) recorded the lowest pollen production. The data presented in Table 71b shows the variation in estimation of pollen production of different genotypes during the three seasons. Among the hybrids, Arka Aruna (263.56) recorded the highest pollen production and H 151 (218.67) recorded the lowest pollen production. Banganapalli (347.56) recorded the highest pollen production followed by Himayuddin (320.67) among the parents involved in breeding and Bennet Alphonso (237.89) recorded the lowest pollen production. Prior (403.00) recorded the highest pollen production and Chandrakaran (315.56) recorded the lowest pollen production among the local types.

Standardization of optimal storage conditions for mango pollen so as to facilitate the transfer of pollen from other regions and even from other state was recommended by Iyer and Schnell (1991). Accordingly, pollen storage studies were undertaken during these investigations. The results are presented in table 72. The studies showed that the mango pollen can be stored without much loss in viability up to 72 hours after dehiscence when it is stored in refrigerated conditions, but the viability was high (78.52 %) after 24 hours of storage.

5.7 Physiological characters

Wide variation was observed among the physiological characters like relative water content (%), radiation interception (μ mol m_{-2} s_{-2}), stomatal index, stomatal frequency (μ mol m_{-2} s_{-2}), stomatal conductance (μ mol m_{-2} s_{-2}), stomatal resistance (μ mol m_{-2} s_{-2}), photosynthetic rate (μ mol m_{-2} s_{-2}), transpiration (mol m_{-2} s_{-2}), leaf area index (LAI) and atmospheric pollution tolerance index (APTI) and were recorded and presented from table 73 to table 82.

The data presented in Table 73 shows the variation in estimation of relative water content (%) of different genotypes during the three seasons. Among the hybrids, H 151 (35.37 %) recorded the highest RWC and Ratna (19.00%) recorded the lowest RWC. Neelum (35.82%) recorded the highest relative water content among the parents involved in breeding and Alphonso (22.71%) recorded the lowest RWC. Vellaikolumban (34.74%) recorded the highest RWC and Tholikaippan (24.31%) recorded the lowest RWC.

The data presented in Table 74 shows the variation in estimation of radiation interception (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, H 151 (0.85 μ mol m_{-2} s_{-2}) followed by the rest of the hybrids and H 45 (0.76 μ mol m_{-2} s_{-2}) recorded the lowest radiation interception. Mulgoa (0.92 μ mol m_{-2} s_{-2}) recorded the highest radiation interception followed by the rest of the parents involved in breeding and Dashehari (0.76 μ mol m_{-2} s_{-2}) recorded the lowest radiation interception. Muvandan (0.87 μ mol m_{-2} s_{-2}) recorded the highest radiation interception and Tholikaippan (0.68 μ mol m_{-2} s_{-2}) recorded the lowest radiation interception.

The data presented in Table 75 shows the variation in estimation of stomatal index of different genotypes during the three seasons. Among the hybrids, Mallika (22.44) recorded the highest stomatal index and Arka Aruna (18.69) recorded the lowest stomatal index. Banganapalli (20.80) recorded the highest stomatal index and Kalepady (18.11) recorded the lowest stomatal index among the parents involved in breeding. Chandrakaran (20.00) recorded the highest stomatal index among the rest of the local types among the local types and Prior (15.59) recorded the lowest stomatal index.

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The data presented in Table 76 shows the variation in estimation of stomatal frequency (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, Mallika (85.11 μ mol m_{-2} s_{-2}) recorded the highest stomatal frequency and H 45 (65.22 μ mol m_{-2} s_{-2}) recorded the lowest stomatal frequency. Banganapalli (88.78 μ mol m_{-2} s_{-2}) recorded the highest stomatal frequency and Mulgoa (77.78 μ mol m_{-2} s_{-2}) recorded the lowest stomatal frequency. Chandrakaran (85.44 μ mol m_{-2} s_{-2}) recorded the highest stomatal frequency and Muvandan (70.67 μ mol m_{-2} s_{-2}) recorded the lowest stomatal frequency.

The data presented in Table 77 shows the variation in estimation of stomatal conductance (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. The variation in stomatal conductance was not significant among the different genotypes over the three seasons.

The data presented in Table 78 shows the variation in estimation of stomatal resistance (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, H 45 (15.36 μ mol m_{-2} s_{-2}) recorded the highest stomatal resistance and PKM 1 recorded the lowest stomatal resistance. Swarnarekha (37.92 μ mol m_{-2} s_{-2}) recorded the highest stomatal resistance and Dashehari (5.33 μ mol m_{-2} s_{-2}) recorded the lowest stomatal resistance. Tholikaippan (16.29 μ mol m_{-2} s_{-2}) recorded the highest stomatal resistance and Prior (8.31 μ mol m_{-2} s_{-2}) recorded the lowest stomatal resistance which was on par with Muvandan (8.45 μ mol m_{-2} s_{-2}).

The data presented in Table 79 shows the variation in estimation of photosynthetic rate (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, PKM 1 (14.14 μ mol m_{-2} s_{-2}) recorded the highest photosynthetic rate and H 151 (7.57 μ mol m_{-2} s_{-2}) recorded the lowest photosynthetic rate. Swarnarekha (17.54 μ mol m_{-2} s_{-2}) recorded the highest photosynthetic rate among the parents involved in breeding and Neelum (8.95 μ mol m_{-2} s_{-2}) recorded the lowest photosynthetic rate. Tholikaippan (17.91 μ mol m_{-2} s_{-2}) recorded the highest photosynthetic rate and Chandrakaran (8.64 μ mol m_{-2} s_{-2}) recorded the lowest photosynthetic rate.

The data presented in Table 80 shows the variation in estimation of transpiration (mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, Sindhu (3.31 μ mol m^{-2} s^{-2}) recorded the highest transpiration and H 45 (1.91 μ mol m^{-2} s^{-2}) recorded the lowest transpiration. Dashehari (4.15 μ mol m^{-2} s^{-2}) recorded the highest transpiration among the parents involved in breeding and Kalepady (1.42 μ mol m^{-2} s^{-2}) recorded the lowest transpiration. Muvandan (3.22 μ mol m^{-2} s^{-2}) recorded the highest transpiration and Vellaikolumban (1.41 μ mol m^{-2} s^{-2}) recorded the lowest transpiration.

The data presented in Table 81 shows the variation in estimation of leaf area index (LAI) of different genotypes during the three seasons. The variation in leaf area index was not significant among the different genotypes over the three seasons.

The data presented in Table 82 shows the variation in estimation of atmospheric pollution tolerance index (APTI) of different genotypes during the three seasons. Among the hybrids, Mallika (68.53) recorded the highest APTI and H 151 (58.92) recorded the lowest APTI. Among the parents involved in breeding Bennet Alphonso (60.39) recorded the highest APTI which was significantly different from rest of the parents involved in breeding and Swarnarekha (46.14) recorded the lowest APTI. Chandrakaran (63.50) recorded the highest APTI which was significantly different from the rest of the local types. Muvandan (42.07) recorded the lowest APTI.

Variation in physiological characters were also observed among the mango genotypes and the findings were in accordance with the results of Singh and Rajan (2009), Rui *et al.* (2010) and Singh and Bhargava (2011).

5.8 Biochemical analysis

Total phenol content (mg g^{-1}), soluble protein content (mg g^{-1}), ascorbic acid (mg $100g^{-1}$), pH of the leaf and chlorophyll content (mg g^{-1}) were recorded and presented from table 83 to table 87c.

The data presented in Table 83 shows the variation in total phenol content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, Ratna (19.07 mg g^{-1}) recorded the highest total phenol and Mallika (5.55 mg g^{-1}) recorded the lowest total phenol among the hybrids. Swarnarekha (10.54 mg g^{-1}) recorded the highest total phenol among the parents involved in breeding and Banganapalli (6.32 recorded the lowest total phenol. Chandrakaran (8.75 mg g^{-1}) recorded the highest total phenol and

Muvandan (4.54 mg g$_{-1}$) recorded the lowest total phenol.

The data presented in Table 84 shows the variation soluble protein content (mg g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, PKM 1 (19.24 mg g$_{-1}$) recorded the highest soluble protein and Neelgoa (9.83 mg g$_{-1}$) recorded the lowest soluble protein. Mulgoa (18.42 mg g$_{-1}$) recorded the highest soluble protein and Alphonso (9.54 mg g$_{-1}$) recorded the lowest soluble protein among the parents involved in breeding. Muvandan (20.04 mg g$_{-1}$) recorded the highest soluble protein and Prior (8.60 mg g$_{-1}$) recorded the lowest soluble protein.

The data presented in Table 85 shows the variation in ascorbic acid (mg 100g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, Ratna (97.21 mg 100g$_{-1}$) recorded the highest ascorbic acid and PKM 2 (75.94 mg 100g$_{-1}$) recorded the lowest ascorbic acid. Banganapalli (79.46 mg 100g$_{-1}$) recorded the highest ascorbic acid and Swarnarekha (63.29 mg 100g$_{-1}$) recorded the lowest ascorbic acid among the parents involved in breeding. Chandrakaran (93.30 mg 100g$_{-1}$) recorded the highest ascorbic acid content which was significantly different from the rest of the local types and Tholikaippan (66.88 mg 100g$_{-1}$) recorded the lowest ascorbic acid.

The data presented in Table 86 shows the pH of leaf of different genotypes during the three seasons. Among the hybrids, PKM 2 (6.45) recorded the highest pH and Amrapali (5.35) recorded the lowest pH. Neelum (6.37) recorded the highest pH among the parents involved in breeding and Mulgoa (5.37) recorded the lowest pH. Vellaikolumban (5.90) recorded the highest pH among the local types and Muvandan (5.14) recorded the lowest pH.

The data presented in Table 87a shows the variation in chlorophyll content a (mg g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, Sindhu (1.31 mg g$_{-1}$) recorded the highest chlorophyll a content and Amrapali (0.85 mg g$_{-1}$) recorded the lowest chlorophyll a content. Kalepady (1.19 mg g$_{-1}$) recorded the highest chlorophyll a content followed by the rest of the parents and Mulgoa (0.86 mg g$_{-1}$) recorded the lowest Chlorophyll content. Muvandan (1.25 mg g$_{-1}$) recorded the highest chlorophyll a content and Chandrakaran (0.82 mg g$_{-1}$) recorded the lowest chlorophyll a content.

The data presented in Table 87b shows the variation in chlorophyll content b (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, Neelgoa (0.23 mg g^{-1}) recorded the highest chlorophyll b content and Mallika (0.16 mg g^{-1}) recorded the lowest chlorophyll b content. Swarnarekha (0.21 mg g^{-1}) recorded the highest chlorophyll b content the parents involved in breeding and Banganapalli (0.13 mg g^{-1}) recorded the lowest chlorophyll b content. Tholikaippan (0.26 mg g^{-1}) recorded the highest chlorophyll b content among the local types and Prior (0.17 mg g^{-1}) recorded the lowest chlorophyll b content.

The data presented in Table 87c shows the variation in total chlorophyll content (mg g^{-1}) of different genotypes during the three seasons. Among the hybrids, H 45 (1.48 mg g^{-1}) recorded the highest total chlorophyll and Amrapali (1.02 mg g^{-1}) recorded the lowest chlorophyll content.

Bennet Alphonso (1.40 mg g^{-1}) recorded the highest total chlorophyll and Mulgoa (1.06 mg g^{-1}) recorded the lowest total chlorophyll. Muvandan (1.44 mg g^{-1}) recorded the highest total chlorophyll among the local types and Chandrakaran (0.99 mg g^{-1}) recorded the lowest total chlorophyll.

Variation in physiological characters were also observed among the mango genotypes and the findings were in accordance with the results of (Sellamuthu *et al.*, 2013), (Naz *et al.*, 2014) and (Rymbai, 2014).

Experiment II. Evaluation of selected mango genotypes in HDP

5.9 Morphological characters

Various observations on morphological characters *viz.*, tree characters, leaf characters, inflorescence characters, fruit characters and seed characters were recorded, analysed and the results are presented in Tables 88 to table 115.

The trees of same age group (5 years) were selected for the study (Table 88). The data presented in Table 89 shows the variation in plant height of different genotypes. All the trees were pruned and maintained in a height of 3 meter.

The observation on trunk circumference of mango trees during three seasons were presented in Table 90. Chandrakaran (31.29 cm) recorded the highest

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circumference which was significantly different from the rest of the varieties / local types and Prior (20.51 cm) recorded the lowest trunk circumference.

The crown diameter (North –South) of mango was measured and presented in Table 91a and Table 91b. Vellaikolumban (3.09 m) recorded the highest crown diameter (North -South) and Ratna (2.39m) recorded the lowest crown diameter (North -South). The crown diameter (East-West) of mango was measured and presented in Table 91b which was not significant among the genotypes and season. Different crown shapes like oblong, semi-circular, and spherical were noticed among the hybrids/local types (Table 92). Different tree growth habit like erect and spreading were noticed among the hybrids/local types (Table 92). Dense and intermediate foliage density were noticed among the hybrid/local types (Table 92) (Fig.29).

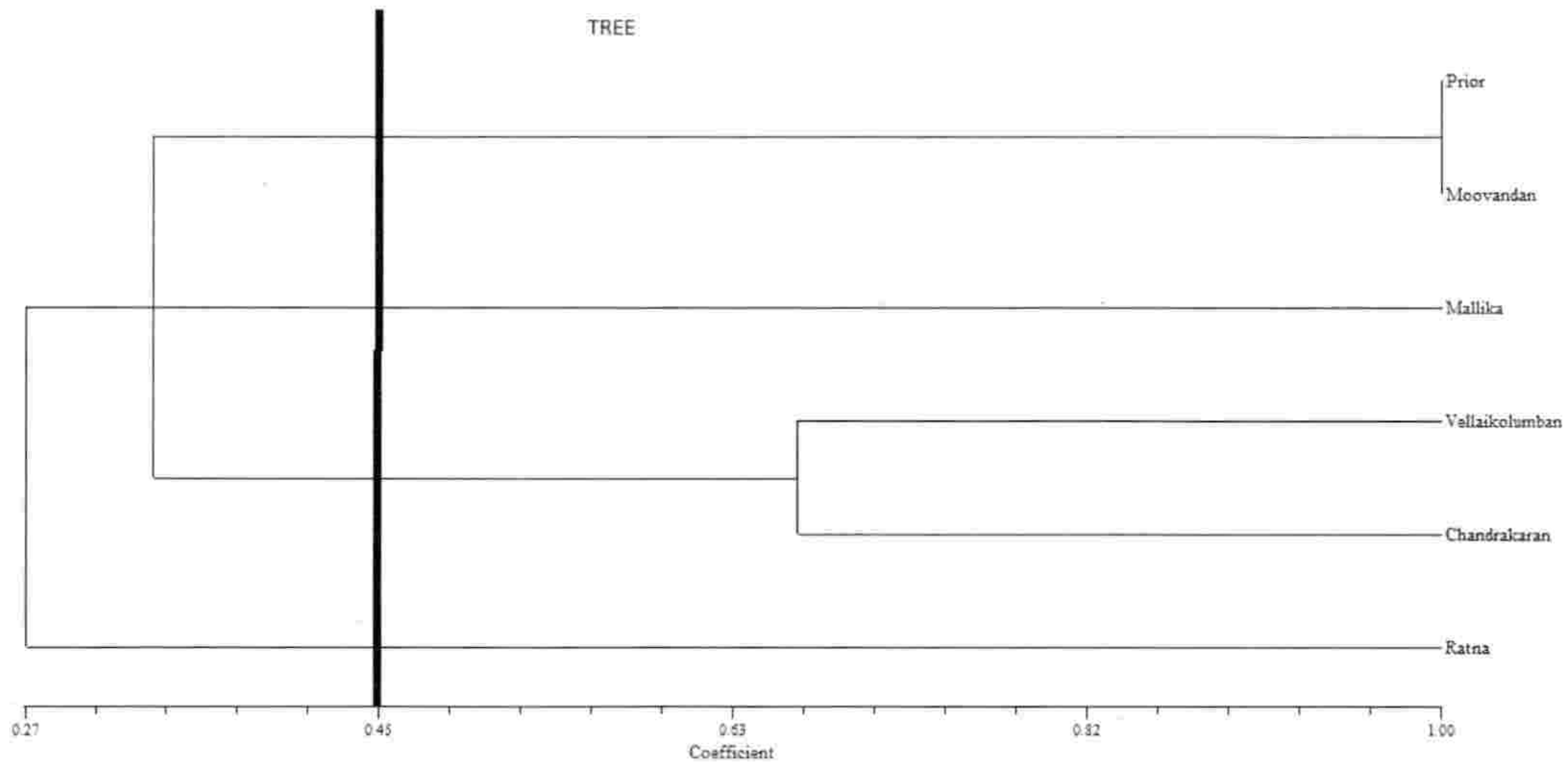
The data presented in Table 95 shows the variation in leaf lade length of different genotypes during three seasons. Ratna (25.40 cm) recorded the highest leaf blade length which was significantly different from the rest of the hybrid/local types and Muvandan (19.17 cm) recorded the lowest leaf blade length.

