PERFORMANCE STUDIES IN SELECTED VARIETIES AND HYBRIDS OF MANGO *(Mangifera indica* L.*)*

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Performance studies in selected varieties and hybrids of mango (*Mangifera indica* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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LIST OF ABBREVIATIONS

DAFS	-	Days after fruit set
E-W	-	East – West
IBPGR	-	International Bureau of Plant Genetic Resources
NS	-	Non significant
N-S	-	North – South
TSS	-	Total Soluble Solids
cm	-	centimetres
Fig	-	Figure
g	-	grams
kg	-	kilograms
mg	-	milligrams
ml	-	millilitres
mm	-	millimetres
no	-	number

Introduction

1. INTRODUCTION

Mango, the choicest fruit of India, is rightly titled as the "King of Fruits" because of its wide adaptability, high nutritive value, richness in variety, delicious taste, excellent flavour, attractive appearance and popularity among the masses.

India ranks first among the mango producing countries accounting for more than half of the world's mango production. It is grown in an area of 1.23 million hectares with an annual production of 10.99 million tonnes. The average productivity is 8.95 t ha^{-1}. Mango accounts for 22.1 per cent of the total area and 22.9 per cent of the total production of fruits in our country (Negi, 1999).

About 1000 varieties are said to be under cultivation in India and there is a wide variation among them. For selection of superior varieties and for use as parents for hybrids it is necessary to know the varieties in the existing germplasm and to have a collection of desirable clones. India, which enjoys a unique and varied climate, enables to grow successfully all the varieties of mango. But in a commercial orchard, selection of varieties has to be restricted to only a few, which are of superior quality and are well adapted to the agroclimatic conditions of the tract. Experiences have shown that different varieties are suited for cultivation in different climatic tracts. The variety Alphonso, which is a great success in Maharashtra, has failed to do well in northern India. Similar is the fate of northern and central Indian varieties when planted in south India. But this rule does not apply with equal force to all the varieties. Langra became the sweetest variety in Banglore and Neelum, a south Indian variety, excelled in yield per unit area in the Gangetic Plains of north India (Singh and Maurya, 1986).

Significance of Kerala mangoes lies in their earliness. In Indian market, mangoes from Kerala appear first. This helps the growers to get a premium price for their produce, capturing the distant markets even during the months of February-March. Detailed and definite information on the varieties and hybrids grown here which have been released from elsewhere is lacking at present.

The area under mangoes in Kerala is estimated to be 85.54 thousand hectares with a production of 247 thousand tonnes with productivity of only 2.89 t ha^{-1} (FIB, 2000).

Main reasons for low productivity of Mango in the state can be attributed to its position as a backyard crop, lack of scientific cultural management, inadequate stress in the form of cold or water stress prior to flowering and lack of information on the performance of commercial varieties introduced from other mango growing regions.

Information on the various aspects such as flushing, flowering and fruiting of mangoes grown under the humid tropical climatic conditions of Kerala is very little. Improved varieties and hybrids released from elsewhere are grown here, but their growth habit and performance under the specific conditions have not been evaluated so far.

Moreover, the overwhelming impact of physico-chemical changes during growth, maturity and ripening on taste, flavour, texture, sweetness, palatability and storage life of the fruit has been emphasised by many eminent scientists.

Keeping in view of the above factors, the present study was undertaken with the following objectives:

1. Gather basic information on the morphological and biochemical aspects of vegetative growth, flowering and fruit development of the varieties Alphonso, Neelum, Prior, Muvandan, Kalapady and hybrids Ratna and H-151.

2. Evaluate their performance when grown under the humid tropical conditions of Kerala.

Review of Literature

2. REVIEW OF LITERATURE

Mango is the most popular fruit among millions of people in Orient, particularly in India, where it is considered to be the choicest of all indigenous fruits. In fact, it will be no exaggeration to say that because of its excellent flavour, attractive fragrance, beautiful shades of colour, delicious taste and healthful value, mango is now recognised as one of the best fruits in the world market. In India no other cultivated tropical fruit possesses such an extensive range of varieties as mango.

The vegetative and reproductive growth patterns of mango trees vary greatly depending on the variety and environmental conditions. Yadav and Rajan (1993) opined that the commercial varieties of a region behave in a different manner when grown in another agro climatic zone of the country. Scientists all over the world had tried to study the growth pattern in response to the environmental conditions, which helped them to develop more effective cultural management.

Review of research work on the variability of mango in the physicochemical characteristics in varying growing conditions has been presented in this chapter.

2.1 Vegetative characters

Form or outline of the general appearance of tree is popularly considered to provide a valuable basis for the classification of mango varieties (Naik and Gangolly, 1950).

According to Singh (1977) shoot growth in mango occurs in periodic flushes and frequency of flushing is mainly regulated by climatic factors. He also stated that shoot growth is more or less continuous under south Indian conditions where as it is in distinct flushes under north Indian conditions. The early initiation and development of each new flush followed by a dormant period helps the shoots to

attain the proper physiology for flower initiation (Singh, 1978). Chacko (1984) also reported that the growth of mango tree is not continuous but tends to be periodic.

The pattern of vegetative and reproductive growth of mango trees in the warm temperate region of western Australia was studied by Kraisila *et al.* (1991). About 70 per cent of shoots produced one or more flushes of vegetative growth while 30 per cent remained dormant and an average of 72 per cent of all shoots, both flushing and dormant, produced inflorescence.

Colour of the new flushes was observed by Davenport and Nunez-Elizea (1997) and the report say that elongating vegetative structures are usually green but may be sometimes bronze red or shades of red, which depend on cultivars. They are considered mature when they turn dark green, which occurs after about two to three months.

2.2 Internodal length

It was generally accepted till recently that shortening of internodes in fruit trees invariably will lead to reduction in vigour.

In mango, internodal length varied from 0.99 centimetres in case of Bennet Alphonso and Mulgoa cultivars to 1.53 centimetres in the case of Raspuri. Though Langra produced two flushes a year and Mulgoa three, the latter remained distinctly dwarfer than the former, probably because of the shorter internodal length of the flushes. (Subbaiah, 1985).

Kurian and Iyer (1992) opined that the number of vegetative flushes produced per year or number of nodes and internodal length of shoots were not the correct indicators of tree size or vigour.

2.3 Leaf characters

Classification and nomenclature of south Indian mangoes were attempted by Naik and Gangolly (1950). In their classification, pose of leaf, shape of leaf, leaf tip, margin, thickness, smell of crushed leaves, colour of mature and emerging leaves have been described.

Earlier studies on leaf area estimation in mango indicated preference of the product of leaf length and breadth for calculation. However, no factor or constant was worked out which could be used for easier leaf area measurement (Rao *et al.*, 1978).

Suggestion for the use of leaf characters in estimating the leaf area of mango was given by Kohli *et al.* (1983). The leaf area was determined with a portable unit (LI – COR model LI-3000). Formulae involving different leaf characters are needed for each cultivar for leaf area estimation, namely fresh weight in Alphonso, length x mean breadth in Dashehari and length x middle breadth in Kalapady.

A rapid method for leaf area measurement was reported by Saidha and Rao (1985). A common factor or constant (K) was worked out for Mulgoa, Neelum and Bangalora varieties. The K values obtained for each cultivar was averaged and the common factor was worked out as 0.737. Varietal variations in leaf area were observed by Agarwal (1986).

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

2.3.1 Chlorophyll

Calculations of rate of photosynthesis were made on the basis of chlorophyll content per unit weight of fresh and dry leaf weight. Chlorophyll content was similar in all cultivars but photosynthesis was highest in Malaviya Bhog. The high rate of photosynthesis indicated higher chlorophyll efficiency in this cultivar (Tyagi and Devi, 1988).

Leaf chlorophyll and nitrogen contents were determined for leaves that developed in full sun and in 25, 50 and 75 per cent shade. Leaf chlorophyll and nitrogen content increased as percentage shading increased (Schaffer and Gaye, 1989).

Chlorophyll content in the fruit peel decreased as ripening advanced and initially for the first two days there was a slow decline followed by a rapid decline. Amrapali reported a considerable loss in chlorophyll content and became yellow much faster than Rataul and Dashehari (Yanru *et al.*, 1995).

Chlorophyll content in terms of total chlorophyll was reported to be 1.44 mg per gram fruit weight in fruit skin of cultivar Dashehari (Singh and Yadav, 1997).

Total chlorophyll content was studied in four cultivars of mango from September to May. Maximum values were found in September and December, the period considered to be crucial for flowering in mango (Pandey and Tyagi, 1999).

2.3.2 Stomatal density

A good correlation between the frequency of stomatal distribution and vigour of mango plants was reported by Chakladar (1967). Based on the frequency of stomatal distribution, Majumdar *et al.* (1972) classified mango rootstocks in nursery stage. Depending on the environmental conditions in which the leaves develop, the

size and distribution of stomata per unit area may show marked variation as per the reports by Rajeevan and Rao (1975).

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

Majumdar *et al.* (1981) reported that lower stomatal density is an indication of dwarfness. However, later results of some long range field rootstock trials indicated that stomatal density cannot be considered as a criteria for dwarfness. Vellaikolumban and Olour produced least vigorous trees when Alphonso and Dashehari scions were grafted on to them (Reddy, 1986). But these have been classified as vigorous and very vigorous respectively, by Srivastava *et al.* (1980) based on stomatal density.

Agarwal (1986) reported that increase in stomata may result in increase in photosynthate formation which eventually may lead to enhanced vigour of plant. However, Kurian (1989) did not find any relation between the vigour and stomatal count in mango.

2.3.3 Leaf nutrients

Nutrient contents of mango leaves were estimated and reported by Koo and Young (1972). They noted that leaf phosphorus and potassium contents declined with age. Basal leaves contained more phosphorus and potassium than terminal leaves on the same shoot but the difference between fruiting and non-fruiting shoots were slight.

Pathak and Pandey (1978) found that the level of all the nutrients were higher before flowering and lower during flowering and growth except calcium in cultivar Dashehari. Major utilisation of nitrogen took place during the flowering and fruiting period.

Chadha *et al.* (1984) reported the leaf nutrient status of three mango cultivars, Dashehari, Chausa and Lucknow Safeda at flowering and post harvest stages. The contents of all nutrients declined at post harvest stage in these cultivars which was attributed to earlier translocation into the developing fruits.

Fruit yield was directly related to leaf nutrient status. A beneficial association between soil nitrogen and phosphorus before flowering and yield was noted in cultivars, Fazli, Himsagar, Langra, Gopalbhog and Aswina (Ray and Mukherjee, 1987). However, as per Dhillon and Malhi (1993) fruit yield and quality of mangoes (cultivar Langra) were not significantly correlated with leaf nitrogen, phosphorus and potassium contents, even though the mineral content of fruiting shoots was lower than that of vegetative shoots.

2.4 Inflorescence characters

Floral characters included in the description of south Indian mangoes by Naik and Gangolly (1950) were shape, hairiness and sex ratio. Kalyanasundaram (1976) reported that Neelum had the highest percentage of perfect flowers (62%)and Mulgoa the least (5%). Gunjate *et al.* (1977) noted that fruit bud differentiation started on August 20th and continued till the end of October. Flowering started on December 1st under Konkan conditions.

The length and breadth of inflorescence in five varieties of mango ranged from 21.33 to 34.36 cm and 18.11 to 32.83 cm respectively (Narayanaswamy, 1982).

Reddy (1983) reported that shoots produced bloom irrespective of time of their emergence and single and double flush shoots were more fruitful than triple flush shoots. According to the reports by Chacko (1984), flower buds were borne generally in terminal buds of shoots produced during the previous season.

According to Yadav and Singh (1985) though the south Indian mango varieties attain a physiological status for flowering earlier than the north Indian cultivars, in the latter such manifestation is suppressed by the prevailing low temperatures resulting in late flowering.

Desai *et al.* (1985 a) noted that percentage of bisexual flowers in Alphonso, Goamankur and Kesar varieties was greatest on the northern side and least on the eastern side of the tree and increased from the early flush to mid flush to the late flush. The average value was highest in Kesar (29.39%) and lowest in Alphonso (11.22%).

Schohefield and Oag (1986) studied the inflorescence size, flower number, flower sex and fruit set in Bangalora, Batavi, Common, Glenn, Irwin and Kensington. Wide variations were noticed between cultivars in the number of flowers per inflorescence (1431 - 3962) and fruit set per inflorescence (0.33 – 1.39%). The flowering, maturity time and fruit characteristics of Harumanin, Common, Sabre, Kensington, Mulgoa and Neelum have also been described by Schohefield (1986).

Even though mango inflorescence is primarily terminal, axillary and multiple panicles may also arise from axillary buds according to Chadha and Pal (1986). They also reported that wide variation occurs in inflorescence length, the range being from a few centimetres to 60 centimetres. Panicle size in mango varied from 11.25 to 42.20 cm according to Thimmappaiah and Suman (1987). Varieties having longer panicles produced largest number of flowers consisting of mostly male flowers. They also opined that the role of perfect flowers was only secondary and indirect on yield.

Under coastal Karnataka conditions, Uthaiah *et al.* (1988) noted that the length of flower panicle ranged from 12.4 to 38.6 cm. The number of male flowers per panicle (428) in Alphonso was the maximum. The variety Mallika recorded the highest percentage of hermaphrodite flowers per panicle with low sex ratio of 1.03.

Inflorescence characters are used in describing mango varieties. These include shape, colour, hairiness, flowering intensity etc. (IBPGR, 1989).

Majumdar and Sharma (1990) reported that sex ratio varied from 0.74 per cent in Rumani to 69.8 per cent in Langra. The sex ratio is also reported to be influenced by environmental conditions.

Flowering time in mango is closely linked with the time of flower bud initiation, which varies with cultivars and area where it is grown. Flowering period usually extends for a shorter duration of two to three weeks. Low temperature may extend it and high temperature may shorten it. (Majumdar and Sharma, 1990).

Flowering and fruiting behaviour studied in ten cultivars revealed that Kesar exhibited earliest panicle emergence followed by Dashehari under Akola conditions. The highest number of panicles per square metre was observed in Dashehari. The lowest ratio of hermaphrodite to male flowers was observed in Kesar (Dod *et al.*, 1998).

Dhaliwal and Dhaliwal (1998) reported higher percentage of hermaphrodite flowers on the northern side and least on the eastern side of the tree. The percentage of hermaphrodite flowers increased with the advancement of season irrespective of the cultivars and direction of panicles on the tree.

The variability in fruit set in twenty six important mango cultivars was studied by Kumar *et al.* (1998) under Lucknow conditions. The results indicated that overall barren panicles were more in Fernandin (42.75%), Beneshan (42.7%) and Alphonso (40.34%). The percentage of fruit bearing panicles was maximum in Chausa (97%) and minimum in Fernandin. Fruits per panicle (after forty days of fruit set) were maximum in Kishanbhog (2.47%) followed by Amrapali. It was lowest in Vanraj (0.26%), Nisar Pasand and Alphonso.

2.5 Fruit set

A high positive relationship is observed between the percentage of perfect flowers and number of fruits carried to maturity per panicle. The first two weeks have been shown to be the most important, from the point of view of fruit shedding in mango. (Naik and Rao, 1943).

Desai *et al.* (1985 b) studied the fruit set and fruit drop in Alphonso, Goa mankur and Kesar. It was found that the mean final number of fruits retained per panicle in the three cultivars were 0.40, 0.13 and 0.59 and the maximum drop of fruits were 75.77, 90.51 and 93.06 per cent during the first five, six and seven weeks from anthesis.

Thimmappaiah and Suman (1987) reported highest initial set and yield for Bangalora and best fruit retention in Prabhasanker in a study conducted at Punjab. Varieties with a moderate number of perfect flowers and good retention of fruits gave the best results. Fruit set at 15^{th} day ultimately determined yield and was significantly correlated with retention and yield.

An initial fruit set of 51.80 fruits per panicle in Himsagar to 101.79 fruits per panicle in Langra was observed by Sanyal and Maity (1989) under west Bengal conditions. Fruit drop was high in all cultivars with no significant difference between them. Fruit drop was found to be positively correlated with fruit growth. Fruit drop was generally the maximum during April.

2.6 Fruit growth

Mango fruit, a drupe, typically follows a single sigmoid growth pattern (Singh *et al.*, 1937, Mukherjee, 1959 and Wang and Shiesh, 1990).

Lakshminarayana *et al.* (1970) noted a slow increase in length and breadth upto five weeks following fruit set and a rapid increase thereafter. Weight of fruits

slowed down between nine and fourteen weeks after fruit set indicating the development of stone.

Sigmoid growth curves were the characteristics of development of both fruits and seeds of mango cultivars, Chausa and Dashehari. The slowing down of fruit growth after 64 days in Dashehari and 79 days in Chausa was associated with the hardening of endocarp and slowing down of seed growth. (Saini *et al.*, 1971). In the same varieties the length and breadth of fruits increased upto fourteen days after fruit set and thereafter the length increased more than the breadth. A negligible change in weight and volume upto twenty eight days took place and thereafter a rapid increase was noted upto forty two days followed by a steep rise till seventy days. (Saini *et al.*, 1972).

Pandey *et al.* (1974) reported a slow increase during early stages and a steady increase thereafter in the physical parameters upto maturity. A continuous increase in length, breadth, weight and volume of fruits was noticed by Shukla and Bajpai (1978). Wang and Fu (1991) noted that fruit weight increased rapidly between 70 and 90 days. Fruit size reached its maximum around 90 days. The seeds were mature at 110 days.

2.7 Specific gravity

The weight to volume relationship which is specific gravity has been suggested as a dependable index of maturity in many mango cultivars like Haden (Harkin and Cobin, 1950), Dashehari (Gangwar and Tripathi, 1973) and Alphonso (Thangaraj and Irulappan, 1991). However, variations in specific gravity between varieties and between fruits of the same tree are known to exist.

Harkness (1951) reported that Haden mango fruits were immature at a specific gravity of less than 1 and ready for picking if the value was 1.02 or more. He further reported that in other varieties studied, the relationship between maturity and specific gravity was somewhat erratic. Harding *et al.* (1954) who worked on the

maturity of many mango varieties have remarked that the specific gravity may not be a reliable index to predict the right stage of maturity.

Krishnamurthy and Subramanyam (1970) who studied the ripening behaviour of Alphonso fruits graded based on specific gravity, reported that fruits with a specific gravity of 1.02 and above at harvest were at the optimum stage of maturity.

Shukla and Bajpai (1978) observed that specific gravity could serve as a reliable index for maturity determination in cultivar Dashehari. Fruits with a specific gravity of 1.02 or more ripened to an excellent rating. Higher specific gravity indicated greater accumulation of food material in the fruit. Pal *et al.* (1987) have suggested specific gravity as a standard for harvesting fruits of the cultivar Fazli. Fruits at maturity should have attained a specific gravity between 1.01 and 1.02 to get good quality ripened fruits in terms of taste and flavour.

Roy and Joshi (1989) also suggested a specific gravity between 1.02 and 1.04 for harvesting Alphonso fruits.

Lee *et al.* (1998) suggested that Chin Hwang mango fruits should be harvested 120 days after anthesis at a specific gravity index of 1.01 in order to maintain fruit quality, yield and to solve the problem of uneven ripening. He also found a close relation between maturity and specific gravity.

Narayana *et al.* (1999) harvested mango fruits at the Tapka stage (when mature fruits start dropping) having a specific gravity of more than 1.00 and found them to have attained optimum maturity. However, majority of mature fruits of Baneshan mango (89.4%) harvested at this stage had a specific gravity of less than 1.00. No clear relationship was observed between the fruit size or fruit weight and specific gravity of this cultivar. Light stone, low stone to pulp ratio (1: 6.04) and a void space between the kernel and internal stone wall in Baneshan mango seemed to be contributory factors for this variability in specific gravity. There were more

vascular vessels in the peel of Baneshan fruits than in Bombay Green and Surkha fruits.

2.8 Fruit yield

Correlation studies of 15 different characters in cultivar Langra indicated that the number of fruits per square metre could be considered as the most effective parameter for predicting the yield, followed by the yield of secondary branches, number of fruits per panicle and number of panicles per square metre. (Baghel *et al.*, 1988).

Whiley (1993) suggested that low mango yields in tropics are often due to the failure of flower induction. In subtropics, plants flower well but fruit set is poor. In subtropical areas cold night temperatures less than 10°C during anthesis was found to be the primary cause of poor fruit set.

Ram and Rajput (1999) reported that under the same conditions, Dashehari fruits could be harvested from the first week of June whereas Langra fruits were ready for harvest only by the second week of June, indicating varietal variation.

2.9 Biochemical aspects

Soule and Harding (1958) reported that the total and non-reducing sugars increased at mature stages while reducing sugars remained constant throughout the period of development in American mango varieties.

The sugar content increased throughout the period of growth and the reducing sugars were present in higher concentration than non-reducing sugars during development. Ascorbic acid reached peak in fifth week, then declined upto eighth week and later remained more or less steady upto harvest (Lakshminarayana *et al.*, 1970).

Three growth stages were demonstrated in the cultivars Pairy, Zibda and Baladi. Starch, alcohol insoluble solids (AIS) and acidity rose in the first stage and Vitamin C, TSS and sugars fell. In second stage, sugars and TSS increased slightly and gradually there was a sharp rise in starch and AIS contents and decrease in acidity and Vitamin C contents. The third stage ripening was characterised by a sharp drop in starch and AIS accompanied by a sharp rise in sugars and TSS. The acidity and Vitamin C contents continued to fall gradually (Askar *et al.*, 1972).

According to Rao *et al.* (1972) total and reducing sugars varied irregularly within narrow limits whereas non-reducing sugars rose consistently with the progressive maturity of fruit. He also observed that there was a twenty eight per cent decline in ascorbic acid in the first six weeks, which was not steady.

The physico-chemical nature of Neelum, Bride of Russia, Anupam, Langra, Kesar and Nisar Pasand has been studied by Teotia *et al.* (1972). Neelum had the highest Vitamin C content, whereas Nisar Pasand had the highest TSS and sugar content. The earliest ripening variety Bride of Russia having an attractive reddish blush on its shoulder exhibited minimum acidity (0.243%).

Gangwar and Tripathi (1973) reported that TSS and sugar contents were found to increase gradually with the date of picking and ripening, but a loss was depicted in the acid content. The organoleptic tests indicated a highly significant positive correlation with TSS. A similar report was given by Pandey *et al.* (1974) who reported an increase in acidity during maturation. Kapur (1974) reported low levels of sugars and high ascorbic acids in young fruit. Palaniswamy *et al.* (1974) found that in general, smaller sized fruits recorded high ascorbic acid than larger fruits.

According to Kapur (1974) the level of reducing sugars was higher than the non-reducing sugars at earlier stages of growth and thereafter it decreased and remained at a lower level than non-reducing sugars in Dashehari, Safed and Sanur-

Bahisut. The increase in TSS was slow during the early period of development and increased suddenly about the eleventh week.

In a study conducted at Bangladesh in mango cultivars it was seen that the vitamin C content ranged from 12.91 mg per 100 g in Dashehari to 28.08 mg per 100 g in Koa Pahari. (Samad *et al.*, 1975). Joshi and Shiralkar (1977) noticed a decrease in ascorbic acid and phenolic contents with the development of fruits.

Investigations carried out to know the bearing behaviour and fruit quality of south Indian varieties of mango in northern India revealed that the maximum TSS (21.59° brix), sugar (18.28%) and least acid (0.312%) was found in Alphonso. Neelum was rated as the next best variety (Prasad, 1977).

Thomas and Oke (1980) compared Vitamin C contents in the peel and pulp of mature unripe Alphonso, Dashehari, Langra and Pairi fruits. The values recorded in the peel of the fruits were 199 to 214, 131, 542 to 597 and 250 mg per 100 g fresh weight and corresponding levels in the pulp were much lower; 89 to 103, 30, 114 to 143 and 41 mg per 100 g respectively.

In a study conducted by Kulkarni and Rameshwar (1981) Alampur Baneshan fruit had the highest weight (400 g). Vitamin C was highest in Peddarasam (73 mg per 100 g) under Lucknow conditions.

Yadav *et al.* (1982) assessed ten cultivars for fruit contents of ascorbic acid, reducing and non-reducing sugars and TSS. Fazli had the highest Vitamin C (16.16 mg per 100 g) and Dashehari the highest TSS content (23.8° brix).

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

Hybridisation works were carried out at DAF, Thaliparamba, Kerala using different parental combinations. A number of hybrids were produced and evaluated

among which four numbers were reported to be promising. Among them H-151 (Kalapady x Neelum) had been described as a good hybrid, which has the fruit shape of Neelum and qualities of Kalapady. H-151 is a profuse bearing, mid-season variety, having small sized fruits. (Kannan, 1982).

Physico-chemical characteristics of mango varieties in Uttar Pradesh were studied by Yadav *et al.* (1984). Out of ten cultivars Dashehari had the highest ascorbic acid content (16.15 mg per 100 mg of flesh) and highest content of total sugars (15.46%).

Prasad (1984) analysed the quality traits in mature fruits of ten varieties. Alampur Baneshan had the highest ascorbic acid content (greater then 29%) and Alphonso had the highest sugar content (9.97-10.1%).

Verma *et al.* (1986) noted that there is a decrease in acidity and ascorbic acid and increase in TSS and sugar with maturity in cultivar Dashehari.

Performance of some late varieties in Gangetic plains in northern India was studied by Singh and Maurya (1986). The average yield per tree was highest in cultivar Sukul (212.8 kg) and lowest in Neelum (71.4 kg).

Studies were conducted by Tandon and Kalea (1986) on developing mango fruits in which the fruits were sampled at frequent intervals until harvest maturity. Changes in fruit weight, length, diameter, TSS, acidity and Vitamin C were noted.

Prasad (1987) noted a high genotypic coefficient of variation for fruit weight, fruit volume, ascorbic acid and reducing sugars, which revealed a least influence of environment. High heritability was found for ascorbic acid, reducing sugars, TSS and number of fruits.

Physico-chemical analysis of varieties in Bihar has shown that Fazli produced the heaviest fruits followed by Langra. Langra had the highest ascorbic acid content, reducing and non-reducing sugars. (Syamal and Mishra, 1987).

Vegetative, flowering, fruiting behaviour and physico-chemical characteristics of fruits of Langra, Neelum, Dashehari etc. had been analysed. Neelum, Langra and Bangalora were the highest yielders. The varieties with best quality were Langra, Mallika, Dashehari and Alphonso (Srivastava *et al.*, 1987).

Salvi and Gunjate (1988) reported a new hybrid Ratna, (Neelum x Alphonso), from Konkan Krishi Vidyapeed, Dapoli. This early maturing cultivar bears large fruits, which are greenish orange with prominent oil glands on the skin. The pulp is firm, orange in colour, fibreless and has good flavour.

In Pico mangoes titrable acidity increased only upto forty four days from fruit set (4.4%) and declined at harvest (2.7%). TSS was found to increase progressively from fruit set to maturity (Alcantara and Mendoza, 1988).

The performance of mango cultivars in the central Gangetic plains was studied by Singh and Singh (1988). Varieties from south like Ambalavi, Neelum and Vellaikolumban excelled the local cultivars in yield and equalled in quality. The yield and quality performance of mango under south Gujarat conditions had shown that the highest TSS and high yield was in Bangalora (Katrodia *et al.*, 1988).

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

Ramakrishna (1988) opined that in developing fruits of mango in Banglore conditions, acidity reduced from 2.26 to 0.28 per cent, TSS increased from 4.1 to 20.0°brix, ascorbic acid reduced from 201.5 to 26.8 mg per 100 g.

Badyal and Bhutani (1989) studied the physico chemical characteristics of mango under sub mountainous region of Himachal Pradesh. Mallika produced the highest fruit weight and volume. TSS was highest in Alphonso.

The cultivar Kalia produced in Chittagong had the largest fruits (214.8 g) with high sugar content (20.3%) as per the reports of Ahmed *et al.* (1989).

The physico-chemical composition of fruits of six cultivars in Ludhiana was studied. Langra fruits had the highest stone, peel, pulp and fruit weight (203.6 g) and Dashehari fruits had the greatest length, breadth, highest TSS and total sugar content. (Minhas *et al.*, 1991).

In an evaluation of nineteen cultivars of mango in red and laterite soil of West Bengal, Fazli was found to be superior to all other varieties. Langra contained highest ascorbic acid (Kundu and Ghosh, 1992).

Mango hybrids were compared with commercial cultivars Alphonso and Totapuri. Arka Puneet and Arka Anmol were comparable with Alphonso for fruit weight, volume, fruit breadth, TSS, ascorbic acid, reducing and total sugars. (Gowda *et al.*, 1994).

Variability in early and mid season mango varieties grown in Bangladesh was reported by Saha *et al.* (1995).

Physico-chemical characteristics of Mango cultivars Alphonso and Bangalora from Palakkad (Kerala) were compared with those from Maharashtra and Andhra Pradesh. Fruits from Palakkad were comparable in weight and showed reduced stone and peel contents (hence higher pulp contents). However, fruits from Palakkad generally had lower total soluble solids content and higher acidity than fruits from other regions of India. Bangalora showed relatively low sugar contents. (Radha *et al.*, 1996).

Langra, Dashehari, Salem and Safed Malihabad proved suitable for commercial plantation in semi-arid region of Maharashtra. Langra and Dashehari gave the highest yield and best physico-chemical composition (Chaudhari *et al.*, 1997).

Fruits of twenty mango varieties from West Bengal were analysed for juice composition, total soluble solids and acids. (Jana *et al.*, 1998). Variety Bimli contained the highest amount of total soluble solids (23.2° brix) and total sugars (21.6%). Daudia, Gulabkhas and Chandan Kosa had the highest contents of titrable acids (0.58%), ascorbic acid and beta-carotene respectively.

An investigation carried out to study the physico-chemical characteristics of mango varieties grown under Bhagalpur conditions showed that Fazli had the maximum size and weight. Kalapady had shown higher value of TSS (26° brix). High acidity to the tune of 0.72 per cent was recorded in cultivar Cluster (Kumar, 1998). Ascorbic acid content was highest in cultivar Langra (150 mg per 100 g) followed by Maldah and lowest in Mohan Bhog.

Ripe fruits of mango hybrids Arka Aruna, Arka Puneet, Arka Anmol, Mallika and Ratna were compared with Alphonso at Banglore conditions. Fruit weight, volume, length, breadth and thickness of Arka Aruna and Mallika were better than Alphonso. Ratna had TSS better than Alphonso. (Doreyappagowda *et al.*, 1998). Performance of mango hybrids Mallika and Amrapali was evaluated by Mahajan *et al.* (1998) under north eastern Madhya Pradesh conditions.

Quality analysis of mango hybrids Amrapali, Langra, Mallika, Neeluddeen and Bombay Green reported from Madhya Pradesh conditions. (Sharma *et al.*, 1998). Langra gave the highest yield followed by hybrids Mallika and Amrapali. Amrapali, Langra, Mallika, Neeluddeen and Bombay Green had the highest TSS, total sugar and lesser acidity.

A study was conducted to know the adaptability performance and to identify promising varieties for rainfed, sub-humid climatic conditions of eastern India. Chausa had the highest TSS and total sugars (Gangopadhayay *et al.*, 1998).

In a study conducted under Akola conditions it has been noted that cultivar Pune Pairi exhibited maximum fruit weight and breadth, Mallika had the maximum length, Kesar was sweetest in taste followed by Dashehari. (Jadhao *et al.*, 1998).

Physico-chemical analysis of different varieties under Kerala conditions has been reported. Imampasand recorded the highest fruit weight and Kalapady produced the smallest fruits. Alphonso recorded the highest TSS and total sugar content indicating the superiority of this variety in terms of quality. Minimum TSS and total sugars were recorded in Prior (Radha and Nair, 1998).

Goncalves *et al.* (1998) and Attri and Singh (1999) reported the physico-chemical characteristics of mango varieties grown in Brazil and Andaman and Nicobar islands respectively. Similarly, Desai and Dhandar (1999) studied the physico-chemical and morphogenetic characters of different varieties of Goa region.

Langra was found the most vigorous followed by Mallika, Dashehari and Amrapali. TSS and reducing sugar contents were highest in Dashehari. Cultivation of Dashehari, Langra, Mallika and Amrapali cultivars were recommended for cultivation in the arid-irrigated region of Punjab. (Sharma *et al.*, 1999).

In an evaluation trial with eighteen mango cultivars, Biswanath Chatterjee was found superior to all other varieties with respect to fruit weight, size and percentage of pulp. Highest TSS was found in Safdar Pasand. (Mitra and Mitra, 1999).

An investigation was carried out to study the performance of mango varieties in marginal land Jalgaon. Varieties such as Kesar, Ratna and Baneshan recorded higher yield over other varieties (Balasubraiimanyan and Diiake, 1999).

Viswanath *et al.* (1999) reported that varieties Bangalora and Neelum exhibited regular bearing habit while Baramasi produced fruit in two seasons when grown in Oman.

In a study conducted to assess the potentiality of some less known mango varieties grown in West Bengal by studying their morphological and physico-chemical characteristics it was seen that the reducing sugar content was maximum in Alam Pasand (7.61%) followed by Biswanath Chatterjee (5.83%), titrable acidity was lowest in Bara Sindure (0.14%) and highest in Bhaduri (0.64%). The ascorbic acid content was appreciably high in fruits of Baramasia (52.5mg/100g) and Begam Pasand (53.3 mg/100g) compared with less than 10mg/100g in fruits of Amrita, Anaras, Bhadhuri and Bira (Mitra and Mitra, 2000).

An assessment of various vegetative, floral and fruit characters were made in ten hybrids and compared with two commercial cultivars of mango in Andhra Pradesh. Sex ratio was very high in Neeleshan (2.3) and Amrapali (3.22) while Swarna Jahangir recorded lowest sex ratio (68.95). Minimum fruit set per panicle was recorded in Ratna followed by Mallika and Swarna Jahangir. Maximum number of fruits and yield per tree was produced by Neeluddin (91.5). The highest TSS was observed by Amrapali (28° brix). Mahmood Bahar recorded maximum pulp recovery (Sarkar *et al.*, 2001).

Materials and Methods

3. MATERIALS AND METHODS

The present study was conducted at College of Horticulture, Vellanikkara utilising the trees in the germplasm collection attached to the Department of Pomology and Floriculture. The duration of the study was from June 2000 to June 2001.

The experiment aimed at studying the morpho-physiological and biochemical aspects of flushing and fruiting of selected mango varieties and hybrids grown under the humid tropical conditions of Kerala.

The study was carried out under three heads.

Growth characters.

Flowering characters.

Fruit set and development.

3.1 Selection of varieties

Following five varieties and two hybrids were selected for the study.

Varieties:	Alphonso, Prior, Muvandan, Neelum and Kalapady
Hybrids:	Ratna (Neelum x Alphonso)
	H-151 (Kalapady x Neelum)

The trees were nine years old and were grown under uniform conditions as per Package of Practices Recommendations (KAU, 1996).

Selection of varieties has been done in such a way as to include the parents of the hybrids selected and at least one variety each from the groups regular and monoembryonic bearer, irregular and polyembryonic type, as follows.

Alphonso – Superior variety, alternate bearer

Prior – Irregular bearer, early variety

Muvandan – Local, popular and polyembryonic variety

Neelum – Regular bearer, late variety

Kalapady – Regular bearer, mid-season variety

Ratna – Regular bearer, released from Konkan Krishi Vidyapeed, Dapoli

H-151 – Released from District Agricultural Farm, Thaliparamba, Kannur

3.2 Growth characters

3.2.1 Flush characters

3.2.1.1 Time of flushing

A total of forty shoots were labelled equally on four quadrants on each tree of a variety for studying the time of flushing. The week and month of flushing was observed and recorded for each variety.

3.2.1.2 Shoot extension

The labelled shoots, which showed the signs of flushing, were used for the observation. The flush extension was recorded in centimetres during weekly intervals.

3.2.1.3 Number of leaves

The number of leaves on the flushes were counted and recorded during weekly intervals.

3.2.1.4 Colour and aroma of new leaves

As per IBPGR descriptor the colour of new flushes was described. By crushing the young leaves the aroma was noted.

3.2.1.5 Chlorophyll content of new and mature leaves

The leaves weighing 100 mg were taken and cut into small pieces. Incubated the samples in 7.0 ml of Dimethyl sulphoxide (DMSO) at 65°C for 30 minutes. At the end of the incubation period the supernatant was decanted and the leaf tissue was discarded. The volume was made up to 10 ml with DMSO. The absorbance was read at 645 and 663 nm using DMSO as blank. (Shoaf and Livm, 1976).

The chlorophyll a and b were calculated using the formula

$$\text{Chlorophyll a} = [12.7\ (A663) - 2.69\ (A645)] \times \frac{V}{1000 \times w \times a}$$

$$\text{Chlorophyll b} = [22.9\ (A645) - 4.68\ (A663)] \times \frac{V}{1000 \times w \times a}$$

$$\text{Total chlorophyll} = [20.2(A645) + 8.02(A663)] \times \frac{V}{1000 \times w \times a}$$

where

A = Absorbance at specific wave lengths 645 and 663 nm

V = Final volume of the chlorophyll extract (ml)

w = Fresh weight of the sample (g)

a = Path length of light (1 cm)

3.2.2 Leaf characters

3.2.2.1 Area of leaves

Leaf area meter (model LI 3100 LI-COR) was used for measuring the area of mature leaves. Area of ten leaves was measured from each tree and the mean was worked out and expressed as square centimetre.

3.2.2.2 Pedicel length and breadth

Pedicel length was measured from the base of petiole to the base of lamina and expressed in centimetres. The breadth of pedicel was also noted.

3.2.2.3 Leaf shape (Fig. 1a)

Fully mature leaves ten in number were collected from each variety and the shape was described as lanceolate, oblong lanceolate or oblong.

3.2.2.4 Leaf margin (Fig. 1b)

As per IBPGR descriptor, the leaf margin was noted as wavy, flat, folded or crinkled.

3.2.2.5 Leaf tip (Fig. 1c)

Shape of the leaf tips was observed as acuminate, acute or obtuse.

3.2.2.6 Nature of leaf lamina/leaf texture

Texture of leaf lamina was classified as rough or smooth.

3.2.2.7 Leaf orientation

Leaf orientation was observed and recorded as drooping or horizontal.

3.2.2.8 Colour of leaf

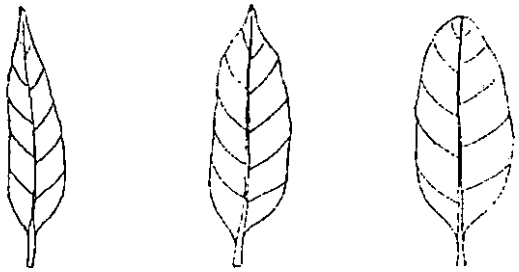
Light green

Dark green

Fig. 1

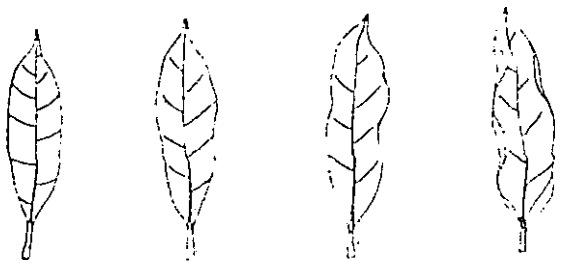
LEAF CHARACTERS

Fig. 1a Leaf shape



Lanceolate Oblong lanceolate Oblong

Fig. 1b Leaf margin



Flat Wavy Crinkled Folded

Fig. 1c Leaf tip

Acuminate Acute Obtuse

Fig. 2

INFLORESCENCE SHAPE

Conical Pyramidal Broadly pyramidal

3.2.3 Fresh and dry weights of leaves

From each tree, ten mature leaves were collected and the fresh weight was noted. The leaves were then dried to constant weight and the dry weight was recorded.

From the values, the moisture percentage was calculated as

$$\frac{\text{Fresh weight - Dry weight}}{\text{Fresh weight}} \times 100$$

3.2.4 Stomatal count

Stomatal count was recorded on mature leaves. Leaves were collected from each variety, quickfix was smeared on the lower surface in the mid position of the leaf during morning hours. After drying, the peel was removed and the number of stomata was counted under microscope (magnification 45 x). Counts were taken from five fields in each sample and average was worked out. The procedure followed was as per Beakhane and Majumder (1975).

3.3 Chemical analysis

The leaf samples were taken as per the leaf sampling technique given by Bhargava and Chadha (1993). Four to seven months old leaves, including petiole, from the middle of the shoot were collected and used for NPK analysis, during vegetative and flowering phase.

Mature leaves were collected from each tree and were dried to constant weight in an electric hot air oven at 80 ± 5°C. The dried leaves were then ground into fine powder using Wiley mill and used for chemical studies.

3.3.1 Nitrogen

Total nitrogen content was estimated colorimetrically (Wolf, 1982).

3.3.2 Phosphorus

Total phosphorus content was estimated by vanadomolybdophosphoric yellow colour method after extraction with diacid. The yellow colour was read in a spectronic 20 spectrophotometer (Jackson, 1973).

3.3.3 Potassium

The extract used for phosphorus estimation was used for estimating total potassium using flame photometer method (Jackson, 1973).

3.4 Flowering characters

3.4.1 Season of flowering

For each variety, the season during which flowering occurred was noted. The fully opened panicles were tagged for taking observations at biweekly intervals.

3.4.2 Number of inflorescence per unit area

With the help of a quadrat, one square meter area was selected and the number of inflorescence in that area was counted. This was done on four sides of tree.

3.4.3 Shape of inflorescence (Fig. 2)

Fully opened inflorescence were collected from each variety and the shape was described as per IBPGR descriptor as

Conical

Pyramidal

Broadly pyramidal

3.4.4 Size of inflorescence

The length of the panicle was measured from the base to the tip and expressed as centimetres. The breadth was measured at the broadest part of the base of the inflorescence and expressed in centimetres.

3.4.5 Colour of inflorescence

The colour of the rachis was noted and expressed as

Light green

Green with red patches

Light red

Dark red

Crimson

3.4.6 Density of flowers in inflorescence

By visual observation, the density was noted as laxly flowered or densely flowered.

3.4.7 Percentage of hermaphrodite flowers

Five inflorescence were collected from each tree and the number of hermaphrodite and male flowers were counted with the help of a hand lens. The percentage of hermaphrodite flowers was worked out as

$$\text{Percentage of hermaphrodite flowers} = \frac{\text{Number of hermaphrodite flowers}}{\text{Total number of flowers}} \times 100$$

3.4.8 Flower characters

The flowers were classified as pentamerous, tetramerous or both by counting the number of petals, sepals and stamens. The flower diameter was measured and expressed as centimetres.

3.4.9 Fruit set and development

Fully opened inflorescence were tagged and after a fortnight the number of fruits set per inflorescence were counted and recorded.

3.4.10 Fruit drop

The initial number of fruits set on the inflorescence was counted. Subsequently at biweekly intervals, the number of fruits retained was noted and the intensity of fruit drop was calculated and expressed as percentage.

3.5 Fruit characters

From the tagged inflorescence, five fruits from each tree were collected at biweekly intervals till full maturity stage for recording the following observations.

3.5.1 Fruit length

The distance between the base and the apex was measured and expressed in centimetres.

3.5.2 Breadth of fruit

Length of the broadest part was measured and expressed in centimetres.

3.5.3 Circumference

Fruit circumference was measured by running a thread around the middle portion of the fruit and was expressed in centimetres.

3.5.4 Weight

Individual fruit weight was recorded and expressed in grams.

3.5.5 Volume

By water displacement method, fruit volume was estimated and expressed in millilitres.

3.5.6 Specific gravity

Specific gravity was the ratio of fruit weight to fruit volume.

3.5.7 Chlorophyll content

Chlorophyll content of the fruit peel was determined at biweekly intervals using Dimethyl sulphoxide.

The peel weighing 100 mg was taken and cut into small pieces. Incubated the sample in 7.0 ml of DMSO at 65°C for 30 minutes. At the end of incubation period, the supernatant was decanted and the peel was discarded. The volume was made up to 10 ml with DMSO. The absorbance was read at 645 and 663 nm using DMSO as blank. (Shoaf and Livm, 1976).

The total chlorophyll was calculated as in 3.2.2.6.

3.6 Biochemical characters

From the tagged inflorescence, fruits were collected at biweekly intervals till ripening and the following were estimated.

3.6.1 Titrable acidity

Acidity was estimated by the method of A.O.A.C. (1984). Ten grams of the macerated sample was digested with boiling water and made to 100 ml. Twenty five ml of the filtered solution was titrated against 0.1 N NaOH using phenolphthalein as indicator. The acidity was expressed as percentage of citric acid.

3.6.2 Ascorbic acid

Ascorbic acid was estimated for the pulp of the fruit. Ten grams of homogenized pulp was taken and extracted with 4 per cent oxalic acid. Ascorbic acid was estimated using standard indicator dye 2,6 – dichlorophenol indophenol and expressed as milligram per 100 gram fruit (Sadasivan and Manickam, 1992).

3.6.3 Reducing sugars

Reducing sugar content was determined by adopting the method given by Lane and Eynon (Ranganna, 1986). To ten grams of fruit pulp, distilled water was added and after thorough mixing the solution was clarified with neutral lead acetate. Excess lead acetate was removed by adding potassium oxalate and volume was made up to 250 millilitres. The solution was filtered and aliquot 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.