The data presented in Table 96 shows the variation in leaf lade width of different genotypes during three seasons. Vellaikolumban (7.68 cm) recorded the highest leaf blade width which was significantly different form the rest of the hybrid/local types and Muvandan (4.84 cm) recorded the lowest leaf blade width.

The data presented in Table 97 shows the variation in petiole length of different genotypes during three seasons. Ratna (4.18 cm) recorded the highest petiole length and Chandrakaran (2.29 cm) recorded the lowest petiole length.

Elliptic, obovate, lanceolate and oblong leaf blade shape were noticed among the hybrids/local types (Table 98). Obtuse, acuminate and acute leaf apex shape were noticed among the hybrids/local types (Table 98). Round, acute and obtuse leaf base shape were noticed among the hybrids/local types (Table 98). Wavy and entire leaf margin were noticed among the hybrids/local types (Table 98). Leaf pubescence was absent among all the hybrids/local types (98). Reddish brown and light green colour of young leaf were noticed among the hybrids/local types (Table 98). Dark green and

Fig.29 Dendrogram of tree characters under HDP



green colour of fully developed were noticed among the hybrids/local types (Table 98). Mild and strong leaf fragrance were noticed among the hybrids/local types (Table 98) (Fig.30).

Different flowering durations like January – February and December – January were noticed among the hybrids/local types (Table 101). Secondary/off season flowering were absent among all the hybrids/local types (Table 101). All the hybrids/local types had trees with terminal inflorescence position (Table 101). Pyramidal and conical inflorescence shape were noticed among the hybrids/local types (Table 101). Sparse, medium and dense flowers were observed among the inflorescence of different hybrids/local types (Table 101). Yellowish green, green with red patches, light green and light greenish with red patches were the inflorescence colour observed among the different hybrids/local types (Table 101). Shorter and equal length of stamen in relation to pistil were found among the hybrids/local types (Table 105). Narrow, reduced or absent and swollen, broader than ovary was the nature of disc found among the hybrids/local types (Table 101) (Fig.31).

The data presented in Table 104 shows the variation in inflorescence length of different genotypes during the two seasons. Vellaikolumban (36.47 cm) recorded the highest inflorescence length and Prior (22.14 cm) recorded the lowest inflorescence length.

The data presented in Table 105 shows the variation in inflorescence width of different genotypes during the two seasons. Vellaikolumban (23.54 cm) recorded the highest inflorescence width which was significantly different from the rest of the hybrid/local types and Chandrakaran (12.53 cm) recorded the lowest inflorescence width. The data presented in Table 110 shows the variation in inflorescence width of different genotypes during the two seasons. Chandrakaran (85.80 cm) recorded the highest hermaphrodite flowers in the inflorescence and Muvandan (36.40 cm) recorded the lowest hermaphrodite flowers in the inflorescence (Table 106).

The data presented in Table 107 shows the variation in number of stamens per flower of different genotypes during the two seasons. All the local types and the variety Mallika had 5 number of stamens per flower whereas Ratna had 5

Fig.30 Dendrogram of leaf characters under HDP

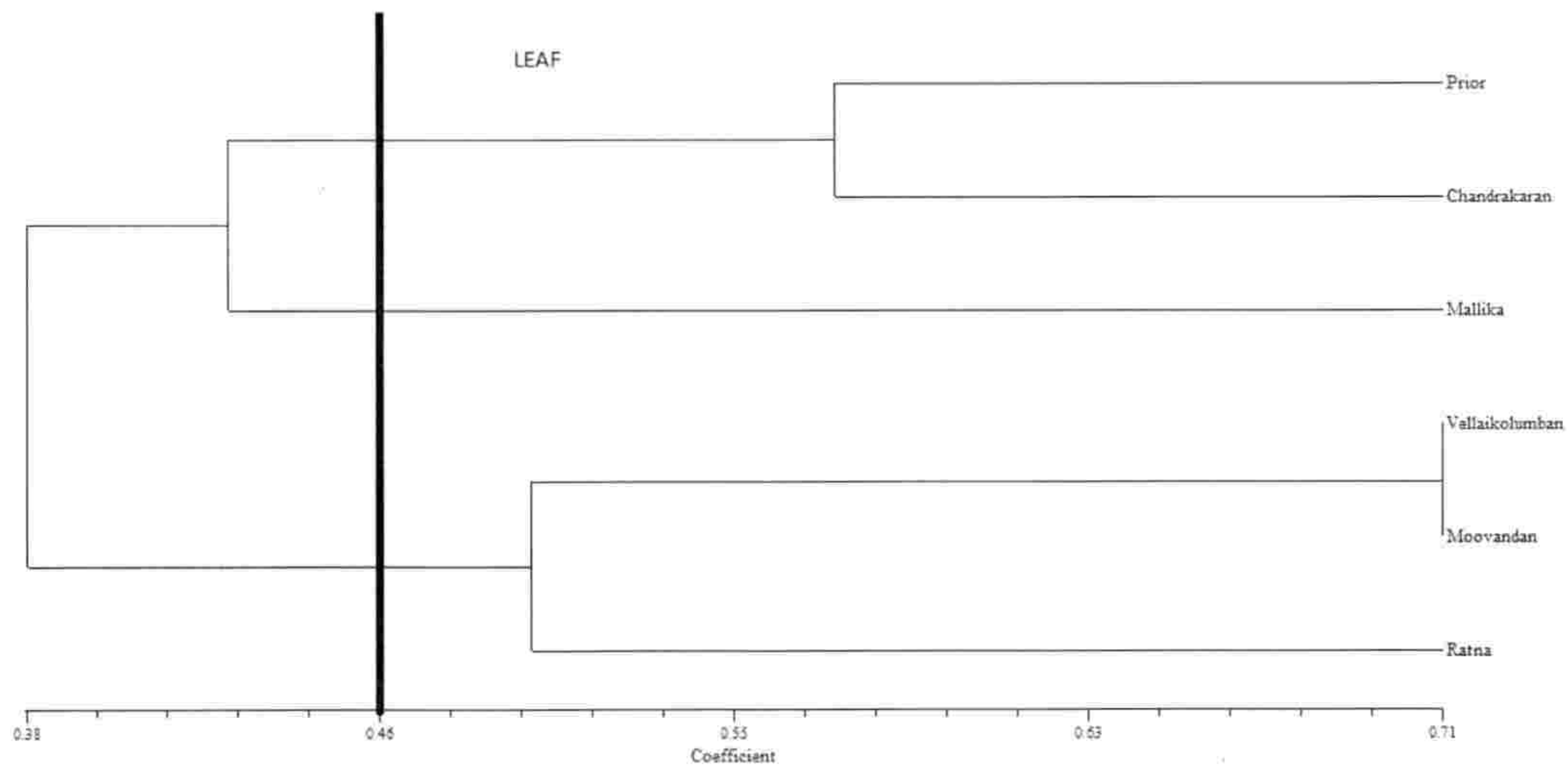
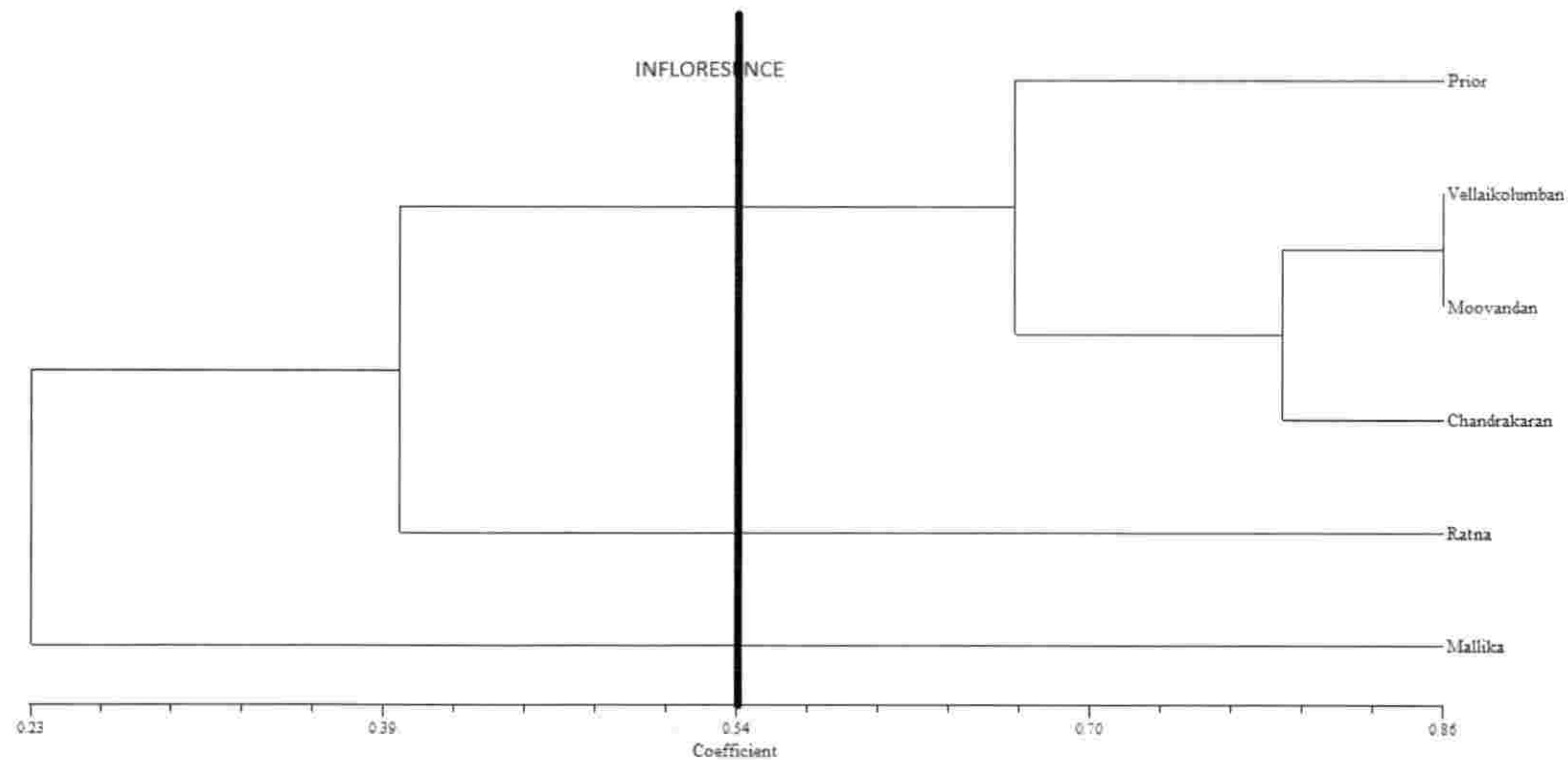


Fig.31 Dendrogram of inflorescence characters under HDP



number of stamens per flower. There was no seasonal effect on the number of stamens per flower.

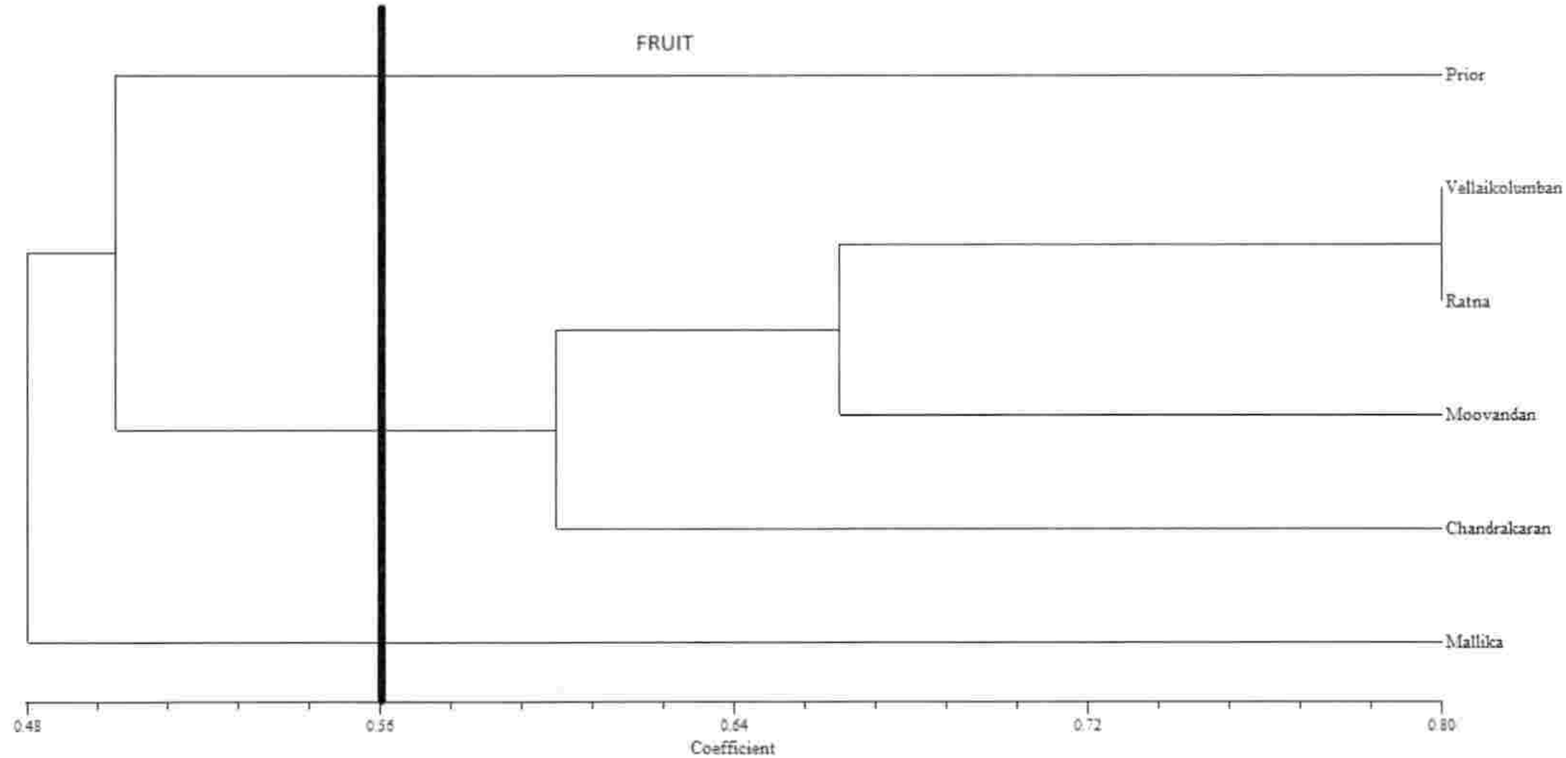
A great diversity was found in morphological characters of mango varieties/types under the study and the variation in the vegetative characters might be due to the variation in the genetic make-up and interaction of various genotypes with agroclimatic conditions. Morphological characters can be used as an efficient tool for proper identification of different mango cultivars well before the commencement of that cultivar to bearing stage. Phenotypic characters are mainly influenced by environments and plant developmental stages. In addition, species with similar morphological characters cannot be easily distinguished. High variability in terms of morphological characters have also been reported by Singh *et al.*, (2017), Ribeiro *et al.* (2013), Rajwana (2011) and (Joshi, 2013).