3.6.4 Total sugars

The total sugar content was determined by adopting the method given by Lane and Eynon (Ranganna, 1986). From the clarified solution 50 milliliters was boiled gently after adding citric acid and water. It was neutralized using NaOH and volume made up to 250 millilitres. The made up solution was titrated against a mixture of Fehling's A and B and total sugar content was expressed as percentage.

3.7 Ripe fruit characters

3.7.1 Physical characters

Data on characters including length, breadth, circumference, weight, volume, specific gravity and chlorophyll content were recorded as described in 3.5.

3.7.2 Morphological characters

Fully ripened fruits were taken for noting the morphological characters as per IBPGR descriptor. The parts of a fruit are shown in the diagram. (Fig. 3a)

3.7.2.1 Fruit shape (Fig. 3b)

The fruit shape was described as oblong, elliptic or round.

3.7.2.2 Colour of skin

The skin colour of the fruits were observed and indicated as red, yellow, green yellow or others.

3.7.2.3 Thickness of peel

Thin

Medium thick

Thick

Very thick

3.7.2.4 Skin texture

The skin texture was noted either as smooth or as rough.

3.7.2.5 Adherence of skin to pulp

The absence or presence of adherence of skin to pulp was noted.

3.7.2.6 Fibre in the pulp

The absence or presence of fibre in the pulp was observed.

3.7.2.7 Quantity of fibre

Scarce

Abundant

3.7.2.8 Length of fibres

Fibre length was classified as short, medium or long.

3.7.2.9 Stalk insertion (Fig. 3c)

Stalk insertion was noted either as vertical or as oblique.

3.7.2.10 Beak type (Fig. 3d)

Beak type was observed and recorded as absent, present or as prominent.

Fig. 3

MORPHOLOGICAL CHARACTERS OF FRUIT

Fig. 3a Parts of a fruit

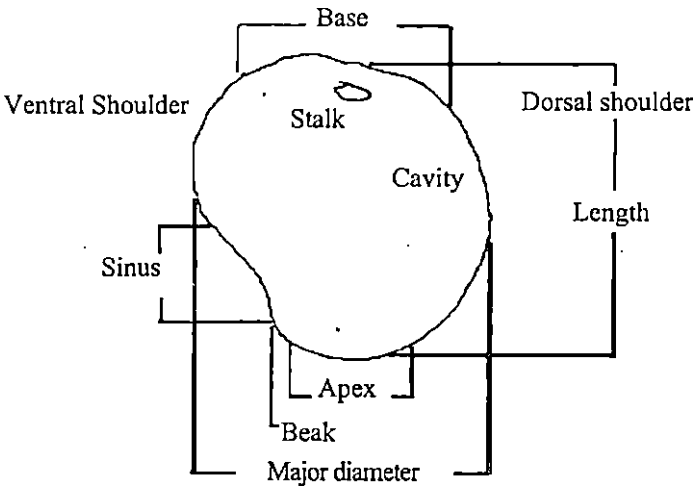
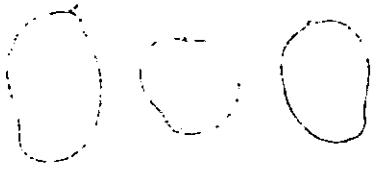


Fig. 3b Shape of fruit

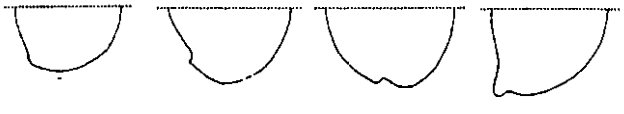


Ellipsoid Round Oblong

Fig. 3c Stalk insertion

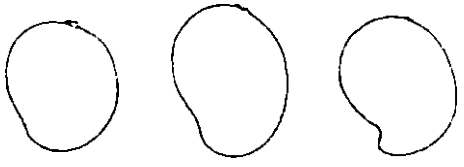
Oblique Straight

Fig. 3d Beak type



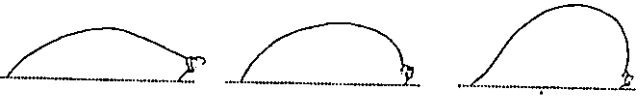
Absent Point Prominent Mammiform

Fig. 3e Sinus type



Absent Shallow Deep

Fig. 3f Slope of shoulders



Sloping abruptly Ending in a long curve Rising and then rounded

Fig. 3g Fruit apex

Acute Rounded

3.7.2.11 Sinus (Fig. 3e)

Absent
Shallow
Deep

3.7.2.12 Shoulders

The shoulders were observed and noted as level or as dorsal higher than ventral.

3.7.2.13 Slope of shoulders (Fig. 3f)

Sloping abruptly
Ending in a long curve
Rising and then rounded

3.7.2.14 Apex (Fig. 3g)

Apex was described as acute, obtuse or rounded.

3.7.3 Biochemical characters

Fruits were analysed for the biochemical constituents including acidity, ascorbic acid, reducing and total sugars. The procedures followed are described in 3.6. Apart from these total soluble solids was recorded after extracting the juice from the homogenized pulp and read using an Erma hand refractometer (range 0-32) and expressed in degree brix.

3.7.4 Stone characters

Weight of the stone per fruit was recorded for each variety.

3.7.5 Pulp, peel and stone percentage

From the values recorded on weights of whole fruit, pulp, peel and stone, the percentage contribution of each component in the total fruit was computed.

3.8 Organoleptic evaluation of fruits

A score chart was prepared after considering parameters like flavour, acidity, sweetness, aroma and astringency. The scores given were

Poor – 1
Intermediate – 2
Good – 3
Excellent – 4

The evaluation was done by a panel of ten judges. The procedure for ranking was as given by Kruskal and Wallis (Siegel, 1959).

3.9 Storage studies

The number of days taken by ten fruits from the day of harvest to the unmarketable stage at ambient room temperature was noted. Unmarketability was attributed when more than 50 per cent of the fruits showed blackening as spots, specks and lesions.

3.10 Yield per tree

The yield of each tree was noted and expressed as number of fruits per tree and as average weight in kg per tree.

3.11 Tree characters

The height, girth, north-south (NS) and east-west (EW) spread, number of primaries, secondaries and tertiaries were noted.

3.12 Heat unit (Cumulative degree days)

Heat unit per day was calculated by subtracting the base temperature of 15°C from the mean of daily maximum and minimum temperature. The total heat units accumulated during peak flowering to peak harvest for six varieties was calculated and expressed as cumulative degree days. (Rao and Srinath, 1967).

3.13 Statistical analysis

The data was subjected to statistical analysis as per Mstat C package. Correlations were carried out between important characters.

Results

4. RESULTS

Results of the experiments conducted to assess the performance of selected mango varieties and hybrids under humid tropical conditions of Kerala are presented in this chapter.

4.1 Flush characters

The data on different flush characters are presented in Table 1.

4.1.1 Season of flushing

In Alphonso and Prior, flushing started during the month of November and extended upto February in Alphonso and upto March in Prior. In H-151 flushing was earlier, started by the month of August and extended up to February. In Ratna flushing was noticed during October and extended upto February. The peak flushing for Alphonso and Prior was during November - December. In H-151 the peak was during August - September and in Ratna during January - February.

In Muvandan, Neelum and Kalapady two distinct flushing could be noticed. In Muvandan the first flushing was during November, in Neelum during August – September and in Kalapady during December - January. In all the three varieties the second flushing was noted during March - April.

4.1.2 Flush length and leaf number

The length of flushes ranged from 7.32 to 17.43 cm, the maximum being recorded in Muvandan. All the varieties except Muvandan during March - April flush were on par with each other in terms of this parameter. In varieties with two flushing shoot length and leaf number were more during the March - April flush, even though the difference was not statistically significant. Number of leaves per

flush ranged from 10.1 to 17.3 in different varieties. As in flush length, maximum was recorded in Muvandan during the March - April flush followed by Alphonso.

4.1.3 Colour of flushes

The flush colour showed wide variations among the varieties from light green to deep coppery tan colour. Light green flushes were seen in Muvandan. Alphonso and Prior had light green leaves with brownish tinge. Light brick red colour leaves were noticed in Neelum and H-151. Ratna had reddish brown leaves. Kalapady had deep coppery tan coloured leaves (Plate 1).

4.1.4 Aroma of leaves

Leaf aroma was strong in Alphonso, Prior and Ratna whereas mild aroma was noted in Neelum, H-151, Kalapady and Muvandan.

4.1.5 Chlorophyll content

Total chlorophyll content ranged from 0.81 to 3.09 mg g^{-1}. Maximum content of chlorophyll was noticed in leaves of Ratna and least in Kalapady. A significant difference could be noticed between the varieties in chlorophyll a and b content.

4.1.6 Pattern of flush growth

The shoot extension pattern and number of leaves in flushes of the seven varieties are shown in Tables 2 (a) to 2 (j).

The growth pattern of flushes was studied at weekly intervals. In all the varieties the elongation of shoots ceased in four weeks time. Maximum growth to the tune of 90 per cent in terms of shoot length and leaf number occurred during the first week in all the varieties.

Table 1. Flush characters

Variety	Duration of flushing	Peak flushing	Flush length (cm)	Leaf number	Flush colour	Aroma	Chlorophyll content (mg g^{-1})		
							a	b	Total
Alphonso	7th November – 22nd February	7th November – 20th December	11.75	14.70	Light green with brownish tinge	Strong	0.21	0.13	2.03
Prior	29th November – 2nd March	29th November – 20th December	11.75	11.70	Light green with brownish tinge	Strong	0.18	0.13	1.85
Muvandan	14th November	14th November	13.63	14.30	Light green	Mild	0.21	0.12	1.88
	23rd March – 14th April	23rd March – 14th April	17.43	17.30	Light green				
Neelum	19th August – 11th September	19th August – 11th September	9.40	13.50	Light brick red		0.33	0.16	2.68
	23rd March – 14th April	23rd March – 14th April	10.45	13.30	Light brick red				
Kalapady	20th December – 10th January	20th December – 10th January	7.32	12.50	Deep coppery tan		0.08	0.06	0.81
	23rd March – 14th April	23rd March – 14th April	8.40	13.20	Deep coppery tan				
Ratna	23rd October – 22nd February	30th January – 22nd February	11.50	12.55	Reddish brown	Strong	0.36	0.19	3.09
H-151	19th August – 22nd February	19th August – 11th September	8.68	10.10	Light brick red	Mild	0.10	0.05	0.89
CD(0.05)			7.66	6.36			0.16	0.05	1.02

Plate-1

FLUSHES OF MANGO VARIETIES

4.1.6.1 Alphonso

No significant difference in the shoot length could be noticed between the sides during the course of development. The increase in shoot length mainly took place during the first week followed by slight growth in the following period. Increment in leaf number exhibited a statistically significant difference among the sides. However, during the fourth week such a difference was not noticed.

4.1.6.2 Prior

In this variety a significant difference was noticed in the first week of development between sides for flush length and leaf number. During the subsequent observations no significant difference could be noticed.

4.1.6.3 Muvandan

Two distinct flushing could be noticed in this variety, the first during November and the second during March - April. The sides did not differ significantly in the case of shoot length and leaf number throughout the course of development except in third week. Shoots on southern and eastern sides had the maximum length and leaf number. Between the two flushing no significant difference could be noticed in shoot length and leaf number.

4.1.6.4 Neelum

Two flushing were noticed first during August - September and second during March - April. No significant difference could be found between the sides during most of the observations. In the second flushing a significant difference between the sides was noticed during the first week of development. Northern side flushes had the maximum length and leaf number.

Table 2(a). Pattern of flush growth in Alphonso during November - December

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	10.80	11.80	12.00	12.40	15.60	15.80	16.20	16.40
	Increment	(3.30) 10.80	(1.15) 1.00	(0.81) 0.20	(0.91) 0.40	(4.00) 15.60	(0.81) 0.20	(0.91) 0.40	(0.81) 0.20
West	Shoot length	5.80	6.20	6.70	7.10	11.60	12.00	12.00	12.20
	Increment	(2.49) 5.80	(0.88) 0.40	(0.97) 0.50	(0.91) 0.40	(3.47) 11.60	(0.91) 0.40	(0.71) 0.00	(0.81) 0.20
North	Shoot length	6.70	7.00	7.30	7.60	9.80	9.80	10.60	10.60
	Increment	(2.58) 6.70	(0.85) 0.30	(0.87) 0.30	(0.87) 0.30	(3.19) 9.80	(0.71) 0.00	(1.12) 0.80	(0.71) 0.00
South	Shoot length	17.50	18.90	19.40	19.90	17.80	19.00	19.00	19.60
	Increment	(4.17) 17.50	(1.35) 1.40	(0.97) 0.50	(0.97) 0.50	(4.24) 17.80	(1.30) 1.20	(0.71) 0.00	(0.99) 0.60
Mean		10.20	0.78	0.38	0.40	13.70	0.45	0.30	0.25
CD (0.05)		0.93	NS	NS	NS	0.57	0.27	0.24	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(b). Pattern of flush growth in Prior during November - December

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	6.20	7.60	8.00	8.60	6.00	6.60	6.80	7.20
	Increment	6.20	(1.34) 1.40	(0.91) 0.40	(0.99) 0.60	6.00	0.60	0.20	0.40
West	Shoot length	9.40	9.80	10.30	11.40	11.20	11.60	12.00	12.60
	Increment	9.40	(0.91) 0.40	(0.95) 0.50	(1.21) 1.10	11.20	(0.88) 0.40	(0.88) 0.40	(1.02) 0.60
North	Shoot length	12.60	13.70	13.90	14.40	13.80	15.00	15.40	15.80
	Increment	12.60	(1.23) 1.10	(0.81) 0.20	(0.97) 0.50	13.80	(1.26) 1.20	(0.88) 0.40	(0.91) 0.40
South	Shoot length	9.90	12.10	12.10	12.60	11.20	11.20	11.20	11.20
	Increment	9.90	(1.57) 2.20	(0.71) 0.00	(0.97) 0.50	11.20	0.00	0.00	0.00
Mean		9.53	1.28	0.28	0.68	10.60	0.60	0.25	0.35
CD (0.05)		3.43	NS	NS	NS	2.27	NS	NS	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(c). Pattern of flush growth in Muvandan during November

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	10.20	11.60	11.80	12.80	13.60	15.00	15.00	15.80
	Increment	10.20	(1.34) 1.40	(0.81) 0.20	(1.15) 1.00	13.60	(1.27) 1.40	(0.71) 0.00	(1.12) 0.80
West	Shoot length	9.70	10.10	10.90	11.40	10.80	12.40	13.40	13.80
	Increment	9.70	(0.91) 0.40	(1.04) 0.80	(0.97) 0.50	10.80	(0.99) 1.60	(1.15) 1.00	(0.91) 0.40
North	Shoot length	11.90	13.40	15.00	15.12	11.40	12.80	13.80	14.60
	Increment	11.90	(1.41) 1.50	(1.38) 1.60	(0.78) 0.12	11.40	(1.27) 1.40	(1.12) 1.00	0.80
South	Shoot length	12.80	15.00	15.00	15.20	11.60	12.60	12.80	13.00
	Increment	12.80	(1.55) 2.20	(0.71) 0.00	(0.81) 0.20	11.60	(1.09) 1.00	(0.81) 0.20	(0.81) 0.20
Mean		11.20	1.38	0.65	0.45	11.85	1.35	0.30	0.55
CD (0.05)		NS	NS	0.51	NS	NS	NS	NS	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(d). Pattern of flush growth in Muvandan during March - April

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	15.40	15.90	18.50	19.00	16.20	16.80	17.60	17.60
	Increment	15.40	(0.97) 0.50	(1.69) 2.60	(0.97) 0.50	16.20	(0.99) 0.60	(1.04) 0.80	(0.71) 0.00
West	Shoot length	13.10	13.70	16.50	17.60	16.20	16.80	18.80	19.00
	Increment	13.10	(1.03) 0.60	(1.81) 2.80	(1.23) 1.10	16.20	(1.02) 0.60	(1.55) 2.00	(0.81) 0.20
North	Shoot length	10.80	11.40	12.80	13.30	12.80	13.40	14.00	14.20
	Increment	10.80	(1.03) 0.60	(1.32) 1.40	(0.97) 0.50	12.80	(1.02) 0.60	(1.02) 0.60	(0.81) 0.20
South	Shoot length	16.00	16.70	19.80	19.80	16.60	17.60	18.00	18.40
	Increment	16.00	(1.07) 0.70	(1.87) 3.10	(0.71) 0.00	16.60	(1.15) 1.00	(0.91) 0.40	(0.91) 0.40
Mean		13.83	0.60	2.50	0.53	15.45	0.70	0.85	0.10
CD (0.05)		2.78	NS	NS	0.33	2.24	NS	NS	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(e). Pattern of flush growth in Kalapady during December - January

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	5.02	6.36	6.66	6.96	11.00	12.80	13.20	13.60
	Increment	5.02	1.34	0.30	0.30	11.00	1.80	0.40	0.40
West	Shoot length	3.70	4.80	5.20	5.40	8.60	9.60	10.00	10.20
	Increment	3.70	1.10	0.40	0.20	8.60	1.00	0.40	0.20
North	Shoot length	5.90	7.10	7.30	7.50	11.20	12.40	12.60	12.80
	Increment	5.90	1.20	0.20	0.20	11.20	1.20	0.20	0.20
South	Shoot length	7.16	8.84	9.04	9.24	10.20	12.80	13.00	13.40
	Increment	7.16	1.68	0.20	0.20	10.20	2.60	0.20	0.40
Mean		5.40	1.33	0.30	7.27	11.10	0.95	1.05	0.30
CD (0.05)		NS	NS	NS	NS	NS	NS	NS	NS

Table 2(f). Pattern of flush growth in Kalapady during March -April

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	5.40	6.90	7.50	7.90	11.00	12.40	13.20	13.40
	Increment	5.40	1.50	0.60	0.40	11.00	1.40	0.80	0.20
West	Shoot length	6.50	8.30	9.40	9.60	9.00			
	Increment	6.50	1.80	1.10	0.20	9.00	0.80	1.80	0.00
North	Shoot length	6.30	7.70	8.80	8.90	12.40			
	Increment	6.30	1.40	1.10	0.10	12.40	1.20	0.40	0.00
South	Shoot length	5.30	5.80	6.70	7.10	12.00			
	Increment	5.30	0.50	0.90	0.40	12.00	0.40	1.20	0.20
Mean		5.88	1.30	0.93	0.30	11.10	0.95	1.05	0.10
CD (0.05)		NS	NS	NS	NS	NS	NS	NS	NS

Table 2(g). Pattern of flush growth in Neelum during August - September

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	7.10	8.10	8.40	8.70	10.40	12.00	12.20	12.20
	Increment	7.10	(1.21) 1.00	(0.88) 0.30	(0.88) 0.30	10.40	(1.44) 1.60	(0.81) 0.20	(0.71) 0.00
West	Shoot length	6.90	7.80	8.10	8.30	12.80	13.80	14.00	14.00
	Increment	6.90	(1.17) 0.90	(0.88) 0.30	(0.82) 0.20	12.80	(1.16) 1.00	(0.81) 0.20	(0.71) 0.00
North	Shoot length	9.60	10.90	11.10	11.20	13.40	14.40	14.80	15.00
	Increment	9.60	(1.34) 1.30	(0.82) 0.20	(0.77) 0.10	13.40	(1.19) 1.00	(0.91) 0.40	(0.81) 0.20
South	Shoot length	8.16	8.90	9.30	9.40	11.60	12.40	12.60	12.80
	Increment	8.16	(1.10) 0.74	(0.93) 0.40	(0.77) 0.10	11.60	(1.12) 0.80	(0.81) 0.20	(0.81) 0.20
Mean		7.94	0.99	0.30	0.18	12.05	1.10	0.25	0.10
CD (0.05)		2.09	NS	NS	NS	NS	NS	NS	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(h). Pattern of flush growth in Neelum during March - April

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	7.00	7.40	8.30	8.50	10.60	10.80	11.40	11.40
	Increment	7.00	(0.93) 0.40	(1.17) 0.90	(0.82) 0.20	10.60	(0.81) 0.20	(1.02) 0.60	(0.71) 0.00
West	Shoot length	7.20	8.30	9.10	9.40	10.80	11.60	12.20	12.20
	Increment	7.20	(1.22) 1.10	(1.13) 0.80	(0.88) 0.30	10.80	(1.04) 0.80	(0.99) 0.60	(0.71) 0.00
North	Shoot length	11.90	12.30	13.00	13.40	13.60	14.20	15.00	15.00
	Increment	11.90	(0.93) 0.40	(1.07) 0.70	(0.94) 0.40	13.60	(1.09) 0.60	(1.12) 0.80	(0.71) 0.00
South	Shoot length	8.70	9.40	10.40	10.50	13.40	13.80	14.60	
	Increment	8.70	(1.08) 0.70	(1.21) 1.00	(0.77) 0.10	13.40	(0.91) 0.40	(1.12) 0.80	(0.71) 0.00
Mean		8.70	0.65	0.85	0.25	12.10	0.50	0.70	0.00
CD (0.05)		2.45	NS	NS	NS	2.69	NS	NS	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(i). Pattern of flush growth in Ratna during January - February

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	8.80	9.20	10.10	10.60	9.20	9.40	10.20	10.60
	Increment	8.80	(0.91) 0.40	(1.12) 0.90	(0.99) 0.50	9.20	(0.81) 0.20	(1.09) 0.80	(0.91) 0.40
West	Shoot length	10.10	10.90	11.20	11.70	11.60	13.00	13.00	13.60
	Increment	10.10	(1.10) 0.80	(0.88) 0.30	(1.00) 0.50	11.60	(1.32) 1.40	(0.71) 0.00	(1.02) 0.60
North	Shoot length	8.30	8.40	8.90	9.70	10.60	10.80	11.20	11.60
	Increment	8.30	(0.77) 0.10	(0.99) 0.50	(1.90) 0.80	10.60	(0.81) 0.20	(0.88) 0.40	(0.91) 0.40
South	Shoot length	12.60	12.80	13.60	13.90	12.60	13.00	14.00	14.10
	Increment	12.60	(0.81) 0.20	(1.09) 0.80	(0.87) 0.30	12.60	(0.91) 0.40	(1.09) 1.00	(0.91) 0.40
Mean		9.95	0.38	0.60	0.51	11.00	0.60	0.60	0.45
CD (0.05)		NS	NS	NS	NS	NS	0.42	NS	NS

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Table 2(j). Pattern of flush growth in H-151 during August – September

Direction		Shoot length (cm)				Number of leaves			
		Weeks after flushing				Weeks after flushing			
		First	Second	Third	Fourth	First	Second	Third	Fourth
East	Shoot length	7.70	8.90	9.20	9.40	7.40	9.40	9.80	9.80
	Increment	7.70	(1.29) 1.20	(0.87) 0.30	(0.82) 0.20	7.40	(1.57) 2.00	(0.88) 0.40	0.00
West	Shoot length	6.20	7.00	7.30	7.40	9.40	10.20	10.80	10.80
	Increment	6.20	(1.11) 0.80	(0.87) 0.30	(0.77) 0.10	9.40	(1.09) 0.80	(0.99) 0.60	0.00
North	Shoot length	7.60	8.70	8.90	9.00	8.60	9.80	10.00	10.00
	Increment	7.60	(1.26) 1.10	(0.82) 0.20	(0.77) 0.10	8.60	(1.30) 1.20	(0.81) 0.20	0.00
South	Shoot length	7.30	8.60	8.80	8.90	8.40	9.60	9.80	9.80
	Increment	7.30	(1.34) 1.30	(0.82) 0.20	(0.77) 0.10	8.40	(1.26) 1.20	(0.81) 0.20	0.00
Mean		7.20	1.10	0.25	0.13	8.45	1.30	0.35	0.00
CD (0.05)		NS	NS	NS	NS	NS	NS	NS	

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

4.1.6.5 Kalapady

In this variety also two distinct flushing during December - January and March - April could be seen. During both the flushing no significant difference could be noticed between the sides.

4.1.6.6 Ratna

No significance between the sides during the course of development was noticed except during second week in terms of leaf number. The least growth was observed during the fourth week.

4.1.6.7 H-151

The sides did not differ statistically in terms of shoot length and leaf number during the course of development. Maximum growth was noticed during the first week followed by second week. Though the shoot length increase was noticed up to fourth week, leaf number did not exhibit any difference during this period.

4.2 Mature leaf characters

The various characters of mature leaves in the selected mango varieties are furnished in Table 3.

4.2.1 Leaf length and breadth

A significant difference could be noticed between the varieties in the case of length and breadth. Leaf length ranged from 18.19 to 26.45 cm. The longest leaves were seen in Ratna followed by Alphonso and Prior and the smallest in Neelum and Kalapady. In the case of leaf breadth variety Alphonso (6.13 cm) followed by Prior (6.03 cm) and Ratna (6.0 cm) had the maximum breadth.

4.2.2 Area of leaves

The leaf area ranged from 59.2 to 119.33 cm^2. The maximum leaf area was noticed in Ratna followed by Alphonso. Neelum and Kalapady had the minimum leaf area.

4.2.3 Chlorophyll content

The maximum chlorophyll content in mature leaves was noted in leaves of Neelum (15.14 mg g^{-1}) and least in Muvandan (7.55 mg g^{-1}). All the other varieties had chlorophyll content which were on par with each other. Chlorophyll a and b content showed significant difference between the varieties.

4.2.4 Stomatal count

The stomatal count differed significantly between the varieties. The maximum stomatal count (788.58 mm^{-2}) was noted in Alphonso followed by Prior and the least in Muvandan.

4.2.5 Pedicel length and breadth

The leaf pedicel length and breadth followed a pattern similar to leaf length and breadth. Ratna had the maximum pedicel length and breadth (5.8 and 0.43 cm).

4.2.6 Leaf dry weight

Dry weight of leaves ranged from 7.35 to 20.13 g. Maximum weight was noticed in Alphonso followed by Ratna and the minimum in Kalapady.

Table 3. Mature leaf characters

Name of variety	Length of leaf (cm)	Breadth of leaf (cm)	Area of leaves (cm^2)	Chlorophyll (mg g^{-1})			Stomatal count (mm^{-2})	Pedicel length (cm)	Pedicel breadth (cm)	Leaf dry weight (g)	Moisture percentage
				a	b	Total					
Alphonso	25.43	6.13	107.70	2.23	0.63	13.39	788.58	5.14	0.43	20.13	53.83
Prior	23.97	6.03	90.94	2.10	0.54	12.13	752.14	3.97	0.37	14.29	54.98
Muvandan	20.36	4.83	75.22	1.38	0.31	7.55	493.90	3.09	0.30	12.07	51.56
Kalapady	18.47	5.10	67.04	1.92	0.39	10.13	648.18	2.04	0.29	12.39	52.16
Neelum	18.19	4.39	59.20	2.13	0.85	15.14	694.98	3.63	0.38	7.35	52.47
Ratna	26.45	6.00	119.33	2.10	0.53	12.53	652.86	5.80	0.43	15.77	54.50
H-151	21.64	4.70	77.40	2.11	0.54	12.16	608.98	2.76	0.23	10.88	50.67
CD (0.05)	4.18	1.16	34.33	0.51	0.36	6.89	81.57	1.19	0.06	6.17	NS

4.2.7 Leaf moisture percentage

The varieties did not differ significantly in the leaf moisture content. Maximum moisture percentage was noticed in Prior (54.98) and the minimum in H-151 (50.67).

4.3 Qualitative leaf characters

The leaf characters are given in Table 4.

4.3.1 Leaf shape

Lanceolate to elliptic lanceolate leaves could be seen in the varieties. Alphonso, Ratna, H-151, Muvandan and Neelum had lanceolate leaves, whereas Prior had oblong lanceolate leaves. Elliptic lanceolate leaves could be seen in the case of Kalapady.

4.3.2 Leaf margin

Prior, Ratna, Muvandan and Neelum had wavy margins whereas flat margins were seen in Alphonso, H-151 and Kalapady.

4.3.3 Leaf texture

All the varieties had thinly coriaceous leaves except in Alphonso and Prior, which had thickly coriaceous leaf texture.

4.3.4 Leaf tip

Acuminate leaf tip was found in all the varieties except Neelum and H-151, which had acute leaf tips.

Table 4. Qualitative characters of mature leaves

Name of variety	Leaf shape	Leaf margin	Leaf Texture	Leaf tip
Alphonso	Lanceolate	Flat	Thickly coriaceous	Acuminate
Prior	Oblong-lanceolate	Wavy	Thickly coriaceous	Acuminate
Muvandan	Lanceolate	Wavy	Thinly coriaceous	Acuminate
Kalapady	Elliptic lanceolate	Flat	Thinly coriaceous	Acuminate
Neelum	Lanceolate	Wavy	Thinly coriaceous	Acute
Ratna	Lanceolate	Wavy	Thinly coriaceous	Acuminate
H-151	Lanceolate	Flat	Thinly coriaceous	Acute

4.4 Nutrient content of leaves during vegetative and flowering phase

The NPK content of mature leaves during vegetative and flowering phase are presented in Table 5.

A significant difference could be noticed between the varieties in all the three nutrients during both the phases. The highest N content during the vegetative phase was found in Ratna and during flowering phase in H–151. In the case of P, the highest during both the phases was in Muvandan. In the case of K, H-151 recorded the maximum during the vegetative phase and Prior the maximum in flowering phase.

On comparing the difference in the level of nutrients during the two phases a decrease in nutrient content could be noticed during the flowering phase than in the vegetative phase.

In all the varieties a significant difference could be noticed between the two phases in the nutrient content except in Alphonso in N and K content and Neelum in P content.

In variety Kalapady since no flowering was seen the nutrient content during post vegetative phase could not be estimated.

4.5 Inflorescence characters

None of the trees of variety Kalapady in the orchard flowered during the period of study. Hence, data pertaining to flowering characters of six varieties only are presented in Table 6.

Table 5. Leaf nutrient content during vegetative and flowering phases(%)

Name of variety	Vegetative phase			Flowering phase			t - statistic		
	N	P	K	N	P	K	N	P	K
Alphonso	1.120	0.078	0.860	0.290	0.051	0.660	NS	3.530	NS
Prior	0.780	0.082	1.070	0.450	0.066	0.850	8.670	5.150	5.150
Muvandan	0.950	0.100	0.720	0.570	0.070	0.680	5.150	8.670	15.180
Neelum	0.590	0.063	1.180	0.330	0.040	0.760	15.190	NS	3.530
Kalapady	1.090	0.039	0.920	-	-	-	-	-	-
Ratna	2.340	0.089	0.960	0.530	0.040	0.720	3.530	15.180	8.670
H-151	1.010	0.058	1.020	0.690	0.034	0.740	4.940	4.940	4.940
CD(0.05)	1.210	0.053	0.150	0.150	0.003	0.120			

4.5.1 Season of flowering

Flowering started in all the varieties except in Neelum during December - January months. In Neelum flowering was observed during the month of April - May.

4.5.2 Number of inflorescence per unit area

A significant difference was noticed among the varieties and Prior ($23.67m^{-2}$) was found to be superior and was on par with H-151. Alphonso and Neelum had the minimum number of inflorescence per square metre.

4.5.3 Number of male flowers per inflorescence

The number of male flowers ranged from 156 to 476, the maximum in Ratna and H-151 and the minimum in Alphonso. Ratna, H-151 and Prior were on par with each other and Alphonso, Muvandan and Neelum on par with each other.

4.5.4 Number of hermaphrodite flowers

A significant difference could be noticed between the varieties. The highest number of hermaphrodite flowers was noted in the hybrids Ratna (141.6) and H-151 (140.8) and the least in Muvandan and rest all were on par with each other.

4.5.5 Percentage of hermaphrodite flowers

The highest value was noted in Alphonso (44.39%). Ratna, H-151 and Neelum were on par next to Alphonso. The least percentage of hermaphrodite flowers was noted in Muvandan.

4.5.6 Length of inflorescence

The length ranged from 16.8 to 33.6 cm. The maximum length was noticed in Ratna, rest all were on par with each other.

4.5.7 Breadth of inflorescence

The range noticed was from 13.4 to 23.0 cm. The maximum length was noticed in Ratna, which was on par with H-151.

4.5.8 Density of flowers

The density of flowers in the inflorescence was classified as per IBPGR descriptor as laxly, densely and medium. H-151, Muvandan and Ratna fell into the group laxly flowered, whereas Prior and Alphonso into densely flowered group. Neelum had medium dense inflorescence.

4.5.9 Colour of inflorescence

The colour of rachis ranged from light green to dark red. Alphonso and Muvandan had light red coloured inflorescence, light green colour was noticed in the case of Prior and H-151. Neelum had green with red patches and dark red coloured inflorescence was seen in Ratna (Plate 2).

4.5.10 Shape of inflorescence

Conical to broadly pyramidal shapes could be noticed in the varieties. Alphonso, H-151, Neelum and Muvandan had inflorescence with pyramidal shape, whereas Prior had broadly pyramidal and Ratna, conical shaped inflorescence.

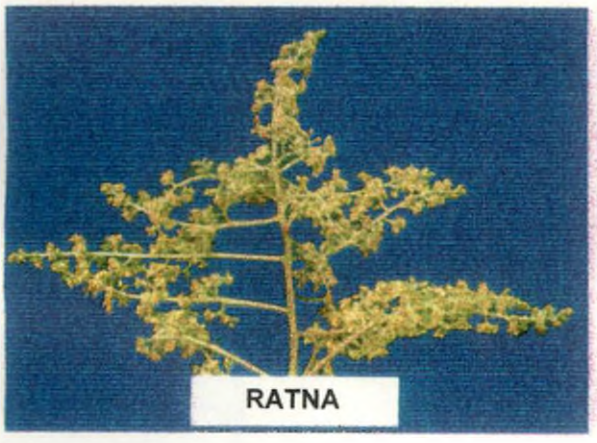
Table 6. Inflorescence characters

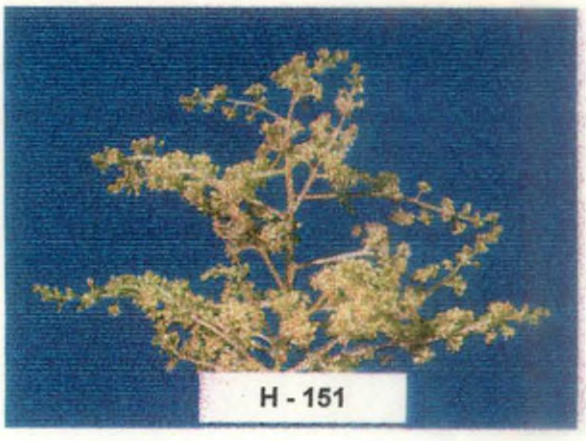
Variety	Season of flowering	Number of inflorescence m^{-2}	No. of male flowers	No. of hermaphrodite flowers/ inflorescence	Percentage of hermaphrodite flowers/ inflorescence	Inflorescence length (cm)	Inflorescence breadth (cm)	Density of flowers/ inflorescence	Colour of rachis	Shape of inflorescence	Hairiness
Alphonso	Jan-Feb	10.30	(12.19) 156.00	67.00	44.39	16.80	13.40	Densely	Light red	Pyramidal	Slightly hairy
Prior	Dec-Jan	23.67	(17.55) 312.80	97.20	32.19	21.00	15.40	Densely	Light green	Broadly pyramidal	Hairy
Muvandan	Jan-Feb	18.33	(14.42) 211.20	33.20	15.77	20.00	15.40	Medium densely	Light red	Pyramidal	Absent
Neelum	Apr-May	7.00	(15.02) 226.00	98.60	42.92	22.00	16.20	Laxly	Green with red patches	Pyramidal	Absent
Ratna	Jan-Feb	18.67	(21.06) 476.00	141.60	34.15	33.60	23.00	Laxly	Dark red	Conical	Slightly hairy
H-151	Dec-Jan	20.30	(20.81) 441.00	140.80	33.08	24.80	18.40	Laxly	Light green	Pyramidal	Absent
CD (0.05)		4.36	8.14	77.70	19.17	14.66	11.45				

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Plate-2

INFLORESCENCE OF MANGO VARIETIES





4.5.11 Hairiness of inflorescence

Prior had hairy inflorescence and Alphonso and Ratna slightly hairy ones. No hairs were found in H-151, Muvandan and Neelum.

4.6 Flower characters

The data on flower characters are presented in Table 7.

4.6.1 Flower type

All the varieties produced pentamerous flowers having petals, sepals and stamens, five in number.

4.6.2 Flower diameter

The flower diameter ranged from 0.45 cm to 0.85 cm. The maximum was noticed in Ratna and the minimum in H-151.

4.6.3 Nature of disc

In four of the varieties the disc was swollen. Narrow disc was seen in Neelum and H-151.

4.6.4 Number of stamens

All the varieties had five stamens, out of which only one was fertile.

4.7 Fruit set and fruit drop studies

The data on fruit drop, taken at biweekly intervals, are furnished in Table 8.

Table 7. Flower characters

Name of variety	Flower type	Flower diameter (cm)	Nature of disc	No. of stamens
Alphonso	Pentamerous	0.60	Disc swollen	5, 1 fertile
Prior	Pentamerous	0.65	Disc swollen	5, 1 fertile
Muvandan	Pentamerous	0.50	Disc swollen	5, 1 fertile
Neelum	Pentamerous	0.50	Disc narrow	5, 1 fertile
Ratna	Pentamerous	0.85	Disc swollen	5, 1 fertile
H-151	Pentamerous	0.45	Disc narrow	5, 1 fertile

Initial set ranged from 5.39 to 8.45 fruits per inflorescence. In all the varieties maximum fruit drop was seen during the initial 15 days after fruit set. During the course of development there was a gradual reduction in the drop and it ceased by 45th day. From Fig. 4 it is clearly evident that about 50 per cent of the fruit drop occurred during the first fortnight. A significant difference could be noticed between the first, second and third fortnights. However, no particular pattern could be noticed between the sides in terms of fruit drop intensity. During the second fortnight of development maximum drop was seen in Alphonso (28.54%) and least in H-151 (12.68%). During the third fortnight, drop intensity to the tune of 6.03 to 12.06 per cent could be noticed in the varieties. In the overall drop percentage, which ranged from 79.65 in H-151 to 89.93 in Alphonso, no significant difference could be noticed between the varieties. The percentage of fruits retained per inflorescence varied from 10.07 in Alphonso to 20.34 in H-151.

4.8 Fruit development studies

Fruits collected at biweekly intervals were subjected to detailed observation. All the varieties took 90 days to reach full maturity whereas in hybrids Ratna and H-151 this stage was reached by 105 days. A sigmoid growth pattern was noticed for fruit characters in all the varieties (Fig. 5). The maximum increase in the fruit characters was over by 75 days in all the varieties except in Ratna, in which a substantial increment was noted between 90 and 105 days, which is evident from Plate 3.

4.8.1 Fruit length

Length of the fruit during the period of development in different varieties is given in Table 9 (a).

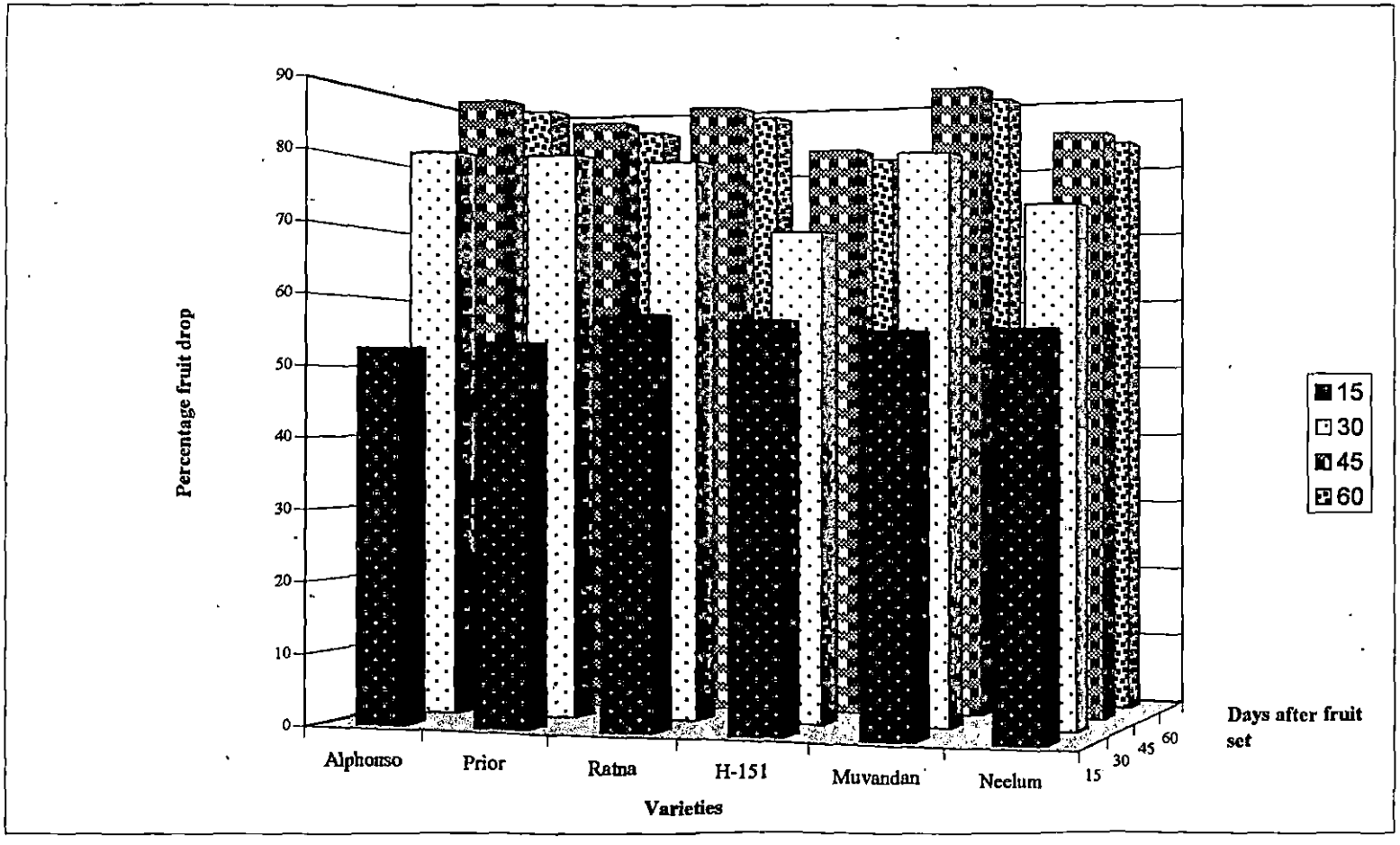
The varieties differed significantly in terms of fruit length throughout the course of development, except during the second observation. Upto 30 days after fruit set, H-151 fruits were longer than others, whereas Prior took this place during

Table 8. Intensity of fruit drop in varieties

Name of the variety	Direction	Initial no. of fruits Inflorescence^{-1}	Percent of fruit drop (days after fruit set)			Total drop (%)	Percent fruits retained	CD (0.05)
			15 days	30 days	45 days			
Alphonso	East	6.85	(6.34) 46.08	(5.64) 39.96	(1.74) 5.46	91.50	8.50	1.34
	West	3.40	(6.21) 46.28	(4.48) 27.17	(2.72) 14.65	88.10	11.90	2.36
	North	8.40	74.66	12.60	2.86	90.13	9.87	10.16
	South	6.45	(6.41) 42.75	(5.68) 34.42	(2.96) 12.82	89.99	10.01	2.13
	Total	6.28	52.44	28.54	8.95	89.93	10.07	
Prior	East	4.25	(7.76) 63.75	(3.44) 19.44	(0.71) 0.00	83.19	16.80	2.23
	West	8.25	(7.35) 55.21	(5.39) 32.01	(1.83) 5.83	93.05	6.95	1.93
	North	8.80	(7.17) 53.29	(5.32) 31.95	(1.73) 6.69	91.92	8.08	2.88
	South	6.60	(5.43) 39.63	(4.53) 24.92	(2.69) 11.59	76.14	23.86	NS
	Total	6.98	52.97	27.08	6.03	86.08	13.92	
Muvandan	East	6.00	(8.43) 71.32	(2.62) 10.41	(2.30) 10.00	91.73	8.27	2.02
	West	3.29	(6.27) 47.21	(4.59) 29.16	(2.28) 9.72	86.14	13.86	3.63
	North	4.30	(7.05) 56.92	(3.90) 23.88	(2.19) 9.20	90.03	9.96	2.05
	South	7.95	(5.94) 41.46	(5.66) 36.11	(3.25) 13.43	90.99	9.01	1.47
	Total	5.39	54.23	24.89	10.59	89.72	10.28	
Neelum	East	4.90	52.00	19.18	7.82	79.00	21.00	1.96
	West	5.30	54.34	22.13	14.50	90.97	9.03	2.00
	North	6.45	55.65	15.28	12.23	83.16	16.84	1.93
	South	7.25	56.21	12.31	9.58	78.10	21.90	2.01
	Total	5.98	54.55	17.23	11.03	82.81	17.19	
Ratna	East	9.20	(7.63) 61.23	(3.86) 20.14	(2.67) 9.82	91.20	8.79	1.97
	West	9.36	(7.56) 62.28	(3.51) 19.08	(1.55) 3.82	85.14	14.85	1.77
	North	7.80	(7.88) 62.89	(3.85) 19.74	(2.13) 6.88	89.50	10.50	2.13
	South	7.42	(6.09) 40.49	(4.82) 29.06	(3.01) 16.14	85.67	14.32	1.62
	Total	8.45	56.72	22.01	9.17	87.88	12.12	
H-151	East	11.36	(6.15) 41.64	(3.76) 20.96	(3.24) 15.59	7.19	21.80	1.55
	West	5.40	(6.29) 49.99	(2.38) 12.18	(2.39) 10.13	68.49	31.50	2.30
	North	4.00	(8.09) 65.56	(2.15) 8.30	(2.41) 11.1	85.00	15.00	2.55
	South	6.30	66.23	9.30	11.40	86.93	13.07	2.00
	Total	6.77	55.86	12.68	12.06	79.65	20.34	
CD (0.05)						NS		

Values in parenthesis denotes $\sqrt{x} + 0.5$ transformed values.