5.10 Fruit characters

All the hybrids/local types had fruiting during April-May (Table 108).

Medium and high fruit bearing intensity was observed among the different hybrids/local types (Table 108). Obovoid and roundish fruit shapes were observed among the different hybrids/local types (Table 108). Round, acute and obtuse fruit apex shapes were observed among the different hybrids/local types (Table 108). Excellent, good and average fruit attractiveness were observed among the different hybrids/local types (Table 108). All the hybrids/local types had trees with green skin colour for unripe fruits (Table 108). Yellow, and greenish yellow skin colours were observed for ripe fruits among the different hybrids/local types (Table 108). Shallow and no depth for fruit stalk cavity were observed among the different hybrids/local types (Table 108). Slightly prominent and no fruit neck were observed among the different hybrids/local types (Table 108). Prominent, perceptible and pointed fruit beaks were observed among the different hybrids/local types (Table 108). Light yellow pulp colour of ripe fruits were observed among all the hybrids/local types (Table 108). Mild, intermediate and strong aroma of ripe fruits were observed among the different hybrids/local types (Table 108) (Fig.32).

Fig.32 Dendrogram of fruit characters under HDP



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The data presented in Table 111 shows the variation in fruit length of different genotypes during the two seasons. Mallika (18.71 cm) recorded the highest fruit length and Chandrakaran (7.49 cm) recorded the lowest fruit length.

The data presented in Table 111 shows the variation in fruit diameter of different genotypes during the two seasons. Mallika (25.25 cm) recorded the highest fruit diameter and Chandrakaran (13.18 cm) recorded the lowest fruit diameter.

The data presented in Table 112 shows the variation in fruit weight of different genotypes during the two seasons Mallika (482.71 g) recorded the highest fruit weight which was significantly different from the rest of the hybrid / local types and Chandrakaran (58.09 g) recorded the lowest fruit weight.

The data presented in Table 112 shows the variation in fruit yield of different genotypes during the two seasons. Mallika (24.69 Kg/tree) recorded the highest fruit yield which was significantly different from the rest of the hybrid/ local types. Muvandan (8.93 Kg/tree) recorded the lowest fruit yield.

The data presented in Table 112 shows the variation in shelf life of different genotypes during the two seasons. Prior (6.00 Days) recorded the highest shelf life fand Muvandan (4.00 Days) recorded the lowest shelf life.

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 is important for studying variability in mango germplasm (Ram and Rajan, 2003).

5.11 Stone characters

The data presented in Table 113 shows the variation in stone length of different genotypes during the two seasons. Mallika (11.67 cm) recorded the highest stone length and Chandrakaran 95.58 cm recorded the lowest stone length.

The data presented in Table 113 shows the variation in stone width of different genotypes during the two seasons. Ratna (8.67 cm) recorded the highest stone width which was significantly different from the rest of the hybrids/ local types. Chandrakaran (3.36 cm) recorded the lowest stone width.

The data presented in Table 113 shows the variation in stone thickness of different genotypes during the two seasons. Vellaikolumban (2.19 cm) recorded the highest stone thickness and Chandrakaran (1.23 cm) recorded the lowest stone thickness.

The data presented in Table 113 shows the variation in stone weight of different genotypes during the two seasons. Mallika (44.33 g) recorded the highest stone weight which was significantly different from the rest of the hybrid / local types. Chandrakaran (17.79) recorded the lowest stone weight (Table 114).

The data presented in Table 114 shows the variation in seed length of different genotypes during the two seasons. Ratna (7.91 cm) recorded the highest seed length which was significantly different from the rest of hybrid/local types. Chandrakaran (4.05 cm) recorded the lowest seed length (Table 114).

The data presented in Table 114 shows the variation in seed width of different genotypes during the two seasons. Ratna (8.47 cm) recorded the highest seed width which was significantly different from the rest of the hybrid/local types and Prior (3.07 cm) recorded the lowest seed width.

The data presented in Table 114 shows the variation in seed weight of different genotypes during the two seasons. Prior (22.22 g) recorded the highest seed weight followed by Mallika (21.86 g). Vellaikolumban (9.44 g) recorded the lowest seed weight.

Low, intermediate and high quantity of fibre on stone were observed among the different hybrids/local types (Table 115). Weak, intermediate and strong adherence of fibre to stone were observed among the different hybrids/local types (Table 115). Coarse and soft texture of stone fibre were observed among the different hybrids/local

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types (Table 115). Ellipsoid and reniform seed shapes were observed among the different hybrids/local types (Table 115) (Fig.33).

5.12 Quality attributes

Different quality attributes like TSS (°Brix), acidity (%), ascorbic acid (mg 100g^{-1}), total carotenoids (mg 100g^{-1}), β carotene (mg 100g^{-1}), total sugar (%), reducing sugar (%) and crude fibre (%) were recorded and presented from table 118 to table 120.

The data presented in Table 130 shows the variation in TSS of different genotypes during the two seasons. Ratna (26.77 °Brix) recorded the highest TSS and Muvandan (14.78 °Brix) recorded the lowest TSS (Table 118).

The data presented in Table 131 shows the variation in acidity of different genotypes during the two seasons. Muvandan (0.07 %) recorded the highest acidity and Mallika (0.02%) recorded the lowest acidity (Table 118).

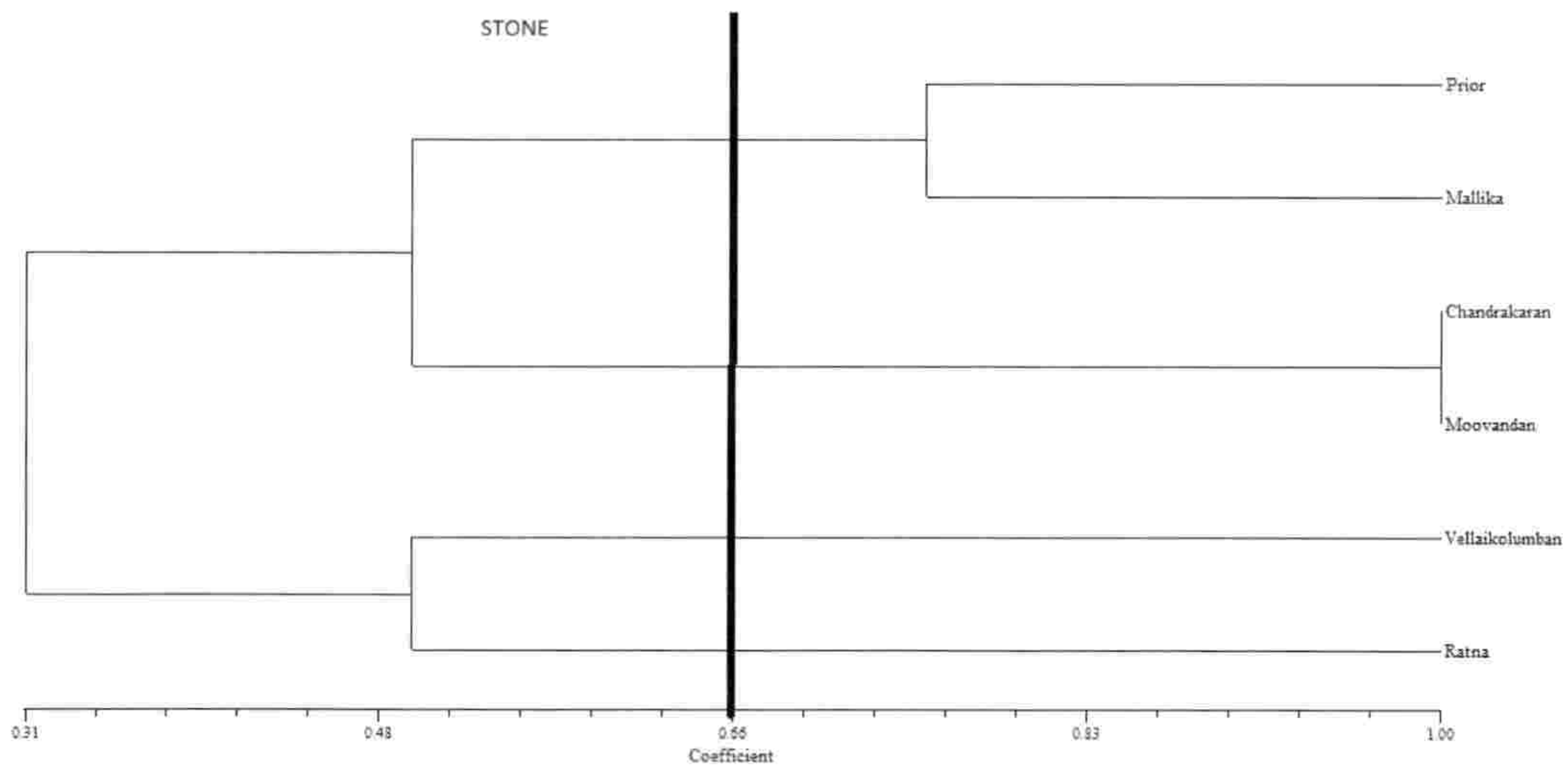
The data presented in Table 118 shows the variation in ascorbic acid of different genotypes during the two seasons. Chandrakaran (79.68 mg 100g^{-1}) recorded the highest ascorbic acid and Vellaikolumban (28.26 mg 100g^{-1}) recorded the lowest ascorbic acid.

The data presented in Table 118 shows the variation in total carotenoids of different genotypes during the two seasons. Muvandan (4.80 mg 100g^{-1}) recorded the highest total carotenoids and Vellaikolumban (1.40 mg 100g^{-1}) recorded the lowest total carotenoids.

The data presented in Table 119 shows the variation in β carotene of different genotypes during the two seasons. Ratna (39.93 mg 100g^{-1}) recorded the highest β carotene which was significantly different from the rest of the hybrid/local type and Vellaikolumban (13.54 mg 100g^{-1}) recorded the lowest β carotene.

The data presented in Table 119 shows the variation in total sugar of different genotypes during the two seasons. The variation in total sugar was not significant among the different genotypes over the three seasons. The data presented in Table 119 shows the variation in reducing sugar of different genotypes during the two seasons.

Fig.33 Dendrogram of stone characters under HDP



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The variation in reducing sugar was not significant among the different genotypes over the three seasons.

The data presented in Table 119 shows the variation in crude fibre of different genotypes during the two seasons. Mallika (13.00%) recorded the highest crude fibre which was significantly different from the rest of the hybrid / local types. Ratna (3.56 %) recorded the lowest crude fibre.

Wide variation was found in quality attributes of mango varieties/types under the study and the variation in these characters might be due to the variation in the genetic make-up. Physio-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. High variability in terms of quality attributes have also been reported by Pradeepkumar *et al.* (2006), Anila and Radha (2003), (Bhuyan and Kobra 2007) and Abdullah *et al.* (2013).

5.13 Sensory evaluation

Among the hybrids/local types, the highest rank for appearance was given for Mallika followed by Ratna and Muvandan (Table 120). For colour highest rank was given for Ratna followed by Chandrakaran and Prior. Ratna got the highest rank for flavour followed by Chandrakaran and Mallika. Ratna recorded highest rank for sweetness followed by Mallika and Chandrakaran. Ratna also recorded highest rank for taste followed by Mallika and Chandrakaran. Ratna was given highest rank for texture followed by Mallika and Prior.

5.14 Pollen studies

Size and shape of pollen grains, pollen fertility, *in vitro* pollen germination, estimation of pollen production and pollen storage were recorded and presented in table 121.

The data presented in Table 121 shows the variation in length of the pollen grains of different genotypes during the two seasons. Prior (44.00 µm) recorded the highest pollen length and Muvandan (24.8 µm) recorded the lowest pollen length. The data presented in Table 121 shows the variation in breadth of the pollen grains of different genotypes during the two seasons. Chandrakaran (33.45 μm) recorded the highest pollen breadth and Muvandan (22.62 μm) recorded the lowest pollen breadth.

The data presented in Table 69 shows the variation in shape of pollen grains of different genotypes. Among the hybrids/local types, Mallika, Ratna and Chandrakaran had oval pollen grains. Vellaikolumban, Prior and Muvandan had oblong pollen grains Tholikaippan recorded roundish pollen grains.

The data presented in Table 121 shows the variation in pollen fertility of different genotypes during the two seasons. Among the hybrids, Mallika (79.20%) recorded the highest pollen fertility which was significantly different from the other hybrid / local types. Prior (59.47%) recorded the lowest pollen fertility.

The data presented in Table 121 shows the variation in estimation of pollen production of different genotypes during the two seasons. Vellaikolumban (306.30) recorded the highest pollen production which was significantly different from the rest of the hybrid / local types. Muvandan (194.50) recorded the lowest pollen production which was on par with Ratna (197.40).

5.15 Physiological characters

Relative water content (%), radiation interception (μ mol m_{-2} s_{-2}), stomatal index, stomatal frequency (μ mol m_{-2} s_{-2}), stomatal conductance (μ mol m_{-2} s_{-2}), stomatal resistance (μ mol m_{-2} s_{-2}), photosynthetic rate (μ mol m_{-2} s_{-2}), transpiration (mol m_{-2} s_{-2}), leaf area index (LAI) and atmospheric pollution tolerance index (APTI) were recorded and presented from table 122 to table 124.

The data presented in Table 122 shows the variation in estimation of relative water content (%) of different genotypes during the three seasons. The variation in relative water content was not significant among the different genotypes over the three seasons.

The data presented in Table 122 shows the variation in estimation of radiation interception (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. Ratna (0.77

μ mol m^{-2} s^{-2}) recorded the highest radiation interception and Prior (0.61 μ mol m^{-2} s^{-2}) recorded the lowest radiation interception.

The data presented in Table 122 shows the variation in estimation of stomatal index of different genotypes during the three seasons. Ratna (21.37 μ mol m^{-2} s^{-2}) recorded the highest stomatal index and Mallika (17.87 μ mol m^{-2} s^{-2}) recorded the lowest stomatal index.

The data presented in Table 122 shows the variation in estimation of stomatal frequency (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Ratna (81.40 μ mol m^{-2} s^{-2}) recorded the highest stomatal frequency and Mallika (63.73 μ mol m^{-2} s^{-2}) recorded the lowest stomatal frequency.

The data presented in Table 123 shows the variation in estimation of stomatal conductance (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Muvandan (0.19 μ mol m^{-2} s^{-2}) recorded the highest stomatal conductance and Prior (0.09 μ mol m^{-2} s^{-2}) recorded the lowest stomatal conductance.

The data presented in Table 123 shows the variation in estimation of stomatal resistance (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Prior (19.79 μ mol m^{-2} s^{-2}) recorded the highest stomata resistance and Muvandan (7.31 μ mol m^{-2} s^{-2}) recorded the lowest stomatal resistance.

The data presented in Table 123 shows the variation in estimation of photosynthetic rate (μ mol m^{-2} s^{-2}) of different genotypes during the three seasons. Vellaikolumban (11.68 μ mol m^{-2} s^{-2}) recorded the highest photosynthetic rate which was significantly different from the rest of hybrid / local types. Chandrakaran (3.17 μ mol m^{-2} s^{-2}) recorded the lowest photosynthetic rate.

The data presented in Table 124 shows the variation in estimation of transpiration (mol m^{-2} s^{-2}) of different genotypes during the three seasons. Chandrakaran (4.19 μ mol m^{-2} s^{-2}) recorded the highest transpiration rate and Ratna (2.44 μ mol m^{-2} s^{-2}) recorded the lowest transpiration.

The data presented in Table 124 shows the variation in estimation of leaf area index (LAI) of different genotypes during the three seasons. The variation in leaf area index was not significant among the different genotypes over the three seasons.

The data presented in Table 124 shows the variation in estimation of atmospheric pollution tolerance index (APTI) of different genotypes during the three seasons. Ratna (68.34) recorded the highest APTI and Vellaikolumban (54.42) recorded the lowest APTI.

Variation in the physiological characters were also observed among the mango genotypes which were in concordance with the results obtained by Rui *et al.* (2010), Singh and Rajan (2009), Singh and Bhargava (2011) and (Rymbai, 2014).

5.16 Biochemical analysis of plants

Total phenol content (mg g_{-1}), soluble protein content (mg g_{-1}), ascorbic acid (mg $100g_{-1}$), pH of the leaf and chlorophyll content (mg g_{-1}) were recorded and presented from table 125 to table 126.

The data presented in Table 125 shows the variation in total phenol content (mg g_{-1}) of different genotypes during the three seasons. Prior (10.66 mg g_{-1}) recorded the highest total phenol and Vellaikolumban (4.81 mg g_{-1}) recorded the lowest total phenol.

The data presented in Table 125 shows the variation soluble protein content (mg g_{-1}) of different genotypes during the three seasons. Chandrakaran (20.75 mg g_{-1}) recorded the highest soluble protein and Ratna (12.72 mg g_{-1}) recorded the lowest soluble protein.

The data presented in Table 125 shows the variation in ascorbic acid (mg $100g_{-1}$) of different genotypes during the three seasons. Ratna (92.34 mg g_{-1}) recorded the highest ascorbic acid and Vellaikolumban (67.74 mg g_{-1}) recorded the lowest ascorbic acid content.

The data presented in Table 125 shows the pH of leaf of different genotypes during the three seasons. Muvandan (6.15 mg g_{-1}) recorded the highest pH content and Ratna (5.57 mg g_{-1}) recorded the lowest pH.

The data presented in Table 126 shows the variation in chlorophyll content a (mg g-1) of different genotypes during the three seasons. Prior (1.29 mg g-1) recorded the highest chlorophyll a content followed by Chandrakaran (1.25 mg g-1) and Muvandan (1.09 mg g-1) recorded the lowest chlorophyll a content which was on par with Ratna (1.14) mg g-1.

The data presented in Table 126 shows the variation in chlorophyll content b (mg g-1) of different genotypes during the three seasons. Chandrakaran (0.29 mg g-1) recorded the highest chlorophyll b content and Muvandan (0.22 mg g-1) recorded the lowest chlorophyll b content.

The data presented in Table 126 shows the variation in total chlorophyll content (mg g-1) of different genotypes during the three seasons. Prior (1.55 mg g-1) recorded the highest total chlorophyll and Muvandan (1.30 mg g-1) recorded the lowest total chlorophyll.

Variation in biochemical characters was observed among mango genotypes which was in accordance with the findings of Sellamuthu *et al.*, (2013).

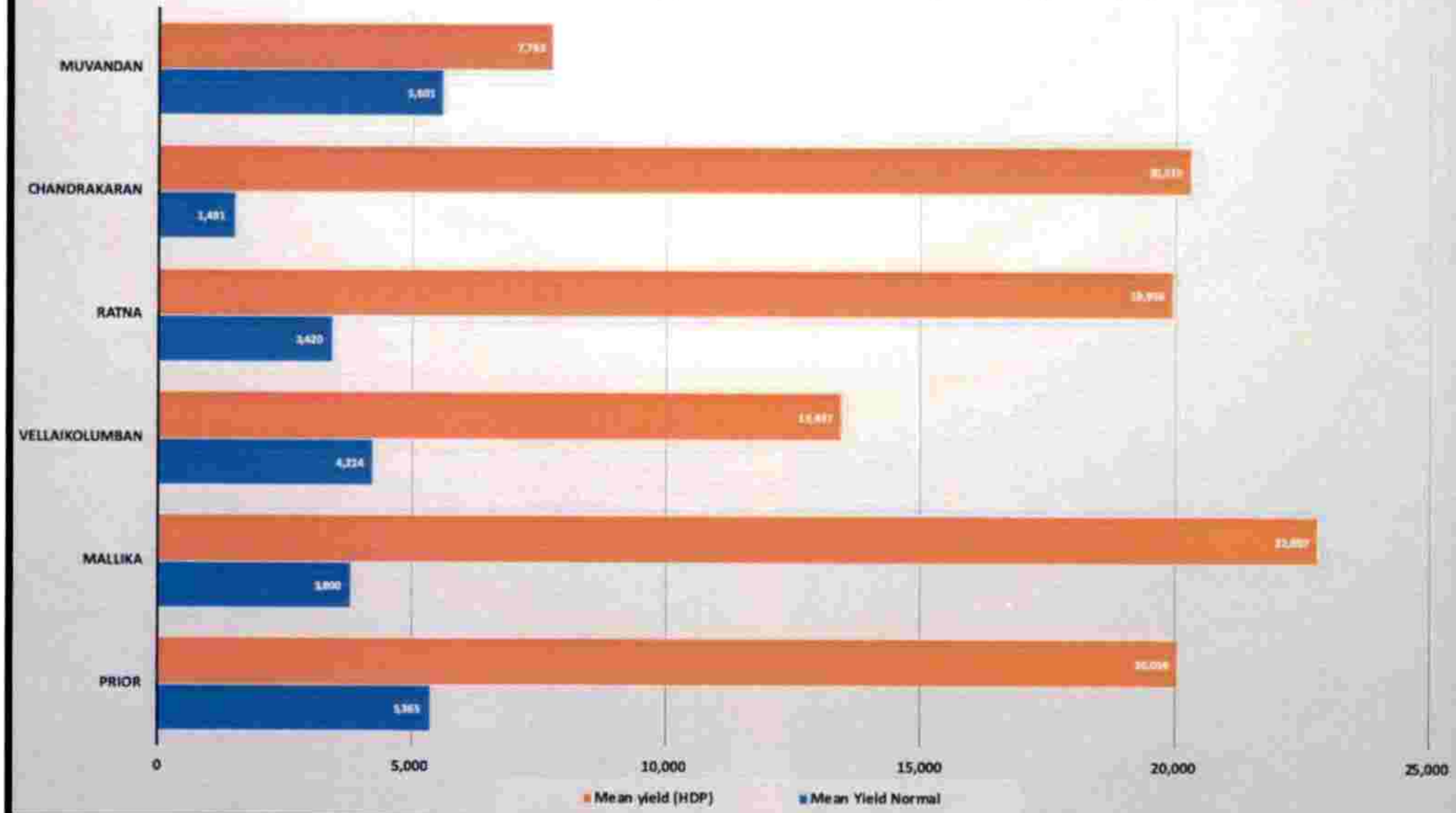
5.17 Performance analysis of genotypes under both normal and high-density planting system

In all the genotypes *viz.,* Prior, Mallika, Vellaikolumban, Ratna, Chandrakaran and Muvandan under HDP had significantly higher yield compared to normal planting density. Mallika (22807.41 kg/ha) recorded the highest yield under HDP followed by Chandrakaran (22807.41 kg/ha) (Fig. 34). These observations were in accordance with the results obtained by Gunjate *et al.*, (2009).

5.18 Experiment III. Development of a crop weather model for mango and screening of genotypes for climate resilience.

Development of a crop weather model for mango and screening of genotypes for climate resilience in which crop weather models was developed using primary/secondary data on growth and environmental parameters to test the performance of different genotypes under varied weather conditions. Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using

Fig. 34 Performance analysis of genotypes under normal and high-density planting system



ECHAM model and the performance of the various genotypes under projected climatic conditions was evaluated using the developed model.

Sindhu, Vellaikolumban, Prior, Alphonso, Kalepady and Tholikaippan showed an increase in the predicted yield in spite of an increase in temperature in flowering phenophase under normal planting system. The predicted yield increased in spite of a decrease in solar radiation in H 45, Mulgoa and Tholikaippan, the predicted yield increased in spite of a decrease in rainfall in Dashehari, Neelum and Muvandan. Amrapali, PKM 1, Alphonso, Himayuddin, Swarnarekha and Mulgoa showed an increase in predicted yield in spite of an increase in rainfall.

Amrapali, PKM 1, Sindhu, Neelum, Himayuddin, Bennet Alphonso, Kalepady, Muvandan, Tholikaippan, Vellaikolumban, Banganapalli and Prior, recorded an increase in predicted yield in spite of an increase in temperature in fruit initiation phenophase under normal planting system. The predicted yield increased in spite of a decrease in rainfall in PKM 1, Amrapali, H 151, H 45, Bennet Alphonso, Mulgoa, Tholikaippan, Chandrakaran and Muvandan. Dashehari showed an increase in predicted yield in spite of an increase in rainfall.

H 151, Kalepady and Swarnarekha showed an increase in the predicted yield in spite of an increase in rainfall in fruit maturation phenophase under normal planting system.

Based on the performance of genotypes in all three phenophases, H 45 can be recommended for regions with lower rainfall and lower solar radiation among the hybrids under normal planting system, whereas, Amrapali and PKM 1 can be recommended for areas with higher temperature and for both higher and lower rainfall regions. Among the parents of the hybrids, Mulgoa can be recommended for regions with lower solar radiation and for both lower and higher rainfall regions. Among the local types, Tholikaippan can be recommended for the regions with higher temperature, lower rainfall and lower solar radiation.

Vellaikolumban, Ratna and Muvandan showed an increase in the predicted yield in spite of an increase in temperature in flowering phenophase under high density planting system. Prior, Chandrakaran, Muvandan, Vellaikolumban, Ratna and Mallika recorded an increase in the predicted yield in spite of an increase in temperature in fruit initiation phenophase under high density planting system. Prior, Chandrakaran, Mallika, Ratna and Muvandan, showed an increase in the yield in spite of an increase in temperature in fruit maturation phenophase under high density planting system, whereas the predicted yield increased in spite of a decrease in rainfall in Mallika, Vellaikolumban and Ratna.

Based on the performance of genotypes in all the three phenophases, all studied genotypes can be recommended for higher temperature regions under high density planting system. The cultural operations including training, pruning and application of flowering hormone like paclobutrazol made the genotypes perform better in adverse climatic conditions.

Varietal responses to the environment within and between mango cultivars account for their relative performance at different locations. Correlation among different agronomic and morphological characters is an important aspect for better planning of selection programs and is also helpful in determining the components of complex trait like yield. But the correlation alone cannot prove the exact picture of the relative importance of direct and indirect influences of each of the component characters towards yield. So, the character association should also be further analysed. The correlation analysis studies are important assets to the breeder; especially in case of fruit crop like mango, where in quantity and quality both are important. The information on the nature and magnitude of variability and correlation in a population owing to genetic and non-genetic factor is one of the prerequisites in any hybridization programme for selecting parents with desirable characters. In present investigation, the correlation between weather variables and flowering and fruiting characters in mango was carried out during main season and different weather parameters, had highly significant and positive correlation with the yield. Considerable differences among mango cultivars and genotypes have also been observed in their flowering response to environmental factors. These findings were in accordance with the results of Parmar *et al.* (2012), Singh *et al.,* (2014), Kumar *et al.*, (2014) and Jignasa *et al*. (2018).

In conclusion, climate change may have a profound impact on mango genotypes since the flower initiation, fruit initiation and fruit maturation phenophases are strongly influenced by the environment. The projected scenario for 2030, 2040 and

2050 indicate that the temperature will tend to increase and the rainfall will decrease from the present condition leading to altered phenophases which necessitate changes in spectrum and distribution of varieties currently being grown. H 45, PKM 1, Amrapali, Mulgoa and Tholikaippan are the climate resilient genotypes for the normal planting systems and Mallika, Ratna, Muvandan, Vellaikolumban and Prior are the climate resilient genotypes for high density planting systems.

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Summary

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6. SUMMARY

The study on "Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes" was conducted with overriding objective of getting basic information on eco physiological responses among selected genotypes of mango on the flushing, flowering and fruit development with a view to identify climate resilient genotypes that are suitable for future climate change scenario in Kerala.

Twenty-four varieties from normal planting and six varieties from high density planting maintained in the mango orchard of Dept. of Fruit Science, College of Horticulture, K.A.U., Vellanikkara, Thrissur were utilized for the studies. The study comprised of three experiments as follows.

The experiment I, Evaluation of Mango Genotypes was conducted utilizing 24 diverse mango germplasm maintained at mango orchard of College of Horticulture, Flanker. All the genotypes are in the age group of 23. Trees are maintained under uniform cultural practices to ensure yield with quality fruits. Three healthy and uniform trees of each genotype were utilized for the study. The experiment consisted of 24 treatments/varieties distributed in CRD with three replicates. Three year of observations were taken *viz.,* 2016, 2017, 2018. Total number of plants in this experiment was 24 x 3 = 72. Selected mango genotypes for the study included hybrids *viz.,* Arka Aruna, Amrapali, Mallika, Ratna, Sindhu, H 45, H 151, PKM 1, PKM 2 and Neelgoa. Parents involved in crossing *viz.,* Banganapalli, Alphonso, Dashehari, Neelum, Himayuddin, Bennet Alphonso, Kalepady, Swarnarekha, Mulgoa and local types *viz.,* Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan. The experiment II, Evaluation of selected mango genotypes in HDP was carried out utilising 6 diverse mango genotypes planted in HDP in mango orchard of College of Horticulture, Vellanikkara. All the genotypes are of 5 years old and in bearing stage. The experiment consisted of 6 treatments/varieties distributed in CRD with five replicates. Three year of observations were taken *viz.,* 2016, 2017, 2018. Total number of plants in this experiment was 6 x 5 = 30. Selected mango genotypes for the study included Prior, Mallika, Vellaikolumban, Ratna, Chandrakaran and Muvandan. The experiment III, Development of a crop weather model for mango and screening of genotypes for climate resilience in which crop weather models was developed using primary/secondary data on growth and environmental parameters to test the performance of different genotypes under varied weather conditions. Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using ECHAM model and the performance of the various genotypes under projected climatic conditions will be evaluated using the developed model. Observation on morphological characters, quality attributes of fruits, physiological characters, biochemical characters of plants, percent incidence of pest and diseases and meteorological data were taken for the study.