Fig. 4 Intensity of fruit drop during the course of development



the subsequent observations. Towards the final stages of development Ratna produced longest fruits (10.3 cm), which was statistically on par with Prior (9.9 cm).

The maximum increase in length of fruits in all the varieties except in Muvandan occurred between 30 and 45 DAFS. Subsequently, the increment in length decreased which is clearly evident from Fig. 5 (a).

4.8.2 Fruit breadth

The data are presented in Table 9 (b).

Significant difference in terms of breadth could be noticed between the varieties during the third observation onwards. As in the case of length, H-151 showed the maximum breadth during the initial stage and Neelum during the second fortnight. During the next three observations, Prior had the maximum breadth. During the final stages of development Ratna recorded the maximum breadth.

Except in Neelum and Muvandan the maximum increase in breadth occurred between 30 and 45 days after fruit set. In Neelum the period between 60 to 75 days recorded the maximum and in Muvandan between 45 to 60 days (Fig. 5b).

4.8.3 Fruit circumference

The trend followed by circumference is shown in Table 9 (c).

During the initial stage of development maximum circumference was noted in Prior and this was on par with Alphonso. During the second and fourth fortnight Muvandan had the maximum value. Prior had the maximum circumference during the third, and fifth fortnight whereas Ratna had the maximum during the sixth and seventh fortnights.

Table 9(a). Fruit length (cm) during the course of development

Days after fruit set	Alphonso	Prior	Muvandan	Neelum	Ratna	H-151	CD (0.05)
15	1.6	1.5	1.5	1.3	1.3	1.7	0.3
30	2.9	2.8	2.4	2.9	2.6	3.1	NS
45	6.0	7.9	4.7	5.5	6.2	6.2	0.9
60	7.7	9.5	7.5	6.8	8.4	8.3	0.5
75	8.4	9.7	7.6	8.0	8.8	8.5	1.1
90	8.7	9.9	8.5	8.6	10.3	8.7	1.0
105					10.9	8.8	

Table 9(b). Fruit breadth (cm) during the course of development

Days after fruit set	Alphonso	Prior	Muvandan	Neelum	Ratna	H-151	CD (0.05)
15	1.2	1.1	1.1	1.0	1.0	1.3	NS
30	2.4	2.0	2.3	2.5	2.1	1.9	NS
45	4.5	6.1	3.8	3.3	4.2	3.8	0.5
60	6.0	7.3	6.3	4.7	6.0	4.8	0.6
75	6.0	7.5	6.4	7.0	6.9	5.5	0.8
90	6.8	7.7	7.1	7.3	7.8	5.6	0.5
105					8.5	5.6	

Table 9(c). Fruit circumference (cm) during the course of development

Days after fruit set	Alphonso	Prior	Muvandan	Neelum	Ratna	H-151	CD (0.05)
15	4.3	4.6	4.1	3.8	3.5	3.7	0.5
30	6.9	6.4	6.9	6.9	6.6	6.2	NS
45	13.3	16.7	12.5	12.3	13.3	11.7	1.2
60	17.3	21.3	21.5	14.8	18.5	14.1	0.9
75	18.5	22.3	22.0	20.7	19.2	17.2	NS
90	21.2	23.0	22.3	23.5	25.2	17.7	1.7
105					26.7	19.3	

Fig. 5 Physical characters of fruits during the course of development

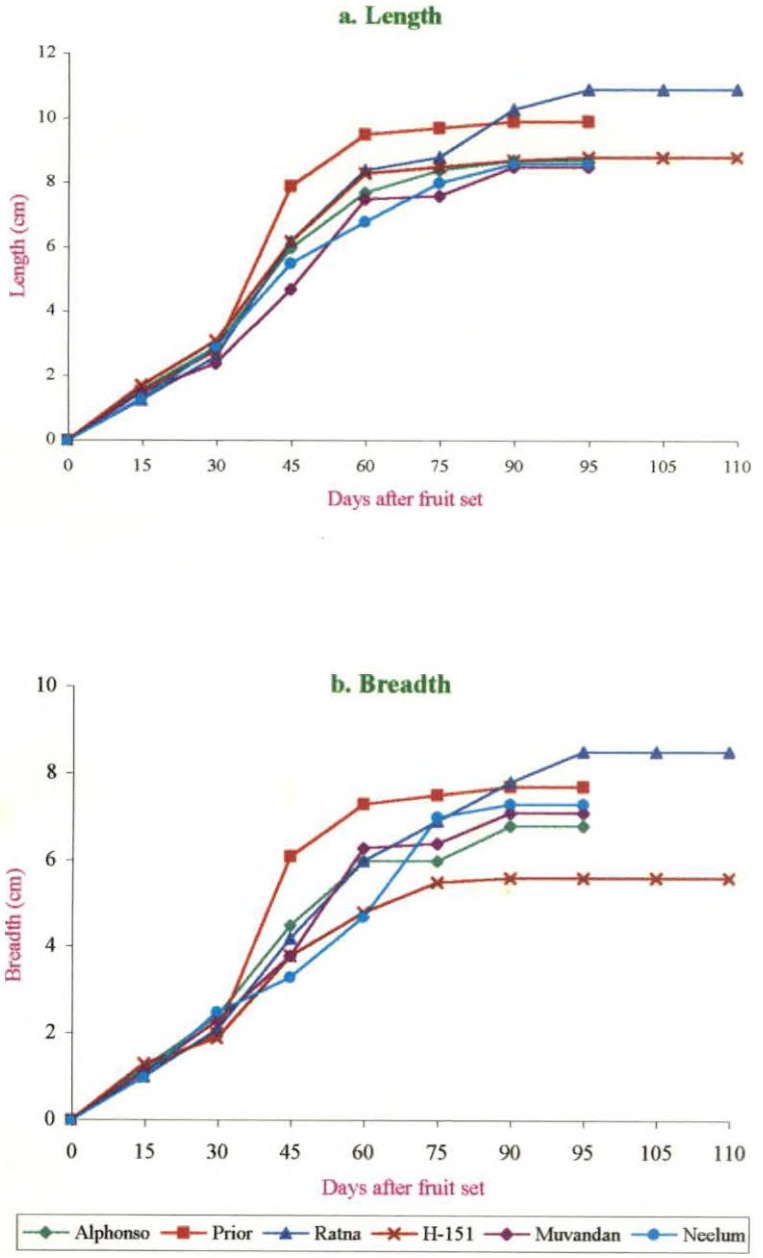
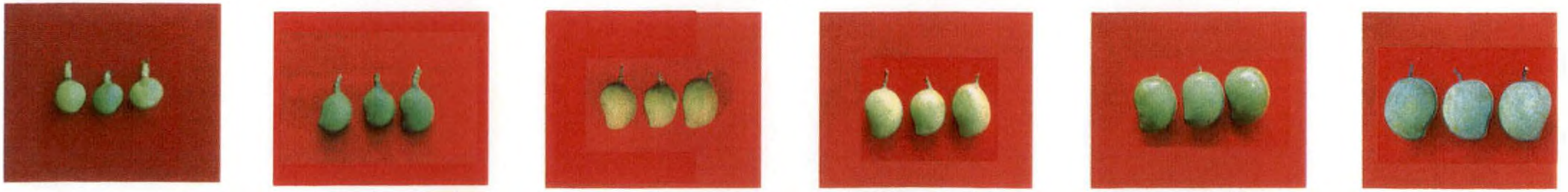


Plate - 3a

STAGES OF FRUIT DEVELOPMENT

ALPHONSO

PRIOR



MUVANDAN

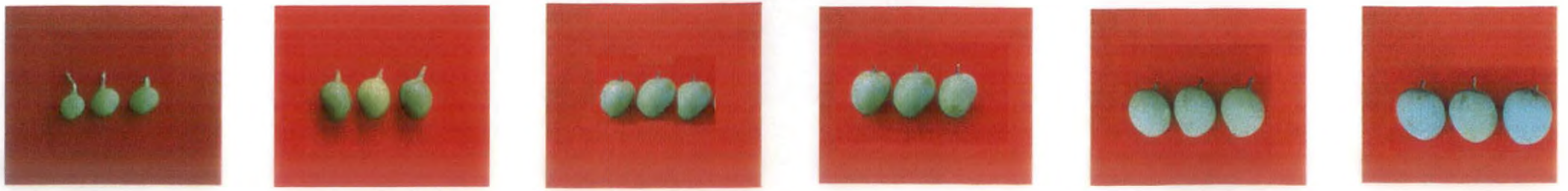
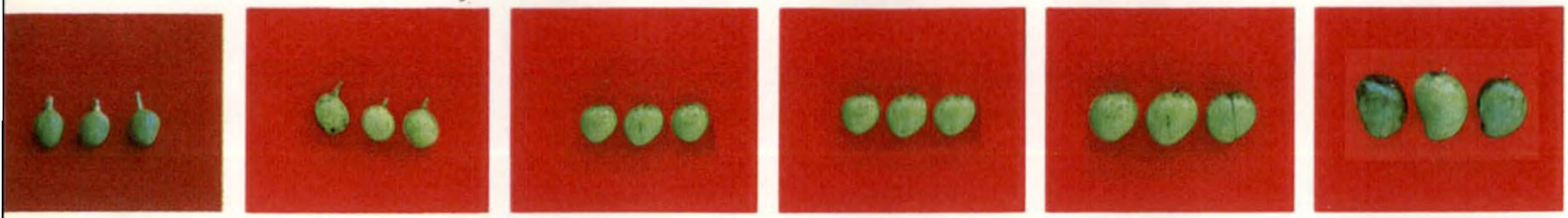


Plate-3b

STAGES OF FRUIT DEVELOPMENT

NEELUM



RATNA

H - 151

The varieties exhibited the same pattern of increase in fruit circumference as seen in fruit breadth.

The maximum increase in circumference was noted in between 30 to 45 DAFS in Alphonso, Prior, Ratna and H-151. In Muvandan, the maximum increase occurred in between 45 to 60 days after fruit set whereas in Neelum it was during 60 to 75 days after fruit set. Significant difference could be noticed between the varieties throughout the development period.

4.8.4 Fruit weight

Increase in fruit weight during the course of development is shown in Table 9 (d).

During all the stages of observations there was a significant difference in weight between the varieties.

The maximum weight was recorded by Muvandan followed by Alphonso, Neelum and Ratna during the first observation. Alphonso had the maximum weight during the second fortnight, which was on par with Muvandan, Neelum and Prior. During the third observation, Muvandan had the maximum weight followed by Prior. Prior had the maximum weight during the fourth and fifth fortnights. During sixth and seventh observation Ratna had the maximum weight. Even though Prior had the maximum values during the fourth and fifth observations, Ratna recorded the highest weight towards the end of development. The weight at the time of full maturity ranged from 156.12 g to 399.10 g.

No particular trend was shown by the varieties during the course of development in terms of increase in fruit weight. The maximum increase in weight was noticed during 60 to 75 days after fruit set in the case of Ratna, H-151 and Neelum. In Alphonso and Prior maximum increment was seen during 45 to 60 days after fruit set. The maximum increase in weight was in between 30 and 45 days after

fruit set in Muvandan (Fig. 5c). In Ratna, a second increase in weight was noted between 90 to 105 days which was not noted in other varieties.

4.8.5 Fruit volume

The change in fruit volume during course of fruit development is shown in Table 9 (e).

Fruit volume showed a trend similar to that of weight. During first and third observations Muvandan had the maximum volume and Alphonso during second fortnight. During fourth and fifth fortnights, Prior had the maximum volume whereas in the final stage Ratna recorded the highest value (355 g). The pattern of increase in volume was similar to that of fruit weight (Fig. 5d).

4.8.6 Specific gravity

The data pertaining to changes in specific gravity are presented in Table 9 (f).

In all the varieties specific gravity was initially less, then it gradually increased and towards maturity a decrease was noticed. Between 45 and 60 DAFS maximum specific gravity was noticed in all the varieties. Towards maturity a specific gravity of 1.01 was noticed in majority of the varieties.

4.9 Biochemical changes during the course of fruit development

4.9.1 Acidity

The acidity values during the course of fruit development in different varieties are shown in Table 10 (a).

All the varieties differed significantly in terms of fruit acidity throughout the observation periods. During all the stages of development Alphonso had the

Table 9(d). Fruit weight (g) during the course of development

Days after fruit set	Alphonso	Prior	Muvandan	Neelum	Ratna	H-151	CD (0.05)
15	1.29	1.09	1.45	1.27	1.25	1.05	0.12
30	7.16	5.47	6.74	5.80	4.74	4.40	1.84
45	55.47	88.42	106.00	28.13	37.21	39.69	11.92
60	116.81	215.92	125.84	70.32	142.95	76.84	15.54
75	149.80	258.30	175.59	171.59	278.00	121.68	38.89
90	174.35	259.41	220.15	268.12	358.56	142.35	10.49
105					399.10	156.12	

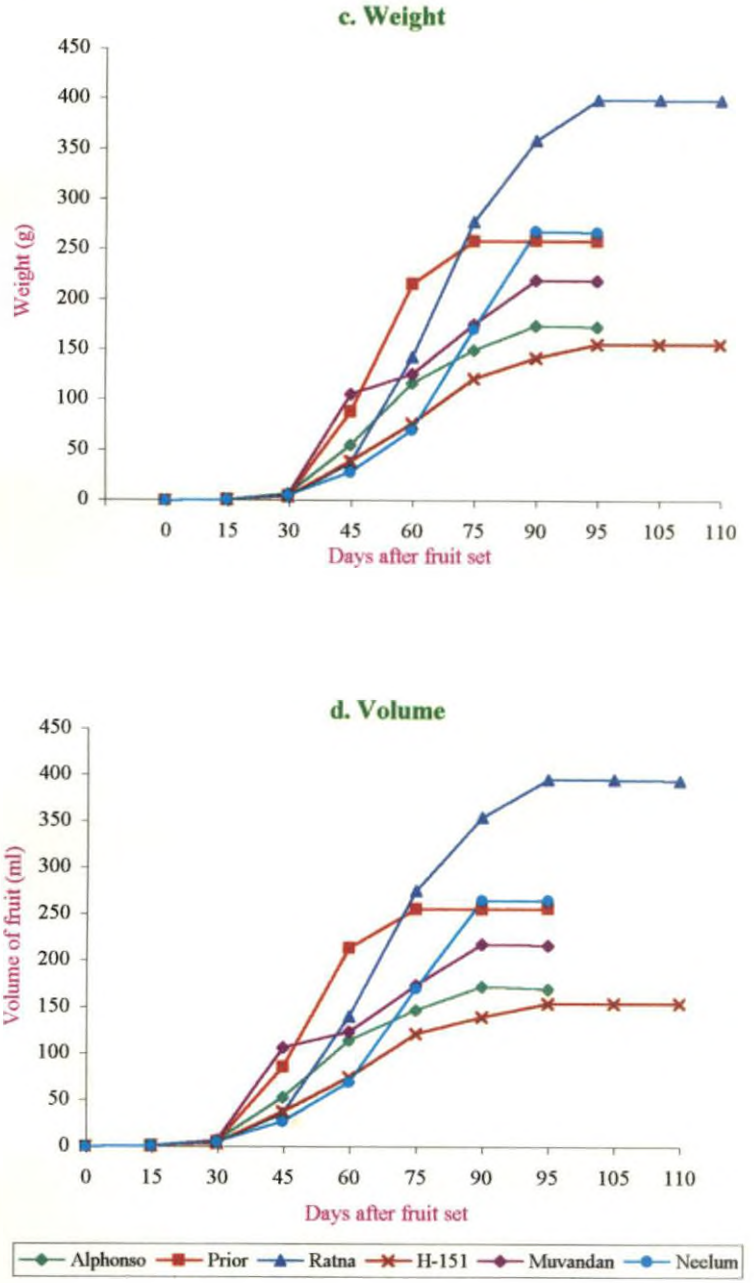
Table 9(e). Fruit volume (ml) during the course of development

	Alphonso	Prior	Muvandan	Neelum	Ratna	H-151	CD (0.05)
15	1.30	1.10	1.47	1.28	1.26	1.06	0.18
30	7.20	5.51	6.80	5.75	4.80	4.49	0.04
45	53.00	86.00	107.00	27.25	36.00	38.00	0.41
60	115.00	214.00	124.00	69.53	141.00	75.00	0.40
75	148.00	256.08	174.00	170.55	276.00	122.00	0.41
90	173.00	256.01	218.13	265.01	355.00	140.00	0.36
105					396.00	155.00	

Table 9(f). Fruit specific gravity during the course of development

Days after fruit set	Alphonso	Prior	Muvandan	Neelum	Ratna	H-151
15	0.99	0.99	0.99	0.99	0.99	0.99
30	0.99	0.99	0.99	1.01	0.99	0.98
45	1.05	1.03	0.99	1.03	1.03	1.04
60	1.02	1.01	1.01	1.01	1.01	1.02
75	1.01	1.00	1.01	1.01	1.01	1.00
90	1.01	1.01	1.01	1.01	1.01	1.02
105					1.01	1.01

Fig. 5 Physical characters of fruits during the course of development



maximum acidity except in first fortnight during which Ratna had the maximum value and in variety Muvandan the least acidity was noticed. The general trend noticed was that acidity in initial stages of development was high and gradually it decreased towards maturity (Fig. 6a).

4.9.2 Ascorbic acid content

The change in ascorbic acid is presented in Table 10 (b).

Throughout the development stages, varieties differed significantly in terms of ascorbic acid content. During the first and second fortnights Neelum had the highest ascorbic acid and H-151 during third, fourth and seventh fortnights. Alphonso had the maximum content during the fifth and sixth fortnights.

The minimum content of ascorbic acid was noticed in Prior almost during the whole development period. The general trend that could be noticed is that ascorbic acid content in the initial stage of development was very low, gradually a rise was noticed and again towards maturity there was a decrease (Fig. 6b).

4.9.3 Sugar content

Data on sugar content of fruits during the period of development from fruit set to ripening are shown in Table 10 (c).

During the first fifteen days sugar content was found to be negligible in all the six varieties. Sugar content reached the maximum at 90 days in Alphonso, Prior, Muvandan and Neelum, whereas in Ratna and H-151 the peak values were recorded at 105 days.

During second, third and fourth fortnights Prior had the maximum reducing sugar content and Alphonso during fifth and sixth fortnights. Ratna recorded the

Table 10. Biochemical changes during the course of fruit development

(a) Acidity (%)

Name of the variety	15 DAFS	30 DAFS	45 DAFS	60 DAFS	75 DAFS	90 DAFS	105 DAFS
Alphonso	0.867	1.567	1.110	0.930	0.570	0.500	
Prior	0.600	0.670	0.400	0.230	0.210	0.200	
Muvandan	0.540	0.620	0.380	0.320	0.310	0.290	
Neelum	0.740	0.730	0.620	0.550	0.510	0.490	
Ratna	1.270	0.860	0.930	0.710	0.630	0.570	0.420
H-151	0.670	0.640	0.530	0.500	0.450	0.330	0.300
CD (0.05)	0.310	0.390	0.090	0.090	0.060	0.120	

(b) Ascorbic acid (mg $100g^{-1}$)

Name of the variety	15 DAFS	30 DAFS	45 DAFS	60 DAFS	75 DAFS	90 DAFS	105 DAFS
Alphonso	1.300	3.000	42.100	51.700	104.500	83.060	
Prior	1.000	2.300	2.700	2.700	2.800	2.530	
Muvandan	6.000	7.700	10.700	14.000	15.700	11.270	
Neelum	7.000	79.600	53.400	22.200	20.200	19.100	
Ratna	1.300	2.500	104.700	42.700	33.300	33.100	32.000
H-151	3.700	69.700	155.000	96.700	72.300	70.900	66.300
CD (0.05)	2.180	5.370	2.918	2.730	2.520	1.400	

Table 10(c). Reducing and total sugar content (%)

Name of the variety	30 DAFS		45 DAFS		60 DAFS		75 DAFS		90 DAFS		105 DAFS	
	Reducing sugar	Total sugar	Reducing sugar	Total sugar	Reducing sugar	Total sugar	Reducing sugar	Total sugar	Reducing sugar	Total sugar	Reducing sugar	Total sugar
Alphonso	1.25	1.91	1.45	2.33	1.77	3.83	2.05	8.70	2.13	10.30		
Prior	1.39	1.82	1.74	1.66	1.85	4.73	2.04	7.40	2.09	9.54		
Muvandan	0.80	1.86	1.30	2.00	1.40	2.07	1.77	3.82	1.94	4.85		
Neelum	1.07	1.40	1.32	1.93	1.29	3.43	1.80	5.83	2.03	9.43		
Ratna	1.20	1.33	1.14	1.87	1.24	3.87	2.05	6.70	2.10	8.56	2.32	12.40
H-151	1.20	1.89	1.39	2.06	1.67	3.07	1.70	5.15	1.91	9.48	2.21	10.70
CD (0.05)	0.18	0.28	0.15	NS	0.28	0.52	NS	0.71	NS	0.06		

Table 10(d). Total chlorophyll content (mg g^{-1})

Variety	15 DAFS	30 DAFS	45 DAFS	60 DAFS	75 DAFS	90 DAFS	105 DAFS
Alphonso	0.758	1.170	1.480	1.730	0.835	0.625	
Prior	0.648	0.698	0.738	0.968	0.814	0.512	
Muvandan	0.585	0.763	0.968	1.550	1.310	0.912	
Neelum	0.656	0.756	0.989	1.860	1.500	1.410	
Ratna	0.825	1.190	1.580	1.860	1.840	1.740	1.530
H-151	0.990	1.580	1.620	2.000	0.730	0.690	0.561
CD (0.05)	0.320	NS	NS	1.516	1.191	0.220	