The salient findings of the study could be summarized as follows.

Experiment I. Evaluation of Mango Genotypes

The trees of same age group (23 years) were selected for the study.

Wide variation was observed among the plant height of different mango genotypes. Among the hybrids Sindhu recorded the highest plant height (11.93m) and H 151 recorded the lowest plant height. Kalepady recorded the highest tree height (12.31m) among the parents involved in breeding and Bennet Alphonso recorded the lowest plant height (8.36m). Chandrakaran recorded the highest plant height (12.49m) followed by Muvandan (11.95m) among the local types and Vellaikolumban recorded the lowest plant height (9.29m).

The maximum trunk circumference was recorded for Mallika (168.13 cm) and H 151 has registered the least trunk circumference (95.17 cm). Swarnarekha (196.53cm) recorded the highest trunk circumference among the parents involved in breeding and Neelum recorded the lowest value of 103.79 cm. Prior recorded the highest trunk circumference of 153.53 cm among the local types and lowest trunk circumference was recorded for Muvandan (91.63 cm).

The variety H 45 recorded the highest crown diameter (North –South) and the lowest crown diameter (North –South) was recorded by H 151 (7.07 m). Mulgoa (13.40 m) recorded the highest value among the parents involved in breeding and the lowest value was recorded by Alphonso (8.23 m). Prior (11.72 m) recorded the highest crown diameter (North-South) among the local types and Muvandan (7.26 m) recorded the lowest value.

The crown diameter (East-West) of mango hybrids were measured and the highest value was registered by Ratna and H 151(5.57 m) recorded the lowest value from all other hybrids. Kalepady (10.27 m) recorded the highest value of 10.27 m which was significantly different from the rest of the cultivars, among the parents involved in breeding, whereas the lowest value was registered by Bennet Alphonso (6.74 m). Prior (11.59 m) recorded the highest crown diameter (East – West) which was significantly different from the other types among the local types, and Tholikaippan recorded the lowest value of 5.94 m.

Different crown shapes like oblong, semi-circular, spreading, broadly pyramidal and spherical were noticed among the varieties/cultivars.

Different tree growth habit like erect, drooping and spreading were noticed among the varieties/cultivars.

Dense and erect foliage density were noticed among the varieties/cultivars. Elliptic, obovate, ovate, lanceolate and oblong leaf blade shape were noticed among the varieties/cultivars. Obtuse, acuminate and acute leaf apex shape were noticed among the varieties/cultivars. Round, acute and obtuse leaf base shape were noticed among the varieties/cultivars. Wavy and entire leaf margin were noticed among the varieties/cultivars. Leaf pubescence was absent among all the varieties/cultivars. Coppery red, light brick red, reddish brown, light green and coppery tan colour of young leaf were noticed among the varieties/cultivars.

Variation in leaf lade length, leaf lade width and petiole length of different genotypes during three seasons.

Different flowering durations like January – February, December – February, December – January, November to January and February – March were noticed among the varieties/cultivars.

Secondary/off season flowering were absent among all the varieties/cultivars. All the hybrids trees had terminal inflorescence position. Broadly pyramidal, pyramidal and conical inflorescence shape were noticed among the varieties/cultivars. Sparse, medium and dense flowers were observed among the inflorescence of different varieties/cultivars. Yellowish green, yellow, light green and greenish with red patches were the inflorescence colour observed among the different varieties/cultivars. All the hybrids/parents involved in breeding had equal length of stamen in relation to pistil.

Variation in inflorescence length of different genotypes during the two seasons. Sindhu (33.45cm) recorded the highest inflorescence length among the hybrids. Bennet Alphonso (42.42 cm) recorded the highest inflorescence length among the parents. Vellaikolumban (36.87 cm) recorded the highest inflorescence among the local types.

Variation in inflorescence length of different genotypes during the three seasons. H 151 recorded the highest inflorescence length followed by among the hybrids. Mulgoa (34.71 cm) recorded the highest inflorescence length among the parents involved in breeding. Chandrakaran (28.14 cm) recorded the highest inflorescence length among the local types.

Variation in inflorescence width of different genotypes during the two seasons. Ratna (25.33 cm) recorded the highest inflorescence width. Bennet Alphonso (20.83 cm) recorded the highest inflorescence width among the parents involved in breeding. Vellaikolumban (30.40 cm) recorded the highest inflorescence width which was significantly different from the rest of the local types.

Variation in inflorescence width of different genotypes during the three seasons. Ratna (23.57 cm) recorded the highest inflorescence width which was significantly different from the other hybrids. Bennet Alphonso (20.56 cm) recorded the highest inflorescence among the parents involved in breeding. Prior (19.99 cm) recorded the highest inflorescence width among the local types.

Variation in hermaphrodite flowers of different genotypes during the two seasons. Among the hybrids, PKM 1 (66.67 %) recorded the highest hermaphrodite flowers and H 151 (37.00 %) recorded the lowest in the inflorescence. Neelam (67.83%) recorded the highest hermaphrodite flowers in the inflorescence among the parents involved in breeding and Mulgoa (14.00%) recorded the lowest hermaphrodite flowers in the inflorescence. Prior (67.00%) recorded the highest hermaphrodite flowers in the inflorescence among the local types and Muvandan (20.83%) recorded the lowest hermaphrodite flowers in the inflorescence.

Variation in hermaphrodite flowers of different genotypes during the three seasons. Among the hybrids, H 45 (55.33%) recorded the highest hermaphrodite flowers in the inflorescence. Bennet Alphonso (65.89%) recorded the highest number of hermaphrodite flowers in the inflorescence among the parents involved in breeding.

Prior (62.22%) recorded the highest hermaphrodite flowers in the inflorescence among the local types.

Variation in number of stamens per flower of different genotypes. All the hybrids had 5 number of stamens of which 1 or 2 may be fertile whereas Ratna, H 45 and H 151 recorded 4 number of stamens per flower. All the parents involved in breeding had 5 number of stamens per flower except Himayuddin with 4 number of stamens per flower. All the local types had 5 number of stamens per flower. There was no seasonal effect on the number of stamens per flower.

Wide variation was observed in fruit characters of different mango genotypes.

Different fruiting durations like March – May, April-May, and May- June were noticed among the varieties/cultivars. Among the parents, Dashehari, Neelum and Mulgoa were having a fruiting duration from May – June. All the local types had a fruiting duration from April to May.

Low, medium and high fruit bearing intensity was observed among the different varieties/cultivars. The findings showed that among the hybrids Ratna, PKM 1, H 45 and H 151 were having high fruit bearing intensity. Among the local types Chandrakaran was having the high fruit bearing intensity.

Oblong, elliptic and roundish fruit shapes were observed among the different varieties/cultivars. Round, acute and obtuse fruit apex shapes were observed among the different varieties/cultivars.

Excellent, good and average fruit attractiveness were observed among the different varieties/cultivars. Shallow, medium and no depth for fruit stalk cavity were observed among the different varieties/cultivars.

Slightly prominent and no fruit neck were observed among the different varieties/cultivars. Prominent, perceptible, pointed and mammiform fruit beaks were observed among the different varieties/cultivars. Mild, intermediate and strong aroma of ripe fruits were observed among the different varieties/cultivars.

Yellow, orange and shallow yellow with blush skin colours were observed for ripe fruits among the different varieties/cultivars. Golden yellow, light yellow, yellow and yellow orange pulp colour of ripe fruits were observed among the different varieties/cultivars.

Fruits were obtained only during two seasons in Arka Aruna, Amrapali, Mallika, Ratna, Sindhu, H 45, H 151, PKM 1, PKM 2 and Neelgoa among the hybrids. Among the local types, Banganapalli, Alphonso, Dashehari, Neelum, Himayuddin, Bennet Alphonso, Kalepady, Swarnarekha and Mulgoa had fruiting during two seasons, while Tholikaippan, Chandrakaran, Vellaikolumban, Prior and Muvandan showed fruiting during two seasons. The results in the present study revealed that there was no flowering during the first season.

Fruits were obtained only during three seasons in Arka Aruna, Ratna, H 45, H 151 and PKM 2 among the hybrids. Among the local types, Banganapalli, Alphonso, Himayuddin, Bennet Alphonso, Swarnarekha and Mulgoa had fruiting during three seasons, while Chandrakaran, and Prior showed fruiting during three seasons.

Variation in fruit length of different genotypes during the two seasons. Among the hybrids, Mallika (17.97 cm) recorded the highest fruit length. Mulgoa (20.08 cm) recorded the highest fruit length the parents involved in breeding. Prior (13.77 cm) recorded the highest fruit length and Chandrakaran (7.60 cm) recorded the lowest fruit length.

Variation in fruit length of different genotypes during the three seasons. Among the hybrids Arka Aruna (16.56 cm) recorded the highest fruit. Mulgoa (19.99 cm) recorded the highest fruit among the parents involved in breeding. Prior (13.67 cm) recorded the highest fruit length among the local types.

Variation in fruit diameter of different genotypes during the two seasons. Among the hybrids Arka Aruna (32.50 cm) recorded the highest fruit and Mulgoa (28.02 cm) recorded the highest fruit diameter among the parents involved in breeding. Prior (26.83 cm) recorded the highest fruit diameter which was significantly different from the rest of the local types.

Variation in fruit diameter of different genotypes during the three seasons. Among the hybrids Arka Aruna (32.87 cm) recorded the highest diameter which was significantly different from the rest of the hybrids. Mulgoa (27.08 cm) recorded the highest fruit diameter which was significantly different from the rest of the parents involved in breeding. Prior (26.57 cm) recorded the highest fruit diameter among the local types.

Variation in fruit weight of different genotypes during the two seasons. Among the hybrids Arka Aruna (631.40g) recorded the highest fruit weight which was significantly different from the rest of the hybrids and H 151 (131.25g) recorded the lowest fruit weight. Mulgoa (738.97g) recorded the highest fruit weight which was significantly different from the other parents involved in breeding and Alphonso (145.83g) recorded the lowest fruit weight. Prior recorded the highest fruit weight among the local types and Chandrakaran (123.10g) recorded the lowest fruit weight.

Variation in fruit weight of different genotypes during the three seasons. Among the hybrids Arka Aruna (660.01 g) recorded the highest fruit weight and H 151 (145.99 g) recorded the lowest fruit weight. Mulgoa (707.69 g) recorded the highest fruit weight which was significantly different from the rest of the parents involved in breeding and Alphonso (147.76 g) recorded the lowest fruit weight. Prior (350.69 g) recorded the highest fruit weight and Chandrakaran (120.49 g) recorded the lowest fruit weight among the local types.

Variation in fruit yield of different genotypes during the two seasons. Among the hybrids H45 (46.92 kg/tree) recorded the highest yield and Arka Aruna (9.75 kg/tree) recorded the lowest yield. Dashehari (48.00 kg/tree) recorded the highest fruit yield which was significantly different from the rest of the parents involved in breeding and Mulgoa (11.42 kg/tree) recorded the lowest fruit yield. Muvandan (52.13 kg/tree) recorded the highest fruit yield and Prior (48.84 kg/tree). Chandrakaran (12.87 kg/tree) recorded the lowest fruit yield among the local types.

Variation in fruit yield of different genotypes during the three seasons. Among the hybrids H 45 (38.61 kg/tree) recorded the highest fruit yield and Arka Aruna (8.67 kg/tree) recorded the lowest fruit yield. Prior (43.46 kg/tree) recorded the highest fruit yield and Chandrakaran (12.08 kg/tree) recorded the lowest fruit yield among the local types.

Among the hybrids H 151 (7.00 days) recorded the highest shelf life and PKM 1 (3.83 days) recorded the lowest shelf life which was on par with PKM 2 (4.00 days). Dashehari (6.67 days) recorded the highest shelf life which was significantly different from the rest of the parents involved in breeding and Himayuddin (4.00 days) recorded the lowest shelf life. Chandrakaran (4.17 days) recorded the highest shelf life which

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followed by the rest of the local types and Tholikaippan (4.00 days) recorded the lowest shelf life.

Variation in shelf life of different genotypes during the three seasons. Among the hybrids H 151 (7.00 days) recorded the highest shelf life and PKM 2 (4 days) recorded the lowest shelf life. Alphonso (6.00 days) recorded the highest shelf life and Himayuddin (4 days) recorded the lowest shelf life. Chandrakaran (4.11 days) and Prior (4.11 days) recorded the same shelf life among the local types both.

Variation in stone length of different genotypes during the two seasons. Among the hybrids, PKM 2 (11.83 cm) recorded the highest fruit stone. Mulgoa (14.05 cm) recorded the highest stone length among the parents involved in breeding. Prior (12.07 cm) recorded the highest stone length among the local types.

Variation in stone length of different genotypes during the three seasons. Among the hybrids, PKM 2 (11.23 cm) recorded the highest stone length which was significantly different from the rest of the hybrids. Mulgoa (13.94 cm) recorded the highest stone length which was significantly different from the rest of the parents involved in breeding. Prior (11.60 cm) recorded the highest stone length among the local types.

Variation in stone width of different genotypes during the two seasons. Among the hybrids, H 45 (12.07 cm) recorded the highest stone width which was significantly different from the rest of the hybrids. Banganapalli (8.68 cm) recorded the highest stone. Prior (5.85 cm) recorded the highest stone width which was significantly different from the rest of the local types.

Variation in stone width of different genotypes during the three seasons. Among the hybrids, H 45 (12.45 cm) recorded the highest stone width among the parents involved in breeding. Banganapalli (8.88 cm) recorded the highest stone width. Prior (5.66cm) recorded the highest stone width among the local types.

Variation in stone thickness of different genotypes during the two seasons. Among the hybrids, Neelgoa (3.15 cm) recorded the highest stone thickness and PKM 1 (1.22 cm). Alphonso (2.37 cm) recorded the highest stone thickness. Vellaikolumban (2.17cm) recorded the highest stone thickness among the local types,

Variation in stone thickness of different genotypes during the three seasons. Among the hybrids, Arka Aruna (2.45 cm) recorded the highest stone thickness.

Alphonso (2.42 cm) recorded the highest stone thickness. Prior (2.00 cm) recorded the highest stone thickness among the local types.

Variation in stone weight of different genotypes during the two seasons. Among the hybrids, Mallika (45.50 g) recorded the highest stone weight. Mulgoa (47.73 g) recorded the highest stone weight which was significantly different from the rest of the parents involved in breeding. Prior (29.43 g) recorded the highest stone weight which is significantly different from rest of the local types.

Variation in stone weight of different genotypes during the three seasons. Among the hybrids, Arka Aruna (47.67 g) recorded the highest stone. Mulgoa (47.46 g) recorded the highest stone weight which was significantly different from the rest of the parents involved in breeding. Prior (29.07 g) recorded the highest stone weight among the local types.

Variation in seed length of different genotypes during the two seasons. Among the hybrids, Amrapali (7.38 cm) recorded the highest seed length. Mulgoa (11.22 cm) recorded the highest seed length among the parents involved in breeding. Tholikaippan (6.25 cm) recorded the highest seed length.

Variation in seed length of different genotypes during the three seasons. Among the hybrids, PKM 2 (7.55 cm) recorded the highest seed length. Mulgoa (10.89 cm) recorded the highest seed length among the parents involved in breeding. Prior (6.00 cm) recorded the highest seed length among the local types.

Variation in seed width of different genotypes during the two seasons. Among the hybrids, Ratna (8.45 cm) recorded the highest seed width. Banganapalli (8.88 cm) recorded the highest seed width among the parents involved in breeding. Tholikaippan (3.45 cm) recorded the highest seed width among the local types.

Among the hybrids, Ratna (8.51 cm) recorded the highest seed width. Banganapalli (8.93 cm) recorded the highest seed width which was significantly different from the rest of the parents involved in breeding. Prior (3.01 cm) recorded the highest stone width among the local types.

Among the hybrids, Neelgoa (24.17 g) recorded the highest seed weight. Mulgoa (28.98 g) recorded the highest seed weight among the parents involved in breeding. Tholikaippan (18.45 g) recorded the highest seed weight among the local types.

Among the hybrids, PKM 2 (23.71 g) recorded the highest seed weight. Mulgoa (26.49 g) recorded the highest seed weight which was significantly different from the rest of the parents involved in breeding. Prior (18.31 g) recorded the highest seed weight among the local types.

Weak, intermediate and strong adherence of fibre to stone were observed among the different varieties/cultivars. Coarse and soft texture of stone fibre were observed among the different varieties/cultivars. Ellipsoid, reniform and oblong seed shapes were observed among the different varieties/cultivars.

Among the hybrids H 151 recorded high ascorbic acid, total carotenoids, reducing sugar and lowest acidity. Highest beta carotene, total sugar, crude fibre and TSS were recorded for Sindhu, PKM 1, Arka Aruna and Neelgoa respectively. However, among the parents involved in breeding, highest reducing sugar and lowest acidity was recorded in Kalepady. Highest total sugar and crude fibre was recoded in Swarnarekha. The highest ascorbic acid, total carotenoid, beta carotene and TSS were noticed in Neelum, Alphonso, Dashehari and Himayuddin respectively. Among the local types, Tholikaippan recorded the highest total carotenoid, beta carotene, reducing sugar and TSS. Chandrakaran recorded lowest acidity, highest ascorbic acid was recorded for Muvandan, highest total sugar content was recorded for Vellaikolumban and highest crude fiber was recorded for Chandrakaran.

Sensory evaluation was conducted, among the hybrids, the highest rank for appearance, flavor, sweetness and texture was given for Mallika. For colour and taste highest rank was given for Ratna. Among the parents involved in breeding, the highest rank for flavor, sweetness and texture was given for Neelum. Himayuddin recorded highest rank for taste, Kalepady for appearance and colour for Swarnarekha. Among the local types, the highest rank for appearance was given for Muvandan. For colour highest rank was given for Chandrakaran. Prior got the highest rank for flavor, sweetness, and texture.

Variation in pollen length of different genotypes during the two seasons. Among the hybrids, Arka Aruna (41.92 μm) recorded the highest pollen and Neelgoa (26.40 μm) recorded the lowest pollen length. Himayuddin (45.72 μm) recorded the highest pollen length among the parents involved in breeding and Swarnarekha (27.11 μm) recorded the lowest pollen length. Chandrakaran (45.22 μm) recorded the highest pollen length and Muvandan (30.10 μm) recorded the lowest pollen length among the local types.

Variation in pollen length of different genotypes during the three seasons. Among the hybrids, Ratna (43.17 μm) recorded the highest pollen length. Bennet Alphonso (46.53 μm) recorded the highest pollen length among the parents involved in breeding. Prior (44.29 μm) recorded the highest pollen length among the local types.

Among the hybrids, Arka Aruna (38.34 μm) recorded the highest pollen width. Neelam (35.32 μm) recorded the highest pollen width. Tholikaippan (35.11 μm) recorded the highest pollen width which was significantly different from rest of the local types.

Variation in pollen width of different genotypes during the three seasons. Among the hybrids, Arka Aruna (37.09 μm) recorded the highest pollen. Alphonso (35.10 μm) recorded the highest pollen. Prior (30.36 μm) recorded the highest pollen width among the local types.

Variation in shape of pollen grains of different genotypes during. Among the hybrids, Arka Aruna, Amrapali, Sindhu, H 45, H 151, PKM 1, PKM 2 and Neelgoa had oblong pollen whereas Mallika and Ratna had oval pollen grains. All the parents involved in breeding had oblong pollen grains except Swarnarekha and Mulgoa. Swarnarekha had round pollen grains whereas Mulgoa had oval pollen grains. Vellaikolumban, Prior and Muvandan had oblong pollen grains among the local types whereas Chandrakaran recorded oval pollen grains and Tholikaippan recorded roundish pollen grains.

Variation in pollen fertility of different genotypes during the two seasons. Among the hybrids, Ratna (93.54 %) recorded the highest fertility. Dashehari (92.18%) recorded the highest fertility among the parents involved in breeding. Tholikaippan (93.60%) recorded the highest pollen fertility.

Variation in pollen fertility of different genotypes during the three seasons. Among the hybrids, Ratna (78.79%) recorded the highest pollen fertility. Swarnarekha (80.45%) recorded the highest pollen fertility among the parents involved in breeding. Chandrakaran (80.47%) recorded the highest pollen fertility and Prior (73.85%) recorded the lowest pollen fertility among the local types.

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Variation in estimation of pollen production of different genotypes during the two seasons. Among the hybrids, Amrapali (438.17) recorded the highest pollen production. Banganapalli (489.00) recorded the highest pollen production among the parents involved in breeding. Prior (541.83) recorded the highest pollen production which was significantly different from rest of the local types and Muvandan (347.33) recorded the lowest pollen production.

Variation in estimation of pollen production of different genotypes during the three seasons. Among the hybrids, Arka Aruna (263.56) recorded the highest pollen production. Banganapalli (347.56) recorded the highest pollen production among the parents involved in breeding. Prior (403.00) recorded the highest pollen production among the local types.

The studies showed that the mango pollen can be stored without much loss in viability up to 72 hours after dehiscence when it is stored in refrigerated conditions, but the viability was high (78.52 %) after 24 hours of storage.

Variation in estimation of relative water content (%) of different genotypes during the three seasons. Among the hybrids, H 151 (35.37 %) recorded the highest RWC. Neelum (35.82%) recorded the highest relative water content among the parents involved in breeding. Vellaikolumban (34.74%) recorded the highest RWC.

variation in estimation of radiation interception (μ mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, H 151 (0.85 μ mol m_{-2} s_{-2}) followed by the rest of the hybrids. Mulgoa (0.92 μ mol m_{-2} s_{-2}) recorded the highest radiation interception followed by the rest of the parents involved in breeding. Muvandan (0.87 μ mol m_{-2} s_{-2}) recorded the highest radiation interception.

Variation in estimation of stomatal index of different genotypes during the three seasons. Among the hybrids, Mallika (22.44) recorded the highest stomatal index. Banganapalli (20.80) recorded the highest stomatal index among the parents involved in breeding. Chandrakaran (20.00) recorded the highest stomatal index among local types.

Variation in estimation of stomatal frequency of different genotypes during the three seasons. Among the hybrids, Mallika (85.11) recorded the highest stomatal frequency. Banganapalli (88.78) recorded the highest stomatal frequency. Chandrakaran (85.44) recorded the highest stomatal frequency.

The variation in stomatal conductance was not significant among the different genotypes over the three seasons.

Variation in estimation of stomatal resistance of different genotypes during the three seasons. Among the hybrids, H 45 (15.36 μ mol m_{-2} s_{-2}) recorded the highest stomatal resistance. Swarnarekha (37.92 μ mol m_{-2} s_{-2}) recorded the highest stomatal resistance. Tholikaippan (16.29 μ mol m_{-2} s_{-2}) recorded the highest stomatal resistance.

Variation in estimation of photosynthetic rate of different genotypes during the three seasons. Among the hybrids, PKM 1 (14.14 μ mol m_{-2} s_{-2}) recorded the highest photosynthetic rate. Swarnarekha (17.54 μ mol m_{-2} s_{-2}) recorded the highest photosynthetic rate among the parents involved in breeding. Tholikaippan (17.91 μ mol m_{-2} s_{-2}) recorded the highest photosynthetic rate.

Variation in estimation of transpiration (mol m_{-2} s_{-2}) of different genotypes during the three seasons. Among the hybrids, Sindhu (3.31 μ mol m_{-2} s_{-2}) recorded the highest transpiration. Dashehari (4.15 μ mol m_{-2} s_{-2}) recorded the highest transpiration among the parents involved in breeding. Muvandan (3.22 μ mol m_{-2} s_{-2}) recorded the highest transpiration.

The variation in leaf area index was not significant among the different genotypes over the three seasons.

During the three seasons, among the hybrids, Mallika (68.53) recorded the highest APTI. Among the parents involved in breeding Bennet Alphonso (60.39) recorded the highest APTI. Chandrakaran (63.50) recorded the highest APTI which was significantly different from the rest of the local types. Muvandan (42.07) recorded the lowest APTI.

Among the hybrids, during the three seasons, Ratna (19.07 mg g_{-1}) recorded the highest total phenol. Swarnarekha (10.54 mg g_{-1}) recorded the highest total phenol among the parents involved in breeding. Chandrakaran (8.75 mg g_{-1}) recorded the highest total phenol.

Variation soluble protein content (mg g_{-1}) of different genotypes during the three seasons. Among the hybrids, PKM 1 (19.24 mg g_{-1}) recorded the highest soluble protein. Mulgoa (18.42 mg g$_{-1}$) recorded the highest soluble protein among the parents involved in breeding. Muvandan (20.04 mg g$_{-1}$) recorded the highest soluble protein.

Variation in ascorbic acid (mg 100g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, Ratna (97.21 mg 100g$_{-1}$) recorded the highest ascorbic acid. Banganapalli (79.46 mg 100g$_{-1}$) recorded the highest ascorbic acid among the parents involved in breeding. Chandrakaran (93.30 mg 100g$_{-1}$) recorded the highest ascorbic acid content which was significantly different from the rest of the local.

During the three seasons, among the hybrids, PKM 2 (6.45) recorded the highest pH. Neelum (6.37) recorded the highest pH among the parents involved in breeding. Vellaikolumban (5.90) recorded the highest pH among the local types.

Variation in chlorophyll content a (mg g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, Sindhu (1.31 mg g$_{-1}$) recorded the highest chlorophyll a content. Kalepady (1.19 mg g$_{-1}$) recorded the highest chlorophyll a content followed by the rest of the parents. Muvandan (1.25 mg g$_{-1}$) recorded the highest chlorophyll a content.

Variation in chlorophyll content b (mg g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, Neelgoa (0.23 mg g$_{-1}$) recorded the highest chlorophyll b content. Swarnarekha (0.21 mg g$_{-1}$) recorded the highest chlorophyll b content the parents involved. Tholikaippan (0.26 mg g$_{-1}$) recorded the highest chlorophyll b content among the local types.

Variation in total chlorophyll content (mg g$_{-1}$) of different genotypes during the three seasons. Among the hybrids, H 45 (1.48 mg g$_{-1}$) recorded the highest total chlorophyll. Bennet Alphonso (1.40 mg g$_{-1}$) recorded the highest total chlorophyll. Muvandan (1.44 mg g$_{-1}$) recorded the highest total chlorophyll among the local types.

Experiment II. Evaluation of selected mango genotypes in HDP

The trees of same age group (5 years) were selected for the study.

Chandrakaran (31.29 cm) recorded the highest circumference which was significantly different from the rest of the varieties / local types and Prior (20.51 cm) recorded the lowest trunk circumference.

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Vellaikolumban (3.09 m) recorded the highest crown diameter (North -South) and Ratna (2.39m) recorded the lowest crown diameter (North -South). The crown diameter (East-West) which was not significant among the genotypes and season.

Different crown shapes like oblong, semi-circular, and spherical were noticed among the hybrids/local types.

Different tree growth habit like erect and spreading were noticed among the hybrids/local types.

Dense and intermediate foliage density were noticed among the hybrid/local types.

Ratna (25.40 cm) recorded the highest leaf blade length which was significantly different from the rest of the hybrid/local types and Muvandan (19.17 cm) recorded the lowest leaf blade length. Vellaikolumban (7.68 cm) recorded the highest leaf blade width which was significantly different form the rest of the hybrid/local types and Muvandan (4.84 cm) recorded the lowest leaf blade width. Ratna (4.18 cm) recorded the highest petiole length and Chandrakaran (2.29 cm) recorded the lowest petiole length.

Elliptic, obovate, lanceolate and oblong leaf blade shape were noticed among the hybrids/local types. Obtuse, acuminate and acute leaf apex shape were noticed among the hybrids/local types. Round, acute and obtuse leaf base shape were noticed among the hybrids/local types. Wavy and entire leaf margin were noticed among the hybrids/local types. Leaf pubescence was absent among all the hybrids/local types. Reddish brown and light green colour of young leaf were noticed among the hybrids/local types. Dark green and green colour of fully developed were noticed among the hybrids/local types. Mild and strong leaf fragrance were noticed among the hybrids/local types.

Different flowering durations like January – February and December – January were noticed among the hybrids/local types. Secondary/off season flowering were absent among all the hybrids/local types.

All the hybrids/local types had trees with terminal inflorescence position. Pyramidal and conical inflorescence shape were noticed among the hybrids/local types. Sparse, medium and dense flowers were observed among the inflorescence of different hybrids/local types. Yellowish green, green with red patches, light green and light greenish with red patches were the inflorescence colour observed among the different hybrids/local types. Shorter and equal length of stamen in relation to pistil were found among the hybrids/local types. Narrow, reduced or absent and swollen, broader than ovary were the nature of disc found among the hybrids/local types.

Vellaikolumban (36.47 cm) recorded the highest inflorescence length and Prior (22.14 cm) recorded the lowest inflorescence length.

Vellaikolumban (23.54 cm) recorded the highest inflorescence width which was significantly different from the rest of the hybrid/local types. Chandrakaran (85.80 cm) recorded the highest hermaphrodite flowers in the inflorescence.

All the local types and the variety Mallika had 5 number of stamens per flower whereas Ratna had 5 number of stamens per flower. There was no seasonal effect on the number of stamens per flower.

All the hybrids/local types had fruiting during April-May.

Medium and high fruit bearing intensity was observed among the different hybrids/local types. Obovoid and roundish fruit shapes were observed among the different hybrids/local types. Round, acute and obtuse fruit apex shapes were observed among the different hybrids/local types.