Fig. 6 Biochemical characters of fruits during the course of development

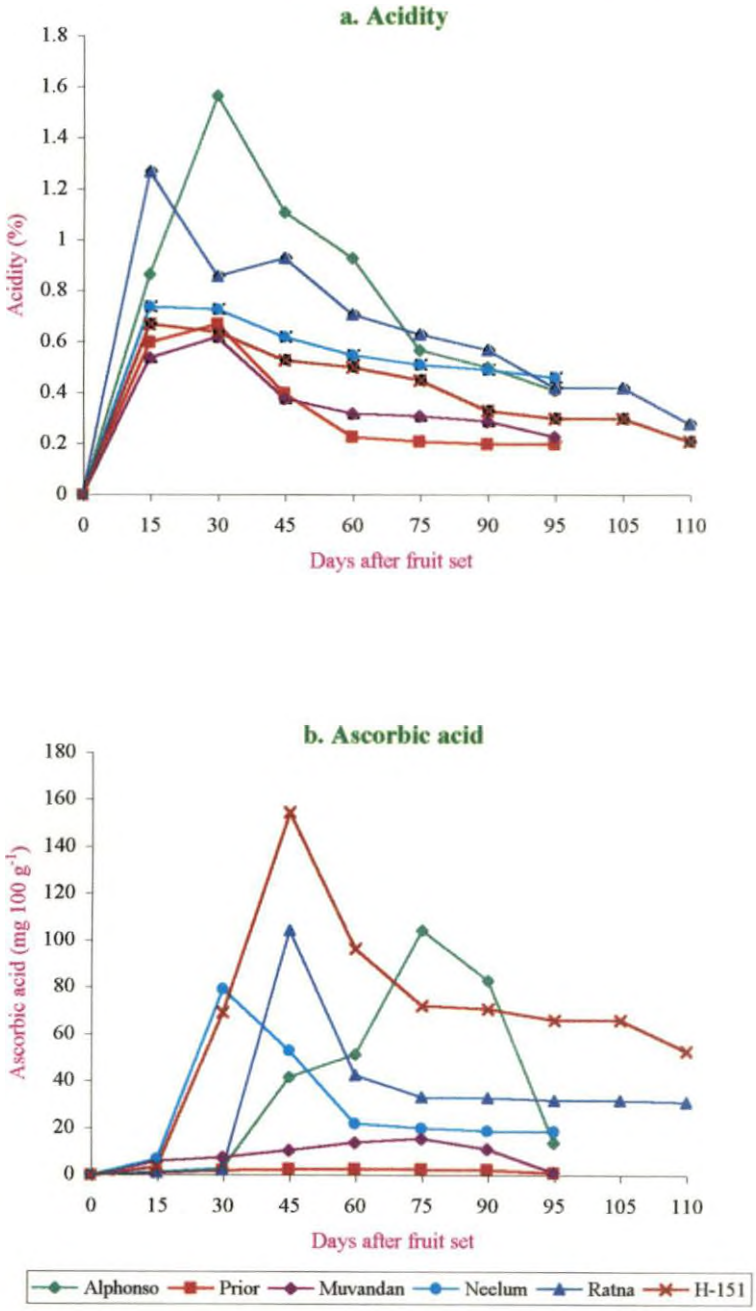
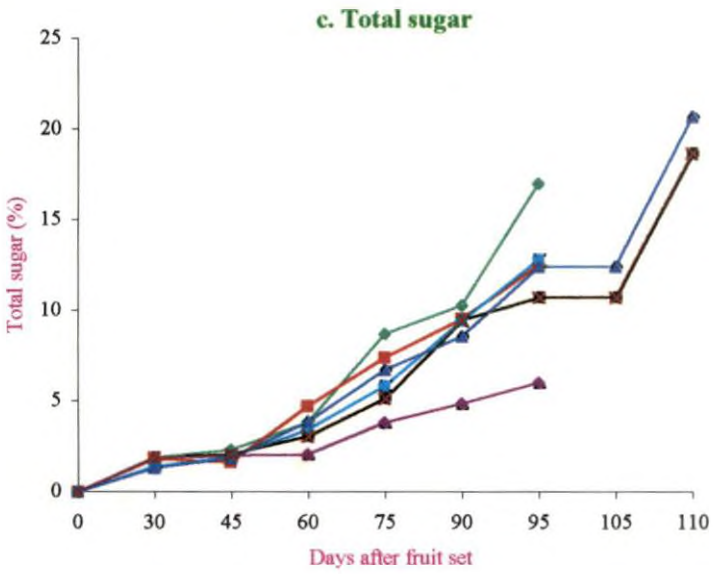
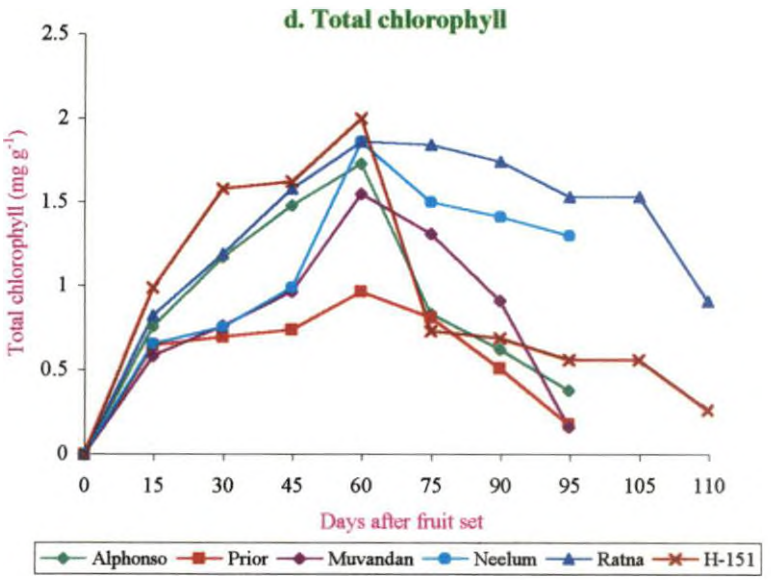


Fig. 6 Biochemical characters of fruits during the course of development





highest value in this parameter during the last observation. Upto 90 DAFS Alphonso recorded the maximum total sugar content except in fourth fortnight during which Prior had the maximum value. However final value was maximum in Ratna.

In Alphonso, Muvandan and Neelum the maximum accumulation of reducing and total sugars took place between 75 and 90 days after fruit set and in Ratna and H-151 the reducing sugar showed the maximum increase during this period. The total sugar content in Ratna and H-151 showed the maximum increase during 90 and 105 DAFS. In Prior the reducing sugar increased to the maximum in between 30 and 45 days and total sugar during 75 and 90 days after fruit set (Fig.6c).

4.9.4 Chlorophyll content

Total chlorophyll content in the developing fruits of all varieties exhibited a progressive increase till 60 DAFS followed by a decrease during the final development stages Table 10 (d). The difference between varieties was significant during 15, 60, 75 and 90 days after fruit set.

The maximum chlorophyll content was noticed in all the varieties at 60 DAFS (Fig. 6d).

During the first observation H-151 and Ratna recorded significantly superior values than others in terms of chlorophyll content. During 60 DAFS Neelum recorded the maximum chlorophyll content whereas Ratna was the topper in the list during 75, 90 and 105 DAFS. Towards the end of observation Prior and Alphonso had the least amount of chlorophyll content.

4.10 Ripe fruit characters

Fruits harvested at full maturity were allowed to ripen under room temperature and they were subjected to detailed observation and analysis. The time taken for ripening of fruits ranged from four to six days in all the varieties. The data

indicated that the physical parameters such as length, breadth and circumference did not show difference during the ripening period. However substantial changes in biochemical characters occurred in all the varieties during ripening. In general the trend was an increase in sugars and decrease in acidity, ascorbic acid and chlorophyll contents, which are evident from Fig. 8.

The results of physical and morphological characters described as per IBPGR descriptor and biochemical characters of ripe fruits are furnished in Tables 11 (a), 11 (b) and 11(c).

Data in Table 11(a) clearly indicate the superiority of Ratna in terms of fruit measurements such as length, breadth, weight, volume and circumference. All the other varieties had length, which were on par with each other. In the case of breadth, Ratna was followed by Prior and Neelum. The least value was noticed in H-151 (5.6 cm). Next to Ratna (398.01g) Neelum had the maximum weight (267.3 g). The smallest fruits were produced by H-151, which recorded the minimum weight, volume, breadth and circumference. However, in terms of length H-151 was on par with other varieties. No significant difference could be noticed between varieties in terms of specific gravity. Alphonso had a specific gravity of 1.02, H-151 (1.00) and the rest, 1.01.

Weight of stone was maximum in Ratna, but the percentage contribution to fruit weight by stone was the minimum here (12%). With regards to these parameters Muvandan was at the other extreme with minimum pulp, maximum stone and peel percentage (Fig. 7).

Fruits of Alphonso, Prior, Ratna and H-151were oblong in shape whereas Neelum and Muvandan produced round fruits (Table 11b). The colour of skin was yellow in Alphonso, Ratna and H-151 and green yellow in Prior, Muvandan and Neelum (Plate 4).

Table 11(a). Physical characters of ripe fruits

Name of variety	Length (cm)	Breadth (cm)	Circumference (cm)	Weight (g)	Volume (ml)	Specific gravity	Stone weight (g)	Stone percentage	Pulp weight (g)	Pulp percentage	Peel weight (g)	Peel percentage
Alphonso	8.70	6.80	21.20	173.53	170.00	1.02	22.55	13.00	126.67	73.00	24.29	14.00
Prior	9.90	7.70	23.00	258.30	256.53	1.01	40.09	14.00	192.45	73.00	34.75	13.00
Muvandan	8.50	7.10	22.30	219.45	217.00	1.01	31.33	20.00	163.38	58.00	33.58	22.00
Neelum	8.60	7.30	23.50	267.29	265.00	1.01	35.12	15.00	101.84	72.00	48.28	13.00
Ratna	10.90	8.50	26.70	398.01	395.00	1.01	47.76	12.00	298.51	75.00	51.74	13.00
H-151	8.80	5.60	19.30	155.66	155.00	1.00	25.57	16.00	112.17	72.00	20.23	13.00
CD (0.05)	0.83	0.58	1.57	42.12	7.45	NS	10.67		83.50		14.33	

Table 11(b). Morphological characters of ripe fruits

Name of the variety	Fruit shape	Colour of skin	Thickness of fruit skin	Skin texture	Flesh texture	Adherence of skin to pulp	Fibre content	Stalk insertion	Beak type	Sinus type	Slope of shoulders	Apex
Alphonso	Oblong	Yellow	Med. thick	Smooth	Soft	Present	Scarce	Vertical	Absent	Absent	Ending in a long curve	Obtuse
Prior	Oblong	Green yellow	Very thick	Rough	Firm	Present	Abundant	Vertical	Point	Shallow	Rising & then rounded	Obtuse
Muvandan	Roundish	Green yellow	Med. thick	Smooth	Juicy	Present	Abundant	Vertical	Absent	Absent	Ending in a long curve	Obtuse
Neelum	Roundish	Green yellow	Med. thick	Smooth	Firm	Present	Scarce	Vertical	Absent	Absent	Rising & then rounded	Rounded
Ratna	Oblong	Yellow	Med. thick	Smooth	Soft	Absent	Scarce	Vertical	Absent	Shallow	Rising & then rounded	Obtuse
H-151	Oblong	Yellow	Med. thick	Smooth	Firm	Present	Scarce	Oblique	Point	Shallow	Sloping abruptly	Obtuse

Fig. 7 Percentage contribution of stone, pulp and peel towards total fruit weight

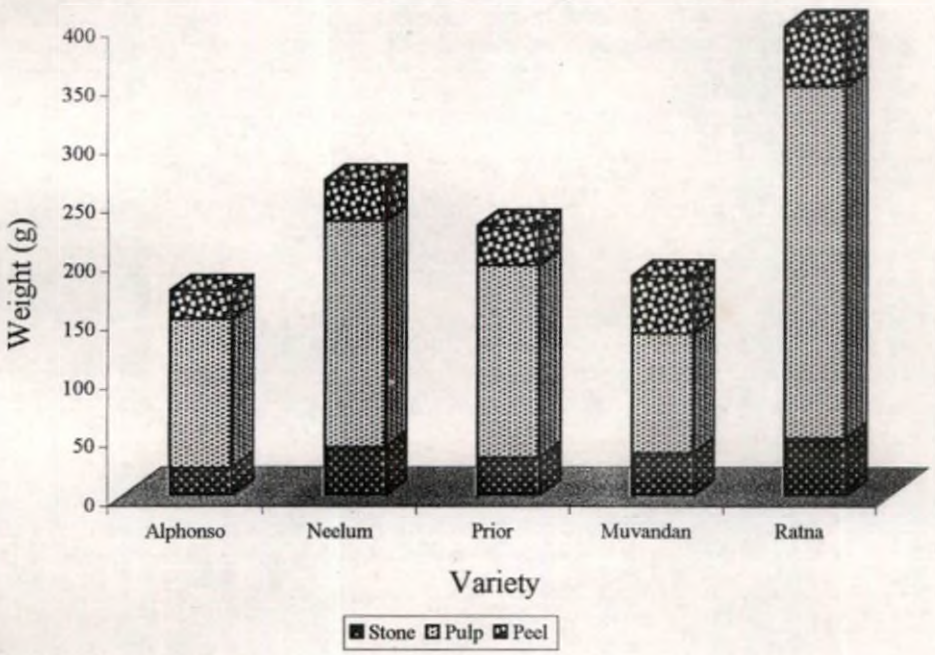
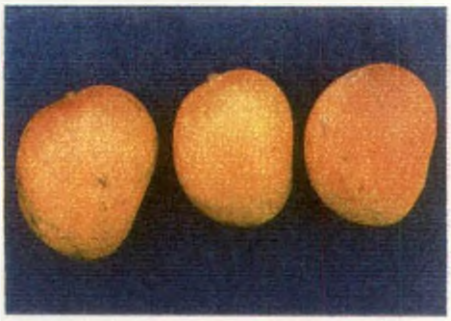
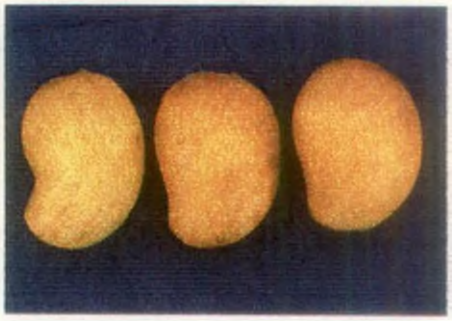


Plate- 4

RIPE FRUITS OF MANGO VARIETIES



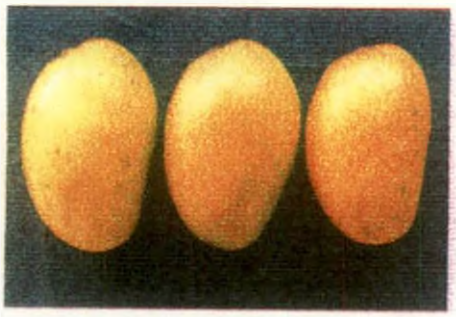
ALPHONSO



PRIOR

NEELUM

MUVANDAN



RATNA

H - 151

In all the varieties except Prior the skin was medium thick, in Prior the skin was very thick. Skin texture was smooth in all the varieties. Soft flesh texture was seen in Alphonso and Ratna, whereas Prior, H-151 and Neelum had a firm texture. Muvandan had a juicy flesh texture.

The skin was found adhering to the pulp in the case of all varieties except Ratna. Fruit fibre was found to be abundant in Prior and Muvandan whereas in all other varieties fibre was found to be scarce. The stalk insertion in all the varieties was vertical except in H-151 in which it was oblique.

Prior and H-151 had point type beak for the fruit whereas in all others it was absent.

Shallow sinus was present in Prior, Ratna and H-151, whereas it was absent in Alphonso, Muvandan and Neelum.

The slope of shoulder was rising and then rounded in the case of Prior, Ratna and Neelum. The slope was ending in a long curve in the case of Alphonso and Muvandan. The slope ended abruptly in the case of H-151. In all the varieties except Neelum the apex was obtuse and in Neelum the fruits were with round apex.

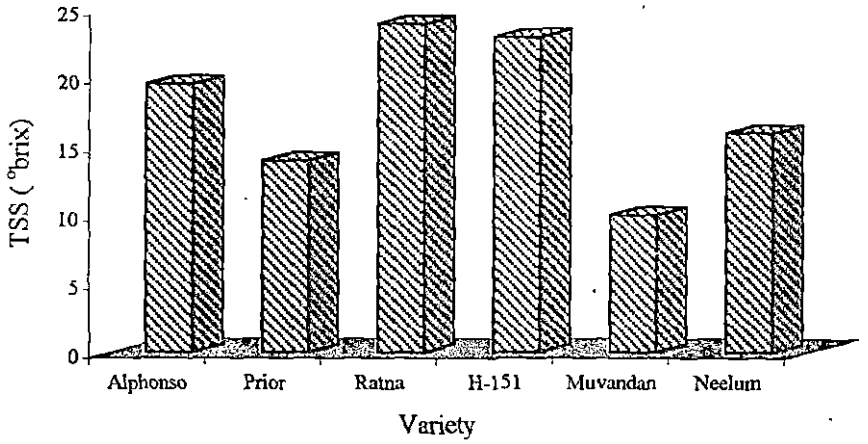
Results of the qualitative analysis of the fruits furnished in Table 11(c) and Fig. 8 indicates the superiority of Ratna in terms of TSS and sugar contents. In the case of TSS, H-151 was on par with Ratna, followed by Neelum and Alphonso (Fig. 8a). The minimum value for TSS (10) was recorded in Muvandan. The total and reducing sugar were found to be high in H-151 and Alphonso next to Ratna. Alphonso and Neelum fruits recorded higher acidity values whereas all other varieties were on par with regards to this parameter (Fig. 8b). Ascorbic acid was maximum in H-151 followed by Ratna as in Table 11(c). The sugar to acid ratio ranged from 26.08 to 88.86. H-151, followed by Ratna had the maximum sugar to acid ratio. Muvandan and Neelum had the least ratio. Minimum chlorophyll content

Table 11(c). Biochemical characters of ripe fruits

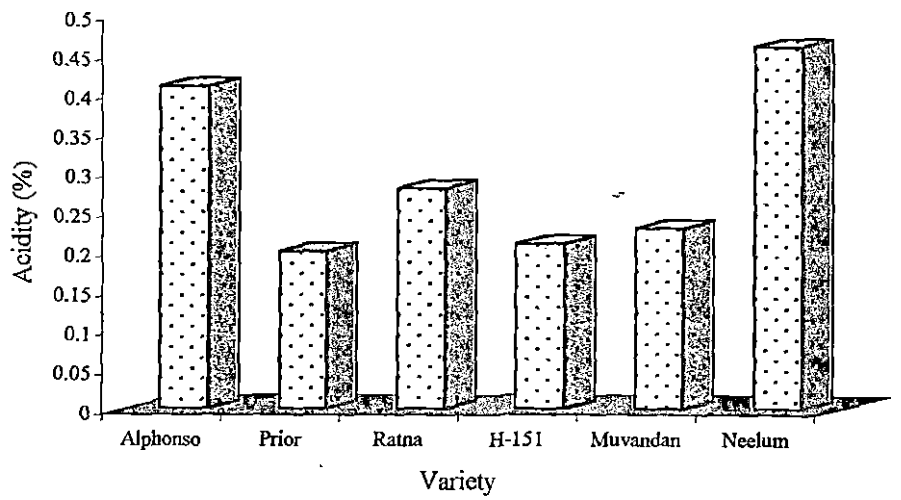
Name of variety	Total soluble solids (%)	Total sugar (%)	Reducing sugar (%)	Acidity (%)	Ascorbic acid (mg $100g^{-1}$)	Sugar/acid ratio	Total chlorophyll (mg g^{-1})
Alphonso	19.60	17.00	2.43	0.41	14.01	42.50	0.38
Prior	14.00	12.50	2.23	0.20	1.23	62.50	0.18
Muvandan	10.00	6.00	2.35	0.23	1.50	26.08	0.17
Neelum	16.00	12.80	2.29	0.46	18.70	27.83	1.30
Ratna	24.00	20.66	2.97	0.28	31.30	73.78	0.91
H-151	23.00	18.66	2.66	0.21	53.00	88.86	0.27
CD (0.05)	1.44	1.14	0.31	0.18	2.18		0.43

Fig.8 Biochemical characters of ripe fruits

a. TSS



b. Acidity



was noticed in Muvandan and Prior followed by H-151 and Alphonso. Neelum had the maximum value.

4.11 Organoleptic qualities of fruits

The data on organoleptic qualities are presented in Table 12. The varieties differed significantly with respect to all the characters given in the scorecard.

A significant difference was noted in flavour between the varieties. The highest score for flavour was obtained for Ratna and the lowest for Muvandan.

In the case of acidity the highest score was obtained for Neelum and lowest for Ratna.

The highly preferred variety with respect to sweetness was H-151 followed by Ratna and the least preferred was Muvandan.

The highest score for aroma was noted in Ratna and the minimum score was for Muvandan.

Alphonso was the most astringent and the least astringent was Ratna, Muvandan and Neelum.

Even though the highest score for flavour and aroma was for Ratna, in overall acceptability Prior was rated the best followed by Ratna. Neelum was the least preferred one.

4.12 Shelf life of fruits

The results are shown in Table 13.

Among the varieties, Prior and H-151 were found to have the longest shelf life (13 days) while Muvandan had the least (7 days). The shelf life of other varieties ranged from seven to ten days.

Table 12. Organoleptic evaluation of fruits

Name of variety	Flavour	Acidity	Sweetness	Aroma	Astringency	Overall acceptability
Alphonso	342.00	314.00	349.00	143.14	459.00	339.80
Prior	282.50	345.00	349.00	394.3	359.00	774.40
Muvandan	70.00	255.00	77.50	75.00	240.00	75.00
Neelum	194.00	435.00	191.00	191.00	240.00	165.10
Ratna	507.00	225.00	482.50	481.90	240.00	476.00
H-151	434.50	255.00	555.50	393.80	297.00	351.30
Kruskal Wallis 'H' value	45.37	16.76	44.24	45.81	24.75	42.36

Table 13. Shelf life of fruits

Name of variety	No. of days
Alphonso	9
Prior	13
Muvandan	4
Neelum	7
Ratna	10
H-151	13

4.13 Tree characters

The results are presented in Table 14.

The height of trees ranged from 3 to 7.2 m. The tallest was Ratna and the smallest was H-151. The range for girth was from 0.40 to 0.86 m. Maximum girth was observed for Ratna and the minimum in Muvandan (Plate 5).