Excellent, good and average fruit attractiveness were observed among the different hybrids/local types. All the hybrids/local types had trees with green skin colour for unripe fruits. Yellow, and greenish yellow skin colours were observed for ripe fruits among the different hybrids/local types. Shallow and no depth for fruit stalk cavity were observed among the different hybrids/local types. Slightly prominent and no fruit neck were observed among the different hybrids/local types. Prominent, perceptible and pointed fruit beaks were observed among the different hybrids/local types. Light yellow pulp colour of ripe fruits were observed among all the hybrids/local types. Mild, intermediate and strong aroma of ripe fruits were observed among the different hybrids/local types.

Mallika (18.71 cm) recorded the highest fruit length and Chandrakaran (7.49 cm) recorded the lowest fruit length. Mallika (25.25 cm) recorded the highest fruit diameter and Chandrakaran (13.18 cm) recorded the lowest fruit diameter.

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Mallika (482.71 g) recorded the highest fruit weight which was significantly different from the rest of the hybrid / local types and Chandrakaran (58.09 g) recorded the lowest fruit weight.

Mallika (24.69 kg/tree) recorded the highest fruit yield which was significantly different from the rest of the hybrid/ local types. Muvandan (8.93 Kg/tree) recorded the lowest fruit yield. Prior (6.00 Days) recorded the highest shelf life and Muvandan (4.00 Days) recorded the lowest shelf life. Mallika (11.67 cm) recorded the highest stone length and Chandrakaran 95.58 cm recorded the lowest stone length. Ratna (8.67 cm) recorded the highest stone width which was significantly different from the rest of the hybrids/ local types. Chandrakaran (3.36 cm) recorded the lowest stone width. Vellaikolumban (2.19 cm) recorded the highest stone thickness and Chandrakaran (1.23 cm) recorded the lowest stone thickness. Mallika (44.33 g) recorded the highest stone weight which was significantly different from the rest of the hybrid / local types. Chandrakaran (17.79 g) recorded the lowest stone weight.

Ratna (7.91 cm) recorded the highest seed length which was significantly different from the rest of hybrid/local types. Chandrakaran (4.05 cm) recorded the lowest seed length. Ratna (8.47 cm) recorded the highest seed width which was significantly different from the rest of the hybrid/local types and Prior (3.07 cm) recorded the lowest seed width. Prior (22.22 g) recorded the highest seed weight followed by Mallika (21.86 g). Vellaikolumban (9.44 g) recorded the lowest seed weight.

Low, intermediate and high quantity of fibre on stone were observed among the different hybrids/local types. Weak, intermediate and strong adherence of fibre to stone were observed among the different hybrids/local types. Coarse and soft texture of stone fibre were observed among the different hybrids/local types. Ellipsoid and reniform seed shapes were observed among the different hybrids/local types.

Ratna (26.77 $_{o}$Brix) recorded the highest TSS and Muvandan (14.78 $_{o}$Brix) recorded the lowest TSS. Muvandan (0.07 %) recorded the highest acidity and Mallika (0.02%) recorded the lowest acidity. Chandrakaran (79.68 mg $100g_{-1}$) recorded the highest ascorbic acid and Vellaikolumban (28.26 mg $100g_{-1}$) recorded the lowest ascorbic acid. Muvandan (4.80 mg $100g_{-1}$) recorded the highest total carotenoids and

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Vellaikolumban (1.40 mg $100g^{-1}$) recorded the lowest total carotenoids. Ratna (39.93 mg $100g^{-1}$) recorded the highest β carotene which was significantly different from the rest of the hybrid/local type and Vellaikolumban (13.54 mg $100g^{-1}$) recorded the lowest β carotene. The variation in total sugar and reducing sugar were not significant among the different genotypes over the seasons. Mallika (13.00%) recorded the highest crude fibre which was significantly different from the rest of the hybrid / local types. Ratna (3.56 %) recorded the lowest crude fibre.

Among the hybrids/local types, the highest rank for appearance was given for Mallika followed by Ratna and Muvandan. For colour highest rank was given for Ratna followed by Chandrakaran and Prior. Ratna got the highest rank for flavour followed by Chandrakaran and Mallika. Ratna recorded highest rank for sweetness followed by Mallika and Chandrakaran. Ratna also recorded highest rank for taste followed by Mallika and Chandrakaran. Ratna was given highest rank for texture followed by Mallika and Prior.

Prior (44.00 μm) recorded the highest pollen length and Muvandan (24.8 μm) recorded the lowest pollen length. Chandrakaran (33.45 μm) recorded the highest pollen breadth and Muvandan (22.62 μm) recorded the lowest pollen breadth. Among the hybrids/local types, Mallika, Ratna and Chandrakaran had oval pollen grains. Vellaikolumban, Prior and Muvandan had oblong pollen grains Tholikaippan recorded roundish pollen grains. Among the hybrids, Mallika (79.20%) recorded the highest pollen fertility which was significantly different from the other hybrid / local types. Prior (59.47%) recorded the lowest pollen fertility. Vellaikolumban (306.30) recorded the highest pollen production which was significantly different from the rest of the hybrid / local types. Muvandan (194.50) recorded the lowest pollen production which was on par with Ratna (197.40).

The variation in relative water content was not significant among the different genotypes over the three seasons. Ratna (0.77 μ mol m^{-2} s^{-2}) recorded the highest radiation interception and Prior (0.61 μ mol m^{-2} s^{-2}) recorded the lowest radiation interception. Ratna (21.37 μ mol m^{-2} s^{-2}) recorded the highest stomatal index and Mallika (17.87 μ mol m^{-2} s^{-2}) recorded the lowest stomatal index. Ratna (81.40) recorded the highest stomatal frequency and Mallika (63.73) recorded the lowest

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stomatal frequency. Muvandan (0.19 µ mol m^{-2} s^{-2}) recorded the highest stomatal conductance and Prior (0.09 µ mol m^{-2} s^{-2}) recorded the lowest stomatal conductance. Prior (19.79 µ mol m^{-2} s^{-2}) recorded the highest stomata resistance and Muvandan (7.31 µ mol m^{-2} s^{-2}) recorded the lowest stomatal resistance. Vellaikolumban (11.68 µ mol m^{-2} s^{-2}) recorded the highest photosynthetic rate which was significantly different from the rest of hybrid / local types. Chandrakaran (3.17 µ mol m^{-2} s^{-2}) recorded the lowest photosynthetic rate. Chandrakaran (4.19 µ mol m^{-2} s^{-2}) recorded the highest transpiration rate and Ratna (2.44 µ mol m^{-2} s^{-2}) recorded the lowest transpiration. The variation in leaf area index was not significant among the different genotypes over the three seasons. Ratna (68.34) recorded the highest APTI and Vellaikolumban (54.42) recorded the lowest APTI.

Prior (10.66 mg g^{-1}) recorded the highest total phenol and Vellaikolumban (4.81 mg g^{-1}) recorded the lowest total phenol. Chandrakaran (20.75 mg g^{-1}) recorded the highest soluble protein and Ratna (12.72 mg g^{-1}) recorded the lowest soluble protein. Ratna (92.34 mg g^{-1}) recorded the highest ascorbic acid and Vellaikolumban (67.74 mg g^{-1}) recorded the lowest ascorbic acid content. Muvandan (6.15 mg g^{-1}) recorded the highest pH content and Ratna (5.57 mg g^{-1}) recorded the lowest pH.

Prior (1.29 mg g^{-1}) recorded the highest chlorophyll a content followed by Chandrakaran (1.25 mg g^{-1}) and Muvandan (1.09 mg g^{-1}) recorded the lowest chlorophyll a content which was on par with Ratna (1.14) mg g^{-1}. Chandrakaran (0.29 mg g^{-1}) recorded the highest chlorophyll b content and Muvandan (0.22 mg g^{-1}) recorded the lowest chlorophyll b content. Prior (1.55 mg g^{-1}) recorded the highest total chlorophyll and Muvandan (1.30 mg g^{-1}) recorded the lowest total chlorophyll.

Experiment III. Development of a crop weather model for mango and screening of genotypes for climate resilience

Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using ECHAM model and the performance of the various genotypes under projected climatic conditions was evaluated using the developed model. Correlation among different meteorological and phenological characters of mango genotypes were done for yield, regression equations were derived and the yield was predicted from the scenario. Three phenophases *viz.*, flower initiation, fruit initiation

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and fruit maturation were taken for the study. In each phenophase, weather parameter for seven, fifteen and thirty days prior to date of expression were averaged individually for correlation.

Sindhu, Vellaikolumban, Prior, Alphonso, Kalepady and Tholikaippan showed an increase in the predicted yield in spite of an increase in temperature in flowering phenophase under normal planting system. The predicted yield increased in spite of a decrease in solar radiation in H 45, Mulgoa and Tholikaippan, the predicted yield increased in spite of a decrease in rainfall in Dashehari, Neelum and Muvandan. Amrapali, PKM 1, Alphonso, Himayuddin, Swarnarekha and Mulgoa showed an increase in predicted yield in spite of an increase in rainfall.

Amrapali, PKM 1, Sindhu, Neelum, Himayuddin, Bennet Alphonso, Kalepady, Muvandan, Tholikaippan, Vellaikolumban, Banganapalli and Prior, recorded an increase in predicted yield in spite of an increase in temperature in fruit initiation phenophase under normal planting system. The predicted yield increased in spite of a decrease in rainfall in PKM 1, Amrapali, H 151, H 45, Bennet Alphonso, Mulgoa, Tholikaippan, Chandrakaran and Muvandan. Dashehari showed an increase in predicted yield in spite of an increase in rainfall.

H 151, Kalepady and Swarnarekha showed an increase in the predicted yield in spite of an increase in rainfall in fruit maturation phenophase under normal planting system.

Based on the performance of genotypes in all three phenophases, H 45 can be recommended for regions with lower rainfall and lower solar radiation among the hybrids under normal planting system, whereas, Amrapali and PKM 1 can be recommended for areas with higher temperature and for both higher and lower rainfall regions. Among the parents of the hybrids, Mulgoa can be recommended for regions with lower solar radiation and for both lower and higher rainfall regions. Among the local types, Tholikaippan can be recommended for the regions with higher temperature, lower rainfall and lower solar radiation.

Vellaikolumban, Ratna and Muvandan showed an increase in the predicted yield in spite of an increase in temperature in flowering phenophase under high density planting system. Prior, Chandrakaran, Muvandan, Vellaikolumban, Ratna and Mallika recorded an increase in the predicted yield in spite of an increase in temperature in fruit initiation phenophase under high density planting system. Prior, Chandrakaran, Mallika, Ratna and Muvandan, showed an increase in the yield in spite of an increase in temperature in fruit maturation phenophase under high density planting system, whereas the predicted yield increased in spite of a decrease in rainfall in Mallika, Vellaikolumban and Ratna.

Based on the performance of genotypes in all the three phenophases, all studied genotypes can be recommended for higher temperature regions under high density planting system.

In conclusion, climate change may have a profound impact on mango genotypes since the flower initiation, fruit initiation and fruit maturation phenophases are strongly influenced by the environment. The projected scenario for 2030, 2040 and 2050 indicate that the temperature will tend to increase and the rainfall will decrease from the present condition leading to altered phenophases which necessitate changes in spectrum and distribution of varieties currently being grown. H 45, PKM 1, Amrapali, Mulgoa and Tholikaippan are the climate resilient genotypes for the normal planting systems and Mallika, Ratna, Muvandan, Vellaikolumban and Prior are the climate resilient genotypes for high density planting systems.

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Appendices

APPENDIX – I

Score card for organoleptic evaluation

Name of the judge:
Date:

Characteristics	Scores				
Appearance					
Colour					
Flavour					
Texture					
Sweetness					
Taste					

9 point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

APPENDIX II

Incidence of pest and disease under normal planting system

Incidence of Anthracnose

	2016	2017	2018
Arka Aruna	Mild	High	Mild
Amrapali	Mild	Mild	Mild
Mallika	High	Mild	High
Ratna	High	Mild	High
Sindhu	Mild	MIld	Mild
H 45	Mild	HIgh	Mild
H 151	Mild	Mild	Mild
Pkm 1	Mild	High	High
Pkm 2	Mild	High	High
Neelgoa	Mild	Mild	Mild
Banganappalli	High	High	Mild
Alphonso	Severe	Severe	Severe
Dashehari	High	MIld	High
Neelum	Mild	MIld	Mild
Himayuddin	Mild	High	Mild
Bennet Alphonso	Severe	Severe	MIld
Kalepady	Severe	High	High
Swarnarekha	Mild	High	High
Mulgoa	Mild	Mild	Mild
Tholikippan	Mild	Mild	Mild
Chandrakaran	Mild	MIld	Mild
Vellaikolumban	Mild	Mild	Mild
Prior	Mild	High	High
Muvandan	Severe	Mild	High

APPENDIX III

Incidence of pest and disease under high density planting system

Incidence of anthracnose of rachis

	2016	2017	2018
Prior	Mild	Mild	Mild
Mallika	Mild	High	Severe
Vellaikolumban	High	High	Mild
Ratna	Mild	High	Severe
Chandrakaran	Mild	Mild	Mild
Moovandan	Severe	Severe	Severe

Incidence of leaf cutting weevil

	2016				Mean	2017				Mean	2018				Mean
	E	W	N	S		E	W	N	S		E	W	N	S	
Prior	2	1	2	1	2	2	2	3	2	2	1	2	2	1	2
Mallika	3	3	4	3	3	3	2	3	3	3	4	3	3	4	4
Vellaikolumban	2	3	4	3	3	3	2	3	3	3	4	4	3	3	4
Ratna	4	4	3	4	4	2	2	2	2	2	4	3	2	2	3
Chandrakaran	2	3	3	3	3	3	2	2	3	3	3	2	2	2	2
Moovandan	5	4	3	5	4	4	3	3	3	3	3	4	3	3	3

APPENDIX IV

Soil data

Parameters	2016	2017	2018
Organic carbon content (%)	1.28	1.07	1.22
Nitrogen (%)	0.25	0.16	0.24
Available phosphorous (kg/ha)	3.95	3.47	3.39
Available potassium (kg/ha)	319.20	179.20	208.30

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ECOPHYSIOLOGY AND SCREENING FOR CLIMATE CHANGE RESILIENCE IN MANGO (*Mangifera indica* L.) GENOTYPES

by

ASWINI A.

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ABSTRACT OF THE THESIS

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COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695 522
KERALA, INDIA

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ABSTRACT

The study on "Ecophysiology and screening for climate change resilience in mango (*Mangifera indica* L.) genotypes" was conducted with the objective of getting basic information on eco physiological responses among selected genotypes of mango on flushing, flowering and fruit development with a view to identify climate resilient genotypes that are suitable for future climate change scenario in Kerala. The study comprised of three experiments *viz.*, evaluation of mango genotypes under normal planting system, evaluation of selected mango genotypes in high density planting system and development of a crop weather model for mango and screening of genotypes for climate resilience with developed crop weather models.

Experiment on evaluation of mango genotypes under normal planting system was conducted with trees of same age group (23 years). Wide variation was observed among the morphological characters, physiological characters, biochemical characters and quality attributes of different mango genotypes. From the observations on tree characters, the plant height varied from 9.78 m (H 151) to 12.49 m (Chandrakaran), the trunk circumference ranged from 91.63 cm (Muvandan) to 196.53 cm (Swarnarekha), and the crown diameter varied from 7.07 m (H 151) to 13.46 m (Mulgoa). The qualitative data on morphological characters *viz.*, tree, leaf, inflorescence, fruit, stone and seed characters were grouped into clusters based on the IBPGRI descriptor. The observation on leaf characters revealed that the leaf blade length varied from 19.78 cm (Chandrakaran) to 29.32 cm (Amrapali), leaf blade width ranged from 4.77 cm (Kalepady) to 8.12 cm (Vellaikolumban), and the petiole length varied from 1.56 cm (H 45) to 3.70 cm (Amrapali). Based on the observations on inflorescence character the inflorescence length varied from 12.58 cm (Dashehari) to 34.42 cm (Bennet Alphonso), the inflorescence width ranged from 9.32 cm to 3.40 cm (Vellaikolumban), the hermaphrodite flowers in the inflorescence varied from 14.00% (Mulgoa) to 67.83% (Neelum), and the number of stamens per flower ranged from 4 to 5. From the observations on fruit characters the fruit length varied from 7.60 cm (Chandrakaran) to 20.08 cm (Mulgoa), fruit diameter ranged from 17.05 cm (h 151) to 32.50 cm (Arka Aruna), the fruit weight ranged from 123.10 g (Chandrakaran) to 738.97 g (Mulgoa), the fruit yield varied from 9.75 kg/tree (Arka Aruna) to 52.13 kg/tree (Muvandan) and

the shelf life ranged from 3.83 days (PKM 2) to 7 days (H 151). From the observations on stone characters stone length, varied from 5.60 cm (Muvandan and Neelum) to 14.05 cm (Mulgoa), stone width ranged from 3.17 cm (Muvandan) to 12.07 cm (H 45), the stone thickness varied from 1.20 cm (Muvandan) to 3.15 cm (Neelgoa) and the stone weight ranged from 15.93 g (Bennet Alphonso) to 47.13 g (Mulgoa). Based on the seed characters the seed length varied from 4.28 cm (Bennet Alphonso) to 11.22 cm (Mulgoa), the seed width ranged from 2.25 cm (Sindhu) to 8.88 cm (Banganapalli) and the seed weight ranged from 8.58 g (Vellaikoamban) to 28.98 g (Mulgoa). The results from the analysis of quality attributes of different genotypes indicated that the acidity ranged from 0.02 % (Kalepady and H 151) to 0.12 % (Himayuddin), the ascorbic acid ranged from 12.17 mg $100g^{-1}$ (Arka Aruna) to 72.49 mg $100g^{-1}$ (Muvandan), carotenoids varied from 0.16 mg $100g^{-1}$ (Neelum) to 8.47 mg $100g^{-1}$ (Alphonso), ß carotene ranged from 9.75 mg $100g^{-1}$ (Mulgoa) to 45.06 mg $100g^{-1}$ (Dashehari), the total sugar varied from 12.55 % (Tholikkaipan) to 27.81 % (Swarnarekha), the reducing sugar ranged from 5.37 % (Swarnarekha) to 10.38 % (Tholikkaipan), the crude fibre varied from 2.67 % (Alphonso) to 16.50 % (Arka Aruna) and the TSS ranged from 16.16 ^{o}Brix (Kalepady) to 27.68 ^{o}Brix (Himayyudin). The results from sensory evaluation indicated that Mallika secured the highest rank for appearance, flavour, sweetness and texture, whereas Ratna secured the highest rank for clour and taste. The studies on pollen characters showed that the pollen length varied from 26.40 µm (Neelgoa) to 45.72 µm (Himayuddin), the pollen breadth ranged from 22.92 µm (Muvandan) to 38.34 µm (Arka Aruna), the pollen fertility ranged from 82.70 µm (Mulgoa) to 93.60 µm (Tholikkaipan) and the pollen production varied from 299.00 (H 151) to 541.83 (Prior). The pollen shapes of different mango genotypes observared were oblong, oval and round. The pollen storage was standardized using the pollen grains of Mallika and it was found that keeping under refrigerated conditions at 4^{o}C was ambient. *In vitro* pollen germination were tried by hanging drop technique in different concentrations of sucrose solution with 1% agar and 0.001% boric acid but no germination was observed. The studies on physiological characters of different mango genotypes revealed that the relative water content varied from 19.00% (Ratna) to 35.82% (Neelum), radiation interception varied from 0.68 µ mol m^{-2} s^{-2} (Tholikkaipan) to 0.92 m^{-2} s^{-2} (Mulgoa), stomatal index varied from 15.59 (Prior) to

22.44 (Mallika), the stomatal frequency ranged from 65.22 to 88.78 (Banganappalli), the variation on stomatal conductance among the mango genotypes was found to be non significant, the stomatal resistance ranged from 5.33 μ mol m-2 s-2 (Dashehari) to 37.92 μ mol m-2 s-2 (Swarnarekha), the photosynthetic rate varied from 7.57 μ mol m-2 s-2 (H 151) to 17.91 μ mol m-2 s-2 (Tholikkaipan), the transpiration rate varied from 1.41 μ mol m-2 s-2 (Vellaikolumban) to 4.15 μ mol m-2 s-2 (Dashehari), the leaf area index varied from 0.69 (Dashehari) to 2.07 (Muvandan), and atmospheric pollution tolerance index ranged from 42.07 (Muvandan) to 68.53 (Mallika). The biochemical studies revealed that total phenol content varied from 4.54 mg g-1 to 19.07 mg g-1 (Ratna), soluble protein varied from 8.60 mg g-1 (Prior) to 20.04 mg g-1 (Muvandan), the ascorbic acid content varied from 63.29 mg g-1 (Swarnarekha) to 97.21 mg g-1 (Ratna), the leaf pH ranged from 5.14 (Muvandan) to 6.45 (PKM 2), the chlorophyll a content varied from 0.82 mg g-1 (Chandrakaran) to 1.31 mg g-1 (Sindhu), the chlrophyll b content ranged from 0.13 mg g-1 (Banganappalli) to 0.26 mg g-1 (Tholikaippan), and the total chlorophyll ranged from 0.99 mg g-1 (Chandrakaran) to 1.48 mg g-1 (H 45).

For the study on evaluation of mango genotypes under high density planting the trees of same age group (5 years) were selected. The observation on tree characters indicated that the trunk circumference ranged from 20.51 cm (Prior) to 31.29 cm (Chandrakaran), crown diameter ranged from 2.39 m (Ratna) to 3.09 m (Vellaikolumban). The qualitative data on morphological characters *viz.*, tree, leaf, inflorescence, fruit, stone and seed characters were grouped into clusters based on the IBPGRI descriptor. The observation on leaf characters revealed that the leaf blade length varied from 19.17 cm (Muvandan) to 25.40 cm (Ratna), leaf blade width ranged from 4.84 cm (Muvandan) to 7.68 cm (Vellaikolumban) and leaf petiole length varied from 2.29 cm (Chandrakaran) to 4.18 cm (Vellaikolumban). Based on the inflorescence characters, the inflorescence length varied from 22.14 cm (Prior) to 36.47 cm (Vellaikolumban), the hermaphrodite flowers ranged from 33.40% (Muvandan) to 85.80% (Chandrakaran) and the number of stamens varied from 3 to 4. The observation on fruit characters revealed that the fruit length varied from 7.49 cm (Chandrakaran) to 18.71 cm (Mallika), the fruit diameter ranged from 13.18 cm (Chandrakaran) to 25.25 cm (Mallika), the fruit weight ranged from 8.93 g (Muvandan) to 24.69 g (Mallika), the yield per tree ranged from 8.93 kg/tree (Muvandan) to 24.69 kg/tree (Mallika), and the shelf life of fruits varied from 4 to 6 days. The observations on stone and seed characters revealed that chandrakaran recorded the lowest stone length (5.58 cm), stone width (3.36 cm), stone thickness (1.23 cm), stone weight (17.79 g) and seed length (4.05 cm). The lowest seed width and seed weight was recorded by Prior (3.07cm) and Vellaikolumban (9.44 cm). The highest stone length was recorded by Mallika (11.67 cm), stone width by Ratna (8.67 cm), stone thickness by Vellaikolumban (2.19 cm), stone weight by Mallika (44.33 g) , seed weight by Prior (22.22 g) and seed length and width by Ratna (7.91 cm and 8.47 cm respectively). Based on the analysis on quality attributes on different mango genotyped under high density planting the TSS ranged from 14.78 $_{o}$Brix (Muvandan), acidity varied from 0.02 % (Mallika) to 0.07 % (Muvandan), ascorbic acid varied from 28.26 mg 100g$_{-1}$(Vellaikolumban) to 79.68 mg 100g$_{-1}$ (Chandrakaran), carotenoids ranged from 1.40 mg 100g$_{-1}$(Vellaikolumban) to 4.80 mg 100g$_{-1}$(Ratna), and ß carotene ranged from 13.54 mg 100g$_{-1}$(Vellaikolumban) to 39.93 mg 100g$_{-1}$(Ratna). The results on sensory evaluation revealed that Ratna recorded the highest rank for colour, flavour, sweetness, texture and taste, whereas Mallika recorded the highest rank for appearance. The pollen studies indicated that the pollen length varied from 24.80 μm (Muvandan) to 44.00 μm (Prior), pollen breadth ranged from 22.62 μm (Muvandan) to 33.35 μm (Chandrakaran), pollen fertility ranged from 59.47% (Prior) to 79.29% (Mallika) and the pollen production ranged from 194.50 (Muvandan) to 306.10 (Vellaikolumban). The studies on physiolological characters showed that the radiation interception ranged from 0.77 μ mol m$_{-2}$ s$_{-2}$ (Ratna and Chandrakaran) to 0.61 μ mol m$_{-2}$ s$_{-2}$ (Prior), the stomatal index ranged from 17.87 (Mallika) to 21.37 (Ratna), the stomatal frequency varied from 63.73 (Mallika) to 81.40 (Ratna), stomatal conductance ranged from 0.09 μ mol m$_{-2}$ s$_{-2}$ (Prior) to 0.19 μ mol m$_{-2}$ s$_{-2}$ (Muvandan), stomatal resistance ranged from 7.31 μ mol m$_{-2}$ s$_{-2}$ ((Muvandan) to 19.79 μ mol m$_{-2}$ s$_{-2}$ (Prior), the photosynthetic rate varied from 3.17 μ mol m$_{-2}$ s$_{-2}$ (Chandrakaran) to 11.68 μ mol m$_{-2}$ s$_{-2}$ (Vellaikolumban), transpiration ranged from 2.44 μ mol m$_{-2}$ s$_{-2}$ (Chandrakaran) to 4.19 μ mol m$_{-2}$ s$_{-2}$ (Muvandan) and atmospheric pollution tolerance index ranged from 54.42 (Vellaikolumban) to 68.34 (Ratna). The studies on biochemical character revealed that total phenol content varied from 4.81 mg g$_{-1}$ (Vellaikolumban) to 10.66 mg g$_{-1}$ (Prior), soluble protein varied from 12.72 mg g$_{-1}$ (Ratna) to 20.75 mg g$_{-1}$ (Chandrakaran), ascorbic acid content ranged from 67.74 mg g$_{-1}$ (Vellaikolumban) to 92.34 mg g$_{-1}$ (Ratna), leaf pH varied from 5.57 (Ratna) to 6.15 (Muvandan), chlorophyll a content ranged from 1.09 mg g$_{-1}$ (Muvandan) to 1.29 (Prior), chlorophyll b varied from 0.22 mg g$_{-1}$ (Muvandan) to 0.29 mg g$_{-1}$ (Chandrakaran) and total chlorophyll varied from 1.30 mg g$_{-1}$ (Muvandan) to 1.55 mg g$_{-1}$ (Prior).

Future climate change projection for 2030, 2040 and 2050 based on RCP 4.5 was generated using ECHAM model and the performance of the various genotypes under projected climatic conditions was evaluated using the developed model. Correlation among different meteorological and phenological characters of mango genotypes were done for yield, regression equations were derived and the yield was predicted from the scenario. Three phenophases *viz.,* flower initiation, fruit initiation and fruit maturation were taken for the study. In each phenophase, weather parameter for seven, fifteen and thirty days prior to date of expression were averaged individually for correlation.

Sindhu, Vellaikolumban, Prior, Alphonso, Kalepady and Tholikaippan showed an increase in the predicted yield in spite of an increase in temperature in flowering phenophase under normal planting system. The predicted yield increased in spite of a decrease in solar radiation in H 45, Mulgoa and Tholikaippan,. The predicted yield increased in spite of a decrease in rainfall in Dashehari, Neelum and Muvandan. Amrapali, PKM 1, Alphonso, Himayuddin, Swarnarekha and Mulgoa showed an increase in predicted yield in spite of an increase in rainfall.

Amrapali, PKM 1, Sindhu, Neelum, Himayyudin, Bennet Alphonso, Kalepady, Muvandan, Tholikaippan, Vellaikolumaban, Banganapalli and Prior, recorded an increase in predicted yield in spite of an increase in temperature in fruit initiation phenophase under normal planting system. The predicted yield increased in spite of a decrease in rainfall in PKM 1, Amrapali, H 151, H 45, Bennet Alphonso, Mulgoa, Tholikkaipan, Chandrakaran and Muvandan. Dashehari showed an increase in predicted yield in spite of an increase in rainfall.

H 151, Kalepady and Swarnarekha showed an increase in the predicted yield in spite of an increase in rainfall in fruit maturation phenophase under normal planting system.

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Based on the performance of genotypes in all three phenophases, H 45 can be recommended for regions with lower rainfall and lower solar radiation among the hybrids under normal planting system, whereas, Amrapali and PKM 1 can be recommended for areas with higher temperature and for both higher and lower rainfall regions. Among the parents of the hybrids, Mulgoa can be recommended for regions with lower solar radiation and for both lower and higher rainfall regions. Among the local types, Tholikaippan can be recommended for the regions with higher temperature, lower rainfall and lower solar radiation.

Vellaikolumban, Ratna and Muvandan showed an increase in the predicted yield in spite of an increase in temperature in flowering phenophase under high density planting system. Prior, Chandrakaran, Muvandan, Vellaikolumban, Ratna and Mallika recorded an increase in the predicted yield in spite of an increase in temperature in fruit initiation phenophase under high density planting system. Prior, Chandrakaran, Mallika, Ratna and Muvandan, showed an increase in the yield in spite of an increase in temperature in fruit maturation phenophase under high density planting system, whereas the predicted yield increased in spite of a decrease in rainfall in Mallika, Vellaikolumban and Ratna.

Based on the performance of genotypes in all the three phenophases, all studied genotypes can be recommended for higher temperature regions under high density planting system.

In conclusion, climate change may have a profound impact on mango genotypes since the flower initiation, fruit initiation and fruit maturation phenophases are strongly influenced by the environment. The projected scenario for 2030, 2040 and 2050 indicate that the temperature will tend to increase and the rainfall will decrease from the present condition leading to altered phenophases which necessitate changes in spectrum and distribution of varieties currently being grown. H 45, PKM 1, Amrapali, Mulgoa and Tholikaippan are the climate resilient genotypes for the normal planting systems and Mallika, Ratna, Muvandan, Vellaikolumban and Prior are the climate resilient genotypes for high density planting systems.