In all the trees the number of primary branches was one. Number of secondary branches was maximum in Neelum and the minimum number was for Kalapady. The maximum number of tertiary branches was noticed in Alphonso and Prior and the least in H-151.

In Ratna the trees were having maximum spread in both directions when compared to the other varieties. Muvandan and H-151 trees were having the minimum spreading nature.

The yield per tree in terms of number of fruits and fruit weight shown in Table 16 indicates wide variation among the varieties. Prior was the highest yielder giving 305 fruits per tree accounting to 78 kg. The hybrid H-151 was the second highest producer in terms of number of fruits, whereas in terms of fruit weight Ratna occupies this position. Alphonso recorded the minimum yield per tree both in terms of number of fruits and weight (Fig. 9).

4.14 Total heat unit requirement of varieties

The heat units in terms of cumulative degree days was calculated for all the varieties during the period from flowering to fruit maturity. The results revealed the variation between varieties with respect to heat unit requirement. The maximum heat units were required for H-151 (1493.55 day °C) followed by Ratna (1491.10 day °C). Prior required a heat unit of 1415.07 day °C. Alphonso, Muvandan and Neelum were

Table 14. Tree characters

Name of the variety	Height (m)	Girth (m)	No. of primary branches	No. of secondary branches	No. of tertiary branches	Spread		Yield per tree	
						E-W (m)	N-S (m)	No. of fruits	Yield (kg)
Alphonso	4.30	0.69	1.00	3.30	13.00	4.10	4.80	45.00	7.80
Prior	5.50	0.69	1.00	3.30	13.00	4.10	4.80	305.00	78.80
Muvandan	2.80	0.40	1.00	2.30	80.00	3.60	2.90	101.60	22.30
Neelum	3.90	0.50	1.00	3.50	115.00	4.30	4.50	93.00	24.90
Kalapady	4.40	0.69	1.00	2.00	10.00	5.70	5.40	-	-
Ratna	7.20	0.86	1.00	3.30	113.00	7.80	7.70	139.60	55.60
H-151	3.00	0.60	1.00	2.70	67.00	3.40	3.70	216.00	33.60
CD (0.05)	1.66	0.17				2.93	2.42	NS	29.38

Fig. 9 Fruit yield

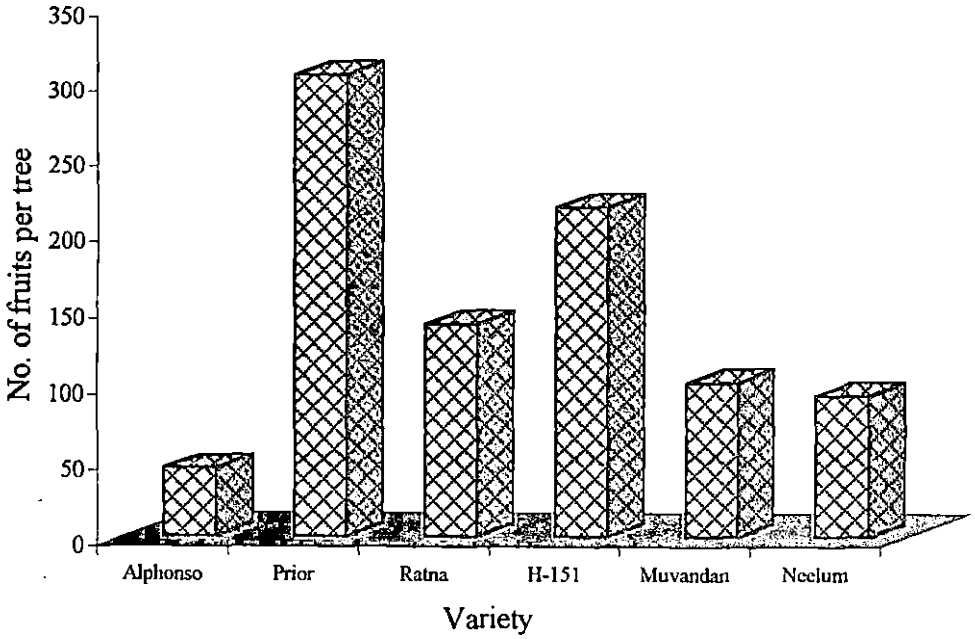


Plate-5

TREES OF MANGO VARIETIES

ALPHONSO

PRIOR

MUVANDAN

NEELUM

KALAPADY

RATNA

H- 151

the varieties, which required the least amount of heat units (Table 15). The hybrids matured later than other varieties and required more heat units.

4.15 Correlation studies

4.15.1 Between flush length and weather parameters

Flush length in Alphonso and Muvandan showed a positive correlation with maximum and minimum temperature whereas Kalapady showed a negative correlation. Neelum and Prior showed a positive correlation with bright sunshine hours. A positive correlation was shown by Ratna with relative humidity whereas a negative correlation was shown by Prior and Muvandan. With rainfall a negative correlation was observed in the case of Prior and a positive one by Kalapady. No correlation was shown by H-151 (Table 16).

4.15.2 Between vegetative and fruit characters

Correlation studies were carried out between characters such as yield, fruit set, leaf area, chlorophyll content, stomatal number, fruit drop, tree girth, height etc and are expressed in Table 17.

Fruit yield was found to be positively correlated with inflorescence per square metre but a negative correlation was found with leaf number. Nitrogen content during vegetative phase had a positive correlation with area of leaves, tree girth and height. Leaf area was positively correlated with tree girth. Flush length and leaf number was found to be positively correlated with each other. Chlorophyll content of leaves had a positive correlation with stomatal count. A negative correlation was worked out between fruit drop and final fruit set. A positive correlation was noted between tree girth and height. Fruit weight and volume also showed a positive correlation.

4.16 Stages of growth and corresponding weather parameters

The variation in weather parameters and the different phases of growth such as flushing, flowering and harvest during the observation period is shown in Fig. 10.

Table 15. Total heat unit requirement of varieties

Name of variety	Date of peak flowering	Date of maturity	Number of days	Total heat units (days degree centigrade)
Alphonso	08/01/2001	08/04/2001	90	1251.92
Prior	20/01/2001	20/04/2001	90	1415.07
Muvandan	02/02/2001	02/05/2001	90	1277.90
Neelum	04/04/2001	04/07/2001	90	1218.20
Ratna	10/02/2001	25/05/2001	105	1491.10
H-151	05/02/2001	20/05/2001	105	1493.55

Table 16. Correlation between flush length and weather parameters

	Alphonso	Prior	Muvandan	Muvandan	Neelum	Neelum	Kalapady	Kalapady	Ratna	H-151
Maximum temperature (° C)	0.554*	0.027	0.515*	0.232	-0.086	0.239	-0.112	-0.644**	0.270	-0.178
Minimum temperature (° C)	0.448*	0.101	0.300	0.046	0.269	0.390	-0.212	-0.494*	0.355	-0.126
Relative humidity (%) 07.30 hrs	-0.367	-0.634**	-0.581**	-0.177	0.103	-0.401	0.169	-0.279	0.472*	0.107
Relative humidity (%) 14.30 hrs	-0.240	-0.671**	-0.533*	-0.256	0.097	-0.177	0.367	0.147	0.405	0.178
Bright sunshine hours (hrs day^{-1})	-0.049	0.626**	-0.237	0.235	0.601**	0.161	-0.163	-0.359	0.096	-0.206
Rainfall (mm)	-0.397	-0.580**	-0.274	-0.196	-0.299	-0.104	0.223	0.504*	0.000	0.181

* Significant at 5% level

** Significant at 1% level

Fig. 10. Stages of growth and corresponding weather parameters

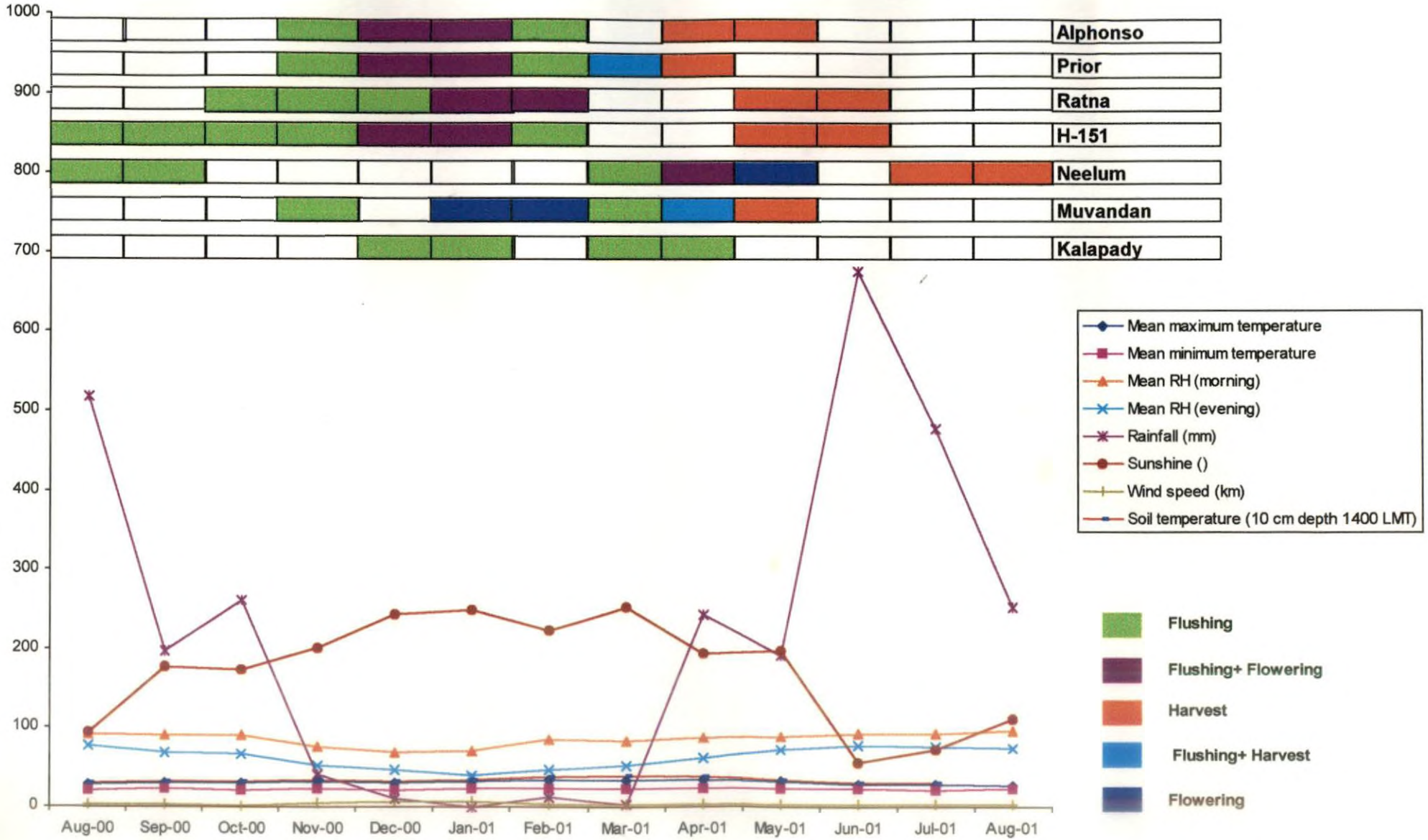


Table 17. Correlation between important characters

	Yield	Leaf area	Leaf no.	Flush length	Stomatal no.	Leaf dry wt.	Leaf moisture %	N vegetative	N-flowering	Sex ratio	Chlorophyll	Initial fruit no.	Final fruit set %	Inflo. m-2	Fruit drop %	Fruit wt.	Fruit vol.	Specific gravity	TSS	Acidity	Tree Girth	Tree Height
Yield																						
af area	0.14																					
Number	-0.579*	-0.146																				
h length	-0.179	-0.091	0.614**																			
omatal number	-0.095	0.036	-0.069	-0.573**																		
af dry veight	-0.197	0.475*	0.094	-0.011	0.203																	
Leaf isture %	0.189	0.28	-0.272	-0.138	0.308	0.402																
N – getative	-0.111	0.691**	-0.139	-0.078	-0.146	0.293	0.256															
lowering	0.199	0.205	-0.118	0.236	-0.648**	-0.342	-0.256	0.201														
ex ratio	-0.354	-0.056	0.189	-0.346	0.706**	0.136	0.098	-0.211	-0.463													
orophyll	-0.274	-0.072	-0.173	-0.359	0.545*	0.343	0.068	-0.057	-0.390	0.425												
ial fruit umber	-0.172	0.333	0.022	0.035	0.031	-0.036	-0.197	0.369	0.294	0.147	0.172											
l fruit set %	0.371	-0.272	-0.417	-0.379	-0.054	-0.417	-0.402	-0.226	0.255	-0.012	0.175	-0.165										
flo. m-2	0.653**	0.459	-0.308	0.204	-0.195	-0.124	0.178	0.197	0.555*	-0.505*	-0.306	0.146	0.025									
t drop %	-0.319	0.266	-0.424	0.393	0.053	0.411	0.402	0.219	0.247	0.02	-0.182	0.168	-0.999**	-0.018								
it weight	0.107	0.221	-0.531*	-0.244	-0.259	-0.254	-0.146	0.513*	0.567*	-0.283	0.116	0.441	0.449	0.292	-0.45							
t volume	0.229	0.286	-0.603**	-0.272	-0.239	-0.315	-0.109	0.515	0.595*	-0.262	0.103	0.426	0.448	0.393	-0.45	0.964**						
Specific gravity	-0.449	-0.125	0.111	0.083	-0.209	0.266	-0.101	0.134	0.039	-0.172	0.046	0.074	0.014	-0.316	-0.012	0.312	0.056					
TSS	-0.026	0.517*	-0.48	-0.606**	0.172	0.054	0.006	0.620**	0.264	0.148	0.313	0.414	0.32	0.1	-0.328	0.773**	0.786**	0.095				
cidity	-0.520*	-0.131	0.414	-0.271	0.434	0.375	-0.063	-0.199	-0.647**	0.610**	0.283	-0.209	-0.211	-0.788**	0.202	-0.571*	-0.620**	0.069	-0.104			
e Girth	0.057	0.504*	-0.405	-0.535*	0.381	0.336	0.406	0.631**	-0.126	0.123	0.189	0.246	-0.121	0.205	0.116	0.302	0.347	-0.093	0.609**	-0.022		
e Height	0.263	0.429	-0.349	-0.278	0.303	0.273	0.548*	0.646**	-0.264	-0.013	0.11	0.061	-0.201	0.276	0.197	0.202	0.279	-0.239	0.389	-0.156	0.830**	

* Significant at 5%

** Significant at 1%

Discussion

5. DISCUSSION

In India mango has been acknowledged as an excellent fruit, which is relished by children and adults alike. Perhaps nowhere in the world mango commands the same popularity as in India. The unique taste and flavour developed in some of the top varieties of mango in India, imparting to the fruit a quality par excellence is unsurpassed anywhere in the world. However, it must be acknowledged that real economic importance of mango at present lies in its tremendous local consumption rather than its export value, although it has a great potential as an item of export both as fresh fruit and in its processed form.

For the successful crop production of perennial fruit trees, a proper understanding of growth and development patterns of plants in relation to prevailing environmental conditions has got a great significance. The present study was aimed to gather basic information on the morpho-physiological and biochemical aspects of vegetative growth, flowering and fruit development of selected mango varieties and hybrids and to evaluate their performance when grown under the humid tropical conditions of Kerala. The results obtained are discussed in this chapter.

Flushing characters

The flushing of mangoes in general takes place from September to February under Kerala conditions. The present investigation indicated that in Alphonso, Prior, Ratna and H-151 flushes were produced during the months of October – November and the flushing period extended for two to three months, whereas in Muvandan, Neelum and Kalapady two distinct flushes were seen first during the normal season as in the other varieties and the second during March – April. The pattern of flushing in mango has been studied by a number of workers (Singh, 1959, Krishnamoorthy *et al.*, 1961). According to Singh (1977) shoot growth in mango is more or less continuous under south Indian conditions rather than in distinct flushes whereas it is in distinct flushes under north Indian conditions. Contrary to this, Chacko (1984) opined that the growth of mango trees is not continuous but is periodic. However, the observations made here clearly indicated the varietal variations in terms of this

character. Hence the pattern of flushing may be considered more as a varietal nature. Similar opinion that flushing may also be a varietal characteristic has been given by Singh (1977).

A definite relationship between the flush growth in terms of length and number of leaves with the tree height and girth could not be made out from the results. Muvandan exhibited two distinct flushing with longer flushes but the trees were dwarf (2.8 m) when compared to other varieties, whereas Ratna with a single extended flushing with medium longer shoots resulted in taller trees with maximum girth (7.2 m and 0·86 m respectively). Kurian and Iyer (1992) have pointed out that number of vegetative flushes produced per year could not be considered as the correct indicator of tree size or vigour.

The shoot growth pattern in terms of length and number of leaves was recorded in all the varieties. The results indicated the significance of the first week after visible signs of flushing. The maximum increase in length and number of leaves of the shoots occurred during this period, which was to the tune of about 90 per cent in all the varieties. The growth of the flushes ceased in four weeks time after which the maturation stage started instead of increase in length and number of leaves. The growth of shoots in different sides of the tree also did not exhibit significant difference.

Vegetative characters

The morphological description of the leaves of different varieties as per the IBPGR descriptors was carried out and the results are in conformity with the description given for the particular varieties. The size of the leaves varied from variety to variety. Ratna was the variety with longer leaves and Neelum and Kalapady with smaller leaves. Stomatal count indicated that Alphonso leaves had the maximum number of stomata (788.58 mm^{-2}) followed by Prior and Muvandan had the minimum count (493.90 mm^{-2}).

A good correlation has been worked out between the frequency of stomatal distribution and vigour of the plants (Chakladar, 1967). Muvandan had the least stomatal count and was dwarfest among all the varieties. A negative correlation between stomatal number and flush length also could be worked out in the present investigation. This was in accordance with Majumdar *et al.* (1981) who have reported that lower stomatal density is an indication of dwarfness. The reason for increased vigour of the plant due to the increase in stomata may be due to the increase in photosynthate formation, which eventually led to the enhanced vigour of the plant (Agarwal, 1986). Moreover, positive correlations between stomatal number and chlorophyll content, leaf dry weight and leaf area obtained here again confirmed the view of Agarwal (1986).

Accumulation of maximum amount of nutrients in the leaves was seen during the vegetative phase and as the tree passed through the stages of flowering, fruit development etc. a decrease was noticed in the nutrient content. The depletion of nutrients indicated that the growing organs essentially require the elements for the growth and development (Pathak and Pandey, 1978). A similar report was given by Chadha *et al.* (1984) in which he stated a decline in nutrient content at post harvest stage, which was due to the earlier translocation of nutrients into the developing fruits.

Flowering characters

Mangoes start flowering by November – December in Kerala. In the present study Prior and H-151 showed commencement of flowering by December followed by Ratna, Alphonso and Muvandan, which flowered during January. Neelum, a well known late variety, flowered during April – May only. The flowering season may be influenced by weather conditions to a certain extent, but under any circumstance Neelum exhibits late flowering and hence this expression may be believed to be controlled by varietal characters mainly.

The flowering intensity can be indicated either by means of number of inflorescence per square metre or by the number of flowers per inflorescence. The number of inflorescence per square metre varied from 7.00 to 23.67 in Neelum and Prior respectively. The number of male flowers per inflorescence ranged from 156 to 441. Uthaiah *et al.* (1988) had noted that under coastal Karnataka conditions Alphonso had 428 male flowers per panicle. Mukherjee (1953) had reported that depending on the variety the total number of flowers in a panicle may vary from 1000 to 6000.

In the present study a positive correlation between the number of inflorescence per square metre and yield in terms of number of fruits could be obtained. Percentage of hermaphrodite flowers ranged from 15.77 to 44.39 in Muvandan and Alphonso, respectively. Naik and Rao (1943) had reported that the percentage of perfect flowers varied from 16.41 in Neelum to 3.17 in Alampur Baneshan. According to Popenoe (1917) the percentage of perfect flowers varies from two to seventy according to the variety.

Percentage of bisexual flowers and bearing capacity are positively correlated in mango according to Majumdar and Mukherjee (1961). In the present study such a definite relation between percentage of bisexual flowers and yield both in terms of number or weight of fruits could not be observed. Yield per tree was the lowest in Alphonso (Table 14) with the maximum percentage of bisexual flowers. Hence the statement of Chadha (1963) that though better sex ratio resulted in better fruit set, the final yield in mango was not always proportionate, holds good here.

The inflorescence length ranged from 15 to 30 cm. Thimmappaiah and Suman (1987) also found that panicle size varied from 11 to 42 cm. According to Narayanaswamy (1982) the range of length and breadth was from 21.33 to 34.0 and 18 to 32 cm respectively. On comparing Ratna and H-151 with their parents, the size of inflorescence was found to be superior.

Fruit set and drop

Initial set ranged from 5.39 to 8.45 fruits per inflorescence in different varieties. Ratna recorded the maximum fruit set initially followed by Prior, H-151 and Alphonso. The pattern of fruit drop in all the varieties was almost the same as clearly seen in Fig. 4. The maximum drop of fruits to the tune of 50 per cent occurred during the first 15 days. With regards to the overall drop percentage ranging from 79.65 in H-151 to 89.93 in Alphonso the varieties did not show significant variations.

Naik and Rao (1943) had opined that the first two weeks have been the most important from the point of view of fruit shedding in mango. In the study also maximum fruit drop occurred during this period. According to Thimmappaiah and Suman (1987) fruit set at 15th day ultimately determined yield and was significantly correlated with retention and yield. The initial drop was principally due to the internal competition between large number of small fruits initially formed and some incompletely fertilised ovules also dropped. Later on the drop was due to the competition among the rapidly growing fruit. The fruits which dropped were shrivelled in appearance. Shrivelling might have occurred due to the disorganisation of the cortical tissue at the abscission zone, which interrupted the supply of water and other food material to the fruit while it stuck to the parent panicle on account of unusual mechanical strength of the connecting tissues and continued to sustain physiological losses.

The overall perusal of the observations recorded on the fruit set, drop and yield indicated that the varieties Prior, Ratna and H-151 were superior to others. In terms of initial fruit set and yield as fruit number and weight these three varieties found places in the top of the list.

Growth and development of fruits

Growth of the fruits can be best measured by characters such as weight, volume and measurements including length, breadth and circumference. The present

study revealed that varieties Alphonso, Neelum, Prior and Muvandan took 90 days to reach full maturity whereas for the hybrids Ratna and H-151, the duration for fruit maturity was a little bit more, 105 days. Varietal variation in the duration for fruit maturity has been reported by many workers. Dashehari, Langra and Mallika fruits took 92, 84 and 96 days respectively to be ready for harvest (Shukla and Bajpai, 1978, Tandon and Kalra, 1983) whereas, Irwin fruits required 120 days to reach maturity under Taiwan conditions (Wang and Shiesh, 1990). The graphical representation of the physical parameters of fruits during the course of development revealed the single sigmoid pattern. A number of earlier workers have indicated that the mango fruit typically follows a single sigmoid growth pattern (Singh *et al.*, 1937, Mukherjee, 1959 and Wang and Shiesh, 1990). The maximum increase in the fruit measurements took place mainly between 45 and 60 days after flowering. Thereafter the rate of increase in the fruit parameters decreased. However, in Ratna a slight difference was noticed in the present study as a second small peak in the growth was noticed towards the end of maturity. A proportionate increase in weight in comparison to volume was noticed in all the varieties during the course of development, which might be clearly indicating the accumulation or synthesis of food materials within the fruit. Shukla and Bajpai (1978) reported a similar pattern of weight and volume increase in developing Dashehari mango fruits.

Specific gravity computed as the ratio between weight and volume of the developing fruits (Table 9.6) indicated a similar pattern in all the varieties. Initially the values were lower, exhibited a rise reaching maximum by 45th day followed by a drop and steadiness. This also indicated the sigmoid growth pattern. Gangwar and Tripathi (1973) have reported a similar trend in specific gravity of developing fruits of Dashehari.

The mango fruits undergo a series of compositional changes during development. Titrable acidity was at its peak during the initial stages of development, which followed a drop gradually towards maturity. Throughout the development period, Alphonso fruits recorded the maximum acidity values. This

result is in conformity with the report of Kundu and Mitra (1997) who observed that fruit acidity increased initially and then declined in cultivars Bombay and Himsagar.

Sugars are the most important fractions of carbohydrates present in fruits and the change in their content contribute to major biochemical activities in the fruits during development. The results obtained in this study showed a steady increase in total sugar content during the course of fruit development in all the varieties. Lakshminarayana *et al.* (1970) have also reported continuous increase in sugar content of mango fruits throughout the period of growth.

Mango is a rich source of vitamin C. Though the pattern of ascorbic acid content in the developing fruits of different varieties exhibited similarity in the present study, absolute values showed significant variations. In all the varieties, the peak ascorbic acid content was reached by 30^{th} day after flowering followed by a decline and then steadiness as seen in Fig. 3(b). This result was in conformity with the report by Lakshminarayana *et al.* (1970) which revealed that the apparent ascorbic acid content of Alphonso fruits increased soon after fruit set reaches peak in the fifth week, then declined and later remained more or less steady up to harvest.

Ripe fruit characters

Mature fruits of all the varieties were harvested and allowed to ripen under room temperature for recording detailed observations on morphological, physical and biochemical characters. The time taken for the fruits to ripen in all the varieties was almost the same ranging from four to six days.

Fully ripened fruits were taken for recording the morphological characters as per the IBPGR descriptor. Fruit shape, colour, peel thickness, skin texture, quantity of fibre, beak type, nature of sinus and shoulders were noted. Varieties exhibited a wide variation in the morphological characters. The morphological characters of the varieties in the present study were in conformity with the descriptions given by Naik and Gangolly (1950), Kannan (1982) and Salvi and Gunjate (1988).

Physical characters of fruits such as length, breadth, weight, volume and specific gravity were recorded. The size of the fruits in terms of length and breadth showed wide variation among the varieties. The length of the fruits ranged from 8.5 – 10.9 cm and breadth from 5.6 – 8.5 cm. Salvi and Gunjate (1988) have reported the length and breadth of Ratna fruits as 10.69 and 8.36 cm respectively. In the present study Ratna fruits recorded almost the same size as given in the literature.

A slight decrease in weight and volume of fruits was noticed during the time of ripening. A wide variation was seen among the varieties in terms of weight and volume of ripe fruits. Ratna was the variety with maximum weight (398.01 g) and H-151 the minimum (155.66 g). In a study conducted by Kulkarni and Rameshwar (1981) the range of fruit weight was from 180 to 400 g. Prasad (1984) observed the range of fruit weight from 105.25 to 318.23 g. Specific gravity which has been suggested, as a dependable index of maturity in mango cultivars is the ratio of weight to volume. Roy and Joshi (1989) had suggested a specific gravity of 1.02 to 1.04 for harvesting Alphonso fruits. Shukla and Bajpai (1978) observed that specific gravity could serve as a reliable index for maturity determination in cultivars Dashehari. Fruits with a specific gravity of 1.02 or more ripened to an excellent rating. Higher specific gravity indicates greater accumulation of food material in the fruit. In the present study the specific gravity of majority of fruits was 1.01 as seen from Table 11(a), except for Alphonso, which had a specific gravity of 1.02.

The TSS gives a rough idea of sweetness in the fruits. TSS of fruits is a genetic character, which might be affected by the date of harvesting (Kumar, 1998). During ripening, the conversion of starch, acids and other insoluble substances into soluble form takes place resulting in the sweetness of the fruits. In the present investigation the TSS ranged from 10° brix in Muvandan to 24° brix in Ratna. Satyavati *et al.* (1972) reported that TSS of ripe fruits of local varieties of Kerala varied from 10° to 20.4° brix. Salvi and Gunjate (1988) have reported the TSS of Ratna fruits as 23, Neelum 17.5 and Alphonso 19.0° brix.

Acidity of the fruit gives a blend whereas sweetness is the taste of sugar or molasses, which are only sweet with no flavour. In the present study Prior was the variety with the least acidity and Neelum had the maximum value. Hybrids Ratna and H-151 had their acidity values lower than their parents.

The sugar content of the ripe fruits ranged from 6.0 to 20.66 per cent and that of reducing sugars from 2.23 to 2.99 per cent. Ratna was the variety with the maximum amount of total (20.66%) and reducing (2.99%) sugars and Muvandan the least (6.0% and 2.35%). According to Singh and Singh (1988) the total sugar content of mango varieties grown under central gangetic plains ranged from 7.8 to 18 per cent. Prasad (1977) noted that the sugar content ranged from 13.76 to 18.38 per cent in south Indian varieties of mango grown in northern India.

A wide variation was noticed among the varieties in the ascorbic acid contents of ripe fruits. The range was from 1.5 to 53 mg per 100 g of fruit. H-151 was the topper of the list and Prior the one with the least value. The ascorbic acid content of local Kerala varieties are known to range from 19.84 to 54.72 mg per 100 g (Satyavati, 1972).

Tree characters

The trees subjected to evaluation were nine years old and the characters such as height, girth, spread and yield were observed. Ratna exhibited a vigorous growth with maximum height and spread of branches in northeast and southwest directions. Muvandan was the dwarfest among the varieties followed by H-151. The yield of mango trees can be expressed either in terms of number of fruits harvested or as weight of fruits. Prior and Ratna were the high yielders both in terms of number of fruits and weight of fruits in the present investigation. Ratna has been classified as a regular, good yielding variety by Salvi and Gunjate (1988). In H-151 eventhough the number of fruits were more than that of Ratna, due to the low weight of fruits (155.66 g) the yield was only next to Prior and Ratna. Though Alphonso is

considered as a superior variety, during the period under study yield per tree was the minimum (7.8 kg).

Ratna can be considered as a high yielder since it is known to be a regular bearing variety and hence we can expect consistent yields every year. Alphonso and Prior are known as alternate or erratic bearers. Hence in these varieties the comparison of yield will be fool proof only if the trees are evaluated for at least three consecutive years. Based on a single year yield values, they cannot be rated as high or low yielders. To assess the overall acceptability of the fruits organoleptic evaluation was carried out. The results indicated that Prior and Ratna were the most acceptable varieties.

Heat unit requirement of varieties

Temperature has long been recognised as an important environmental factor in determining the time required for maturity of fruits (Chandler, 1985). In mango, however the usefulness of heat unit calculated from orchard temperatures has not been investigated in detail. In the present study the heat requirement unit varied among the varieties. H-151 was the variety with the maximum heat unit requirement and Neelum the minimum. For Baneshan mangoes Rao and Srinath (1967) suggested that harvesting can be predicted by counting 1426 heat units from the date of bloom.

Overall performance

The present study conducted with an objective of assessing the performance of selected mango varieties under Kerala conditions indicated wide variations among the varieties in terms of all the parameters studied. However, the overall perusal of the results showed that Prior, Ratna and H-151 are acceptable varieties with better performance in terms of desirable characters such as yield, fruit quality and overall acceptance. Ratna exhibited vigorous nature with taller and well-spread trees producing large sized fruits in the months of April – May with superior quality

aspects. Being a regular bearer as per literature this can be considered as a suitable variety for Kerala conditions. Adaptability of this hybrid may be due to the parental combination of Neelum x Alphonso both being south Indian varieties. Regarding Prior, the trees were vigorous with large leaves, early season fruiting giving medium sized fruits, large in number. The fruits were of medium quality with very less acidity but the overall acceptability was the maximum for this in organoleptic evaluation. Being an erratic bearer the performance should be evaluated continuously for three years to draw conclusive results. The high yield obtained in the present study may be due to the fall of 'on' year in the trees under observation during the period under report. H-151 is a hybrid of Kerala origin and the evaluation studies conducted and reported are very little. Kannan (1982) has given the characters of this hybrid and it has been described as high yielding mid season variety. The result of the present study was also in conformity with this respect. The fruits were small in size but trees produced large number of fruits and hence yield in terms of number of fruits was comparable. The overall rating of the fruits was also good in the organoleptic evaluation.

The other varieties Alphonso, Neelum and Muvandan gave medium performance with differential characters. Alphonso designated as superior variety in the country did not give satisfactory yields under the present study. Variety Neelum produced fairly large fruits, but organoleptically the qualities were not as good as Prior and Ratna. Muvandan a popular local variety of Kerala, which had a low TSS and sugar content, could not be considered as a good table variety, but can be used for various other preparations like pickle, juice etc.

Though the results could give basic information regarding the performance of these varieties under Kerala conditions and a comparative evaluation between them, to draw conclusions, such evaluation studies are to be carried out including all the popular varieties and considering the basic alternate bearing nature of mango, the studies should be conducted for a minimum period of three years. Such studies are needed to evaluate the performance of all the popular varieties grown here and also

of the hybrids evolved elsewhere and being grown under our conditions, the information on which are lacking very much at present.

Summary

6. SUMMARY

The experiment entitled "Performance studies in selected varieties and hybrids of mango (*Mangifera indica* L.)" was carried out with an aim to study the morphological and biochemical aspects of flushing, flowering and fruiting of selected mango varieties and hybrids grown under the humid tropical conditions of Kerala. The varieties included for the study were Alphonso, Prior, Muvandan, Neelum, Kalapady and hybrids Ratna and H-151. The results obtained are summarised as follows.

Vegetative characters

In general more flushing in mango was noticed during the months of September to January. Alphonso, Prior, H-151 and Ratna exhibited single flushing extending for a period of two to three months. Neelum, Kalapady and Muvandan showed two flushing, one during the normal season of flushing and the second during March-April. The growth of the flushes was recorded in terms of shoot length and leaf number.

The pattern of flush growth was studied in all the varieties. The trend noticed was that about 90 per cent of the growth in terms of shoot length and leaf number occurred during the first week of observation. Varieties such as Alphonso, Prior and Muvandan showed a significant difference between the sides in the length and leaf number whereas in the remaining varieties no significant difference was noticed.

The flush length ranged from 7.32 to 17.43 cm and leaf number from 10.1 to 17.3. In varieties with two flushing, the shoots of second flush showed more growth in terms of shoot length and leaf number even though the difference was not statistically significant. A wide variation was noticed in colour, aroma and chlorophyll content of flushes between the varieties.

Mature leaf characters

The leaf length ranged from 18.47 to 26.45 cm. Ratna had the largest leaves and Neelum the smallest. Maximum leaf breadth was noticed in Alphonso. Ratna had the maximum area for leaves (119.33 cm^2). Stomatal count was found to be maximum in Alphonso and the least in Muvandan. A wide variation was noticed in leaf dry weights. Alphonso had the maximum dry weight and H-151 the minimum. No significant difference could be noticed in the case of leaf moisture percentage.

A wide variation was noticed in leaf shape. Varieties had lanceolate to elliptic lanceolate leaves. Most of the varieties had wavy margins and acuminate leaf tips.

A significant difference between the varieties was noticed in leaf nutrient contents during vegetative and flowering periods. A decrease in nutrients could be noticed during the flowering phase compared to vegetative phase. The range of nutrients in leaf was 0.59 to 2.34 per cent in nitrogen, 0.039 to 0.1 per cent in phosphorus and 0.72 to 1.18 per cent in case of potassium during the vegetative phase. During flowering phase the nutrient content ranged from 0.33 to 0.69 per cent in nitrogen, 0.03 to 0.06 per cent in phosphorus and 0.66 to 0.85 per cent in the case of potassium.

Flowering characters

In most of the varieties flowering was noticed during December-January months except in Neelum in which the flowering was late during April-May.

The number of inflorescence per unit area showed a significant difference between the varieties. Prior had the maximum number of inflorescence per square metre and Neelum and Alphonso the minimum.

The highest number of hermaphrodite flowers was noticed in Ratna (141.6) and H-151 (140.8) and the least in Muvandan. However the highest percentage of hermaphrodite flowers was for Alphonso (44.39) and the least in Muvandan (15.77).

The inflorescence size in terms of length and breadth was maximum in Ratna (33.6 cm and 23 cm respectively). Prior and Alphonso had densely flowered inflorescence whereas H-151, Muvandan and Ratna produced laxly flowered ones.

A wide variation was noticed in shape and colour of inflorescence between the varieties.

All the varieties produced pentamerous flowers, which had a range of flower diameter from 0.45 to 0.85 cm and a single fertile stamen.

Fruit set and drop

In general the fruit set ranged from 5.39 to 8.45 fruits per inflorescence. The first 15 days was found to be crucial during which fruit drop to the tune of 90 per cent occurred in all the varieties. The fruit drop came to an end by the 45th day. A significant difference was noticed during the first, second and third fortnights in terms of fruit drop intensity. The drop decreased towards maturity. Retainment percentage varied from 10.07 in Alphonso to 20.34 in H-151.

Fruit development

Development of the fruits, up to maturity were observed in terms of physical and biochemical characters. Fruit size measured as length, breadth and circumference were having a similar trend with regard to the changes during development. Maximum increment in length occurred between 30 and 45 days after flowering in most of the varieties.

Changes in fruit weight, volume and specific gravity exhibited a similar trend during fruit development period. Even though other varieties were having the maximum fruit weight and volume up to 60 days after set, Ratna was at the top of the list towards the final stages of development.

Significant variations were noticed between varieties with respect to the biochemical changes during the fruit development. The general trend in acidity was a decrease towards maturity. Alphonso was the variety with maximum acidity and Muvandan the least acidic one.

Ascorbic acid content in the initial stages of fruit development was very low, gradually a rise was noticed and towards ripening again a drop was noticed. Variety H-151 had the maximum ascorbic acid content towards maturity and Prior the minimum ascorbic acid throughout the period of fruit development.

In all the varieties sugar content was found to increase towards maturity. Among the varieties, which took 90 days for maturity, Alphonso had the maximum sugar content and Ratna in varieties that took 105 days.

Total chlorophyll content in the developing fruits of all the varieties exhibited a progressive increase till 60 DAFS followed by a decrease during the final development stages. The least amount of chlorophyll towards the maturity was noted in Prior and H-151.

Ripe fruit characters

The fruits harvested at full maturity were allowed to ripen at room temperature. The time taken for ripening ranged from 4 to 6 days in the varieties. In length, breadth and circumference no difference was noted in the ripened fruits from that of matured fruits. However, weight and volume showed a slight decrease. In the case of biochemical characters acidity, ascorbic acid and total chlorophyll content decreased whereas reducing and total sugars increased towards ripening.

The percentage contribution of different components, viz. pulp, stone and peel towards fruit weight showed variations among varieties. Ratna had the minimum percentage contribution by stone and Muvandan the maximum. The maximum pulp was recorded in Ratna (75%) and the minimum in Muvandan (58%).

Fruits were described for the morphological characters based on the IBPGR descriptor. There existed wide variation between varieties with respect to shape, stalk insertion, beak and sinus characters and shoulder.

Ratna had the superiority in TSS, reducing and total sugar content followed by H-151. Alphonso had the maximum values for acidity.

The organoleptic evaluation of fruits was done by a panel of ten judges. Ratna scored the maximum value for aroma and flavour while H-151 was ranked first in terms of sweetness. Alphonso exhibited more astringency as indicated by the high score obtained for this parameter. In the overall acceptability Prior was the one with the highest score followed by Ratna.

Prior and H-151 were found to have the maximum shelf life and Muvandan the least.

Height of trees ranged from 3 to 7.2 m. Ratna was the tallest among the varieties and H-151 the shortest. Girth also was maximum for Ratna. Prior was the highest yielder giving 305 fruits per tree accounting to 78 kg. In terms of number of fruits H-151 was the next best and in the case of fruit weight Ratna occupied this position. The minimum yield was for Alphonso both in terms of number of fruits and weight.

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* Originals not seen.

Appendices

APPENDIX I

Daily maximum and minimum temperature from flowering to fruit set

	January		February		March		April		May		June		July	
	Max. Temp. ° C	Mini. Temp. ° C	Max. Temp. ° C	Mini. Temp. ° C	Max. Temp. ° C	Mini. Temp. ° C	Max. Temp. ° C	Mini. Temp. ° C	Max. Temp. ° C	Mini. Temp. ° C	Max. Temp. ° C	Mini. Temp. ° C	Max. Temp. ° C	Mini. Temp. ° C
1			33.6	24.2	35.4	23.8	35.4	25.0	33.8	25.6	32.6	25.0	30.0	23.1
2			31.4	23.5	35.1	23.7	35.6	24.1	33.4	25.0	32.8	25.5	29.4	22.2
3			34.2	22.6	35.4	22.7	35.6	25.2	34.4	26.5	31.8	25.6	28.6	23.0
4			32.8	23.8	36.0	24.0	35.6	25.6	34.5	25.0	29.0	21.0	30.0	22.5
5			32.0	24.5	35.2	23.2	36.8	25.5	33.4	26.0	29.2	21.0		
6			34.2	23.6	34.8	23.3	38.4	24.6	32.2	23.4	27.4	22.5		
7			36.2	23.0	37.0	23.5	34.6	25.8	30.8	22.8	28.0	21.4		
8	30.8	22.4	34.8	21.5	35.6	25.5	33.2	26.0	33.6	24.8	29.6	22.4		
9	33.2	23.04	35.2	18.4	32.3	23.8	35.2	24.2	32.8	26.5	30.2	22.5		
10	32.8	22.4	33.4	21.4	34.6	22.6	35.4	23.8	33.6	25.8	29.7	23.2		
11	32.8	23.8	34.0	22.5	35.6	22.4	34.2	24.2	33.6	26.0	26.0	23.5		
12	32.4	23.8	35.6	21.6	35.6	22.8	32.6	22.6	33.5	26.5	27.0	23.5		
13	33.6	22.6	34.2	22.8	35.5	23.0	27.4	22.5	33.1	26.0	25.6	23.0		
14	33.2	21.5	34.2	21.3	35.2	23.0	33.6	23.6	33.8	25.5	29.4	23.0		

APPENDIX I Contd.

15	32.2	22.6	34.4	22.5	35.0	24.0	33.0	23.0	33.7	25.8	28.6	22.4		
16	31.0	21.4	35.0	22.5	34.4	23.5	34.0	23.8	33.0	25.2	30.0	22.4		
17	33.6	23.2	35.0	22.5	35.7	23.5	34.0	24.6	33.0	25.6	29.4	24.0		
18	33.6	25.2	35.6	23.0	35.2	24.0	33.8	24.8	32.6	24.2	30.4	28.6		
19	32.3	24.6	35.4	23.0	35.0	23.8	33.4	24.3	33.0	24.6	30.6	23.4		
20	32.5	22.8	35.6	23.2	35.7	24.3	33.7	24.6	30.8	24.0	30.6	23.0		
21	33.4	20.5	35.4	23.6	34.6	23.5	32.8	24.5	33.4	24.3	28.2	24.0		
22	33.2	23.8	34.6	23.6	33.6	23.6	34.0	24.8	30.6	22.6	28.2	23.2		
23	34.6	23.8	35.0	22.8	34.6	23.0	34.0	25.0	32.2	24.0	28.8	22.0		
24	35.2	24.8	35.5	23.4	34.2	25.5	36.0	25.0	32.4	23.0	31.0	24.0		
25	33.4	24.7	35.2	24.0	32.5	26.0	34.4	26.4	31.0	25.0	29.2	24.0		
26	32.6	23.5	34.2	23.8	33.4	25.0	35.0	26.4	28.8	23.4	30.4	22.5		
27	32.4	22.8	33.7	23.8	33.8	24.6	34.6	25.6	31.2	22.4	29.6	22.4		
28	30.4	23.2	34.6	24.0	33.7	24.6	33.4	25.0	27.6	22.6	29.4	22.4		
29	33.2	23.8	36.0	24.0	35.0	26.5	33.0	25.4	27.2	22.2	27.8	23.0		
30	32.0	24.4			34.0	26.0	33.0	26.4	31.0	22.8	28.6	22.4		
31					34.5	25.0			32.6	22.0				

APPENDIX II

Weekly weather parameters (July 2000 to April 2001)

Meteorological week	Max. Temp. ° C	Mini. Temp. ° C	R. H. (%) 07.30 hrs.	R. H. (%) 14.30 hrs.	Bright Sunshine (hrs day $^{-1}$)	Rainfall (mm)
1	28.9	22.0	93.0	76.0	1.5	87.8
2	29.2	21.5	94.0	74.0	3.5	170.0
3	30.1	22.8	93.0	66.0	5.7	48.9
4	30.9	23.2	92.0	62	8.5	5.9
5	31.1	23.6	92.0	69.0	6.4	9.0
6	29.0	22.8	94.0	80.0	2.5	93.3
7	29.4	22.6	93.0	78.0	4.1	139.5
8	27.7	22.0	95.0	88.0	0.3	232.8
9	29.4	22.1	94.0	73.0	4.6	44.2
10	30.6	22.9	92.0	69.0	7.1	31.9
11	31.2	23.3	90.0	65.0	7.5	0.0
12	30.4	22.9	92.0	72.0	3.9	16.2
13	30.7	23.3	90.0	76.0	4.6	150.0
14	28.9	22.0	92.0	79.0	3.2	79.3
15	30.9	22.1	91.0	65.0	7.1	18.1
16	30.6	23.6	92.0	72.0	3.7	160.8
17	31.7	19.8	90.0	58.0	7.4	6.8
18	32.6	23.3	88.0	57.0	8.5	0.4
19	33.4	23.0	73.0	47.0	8.3	0.0
20	32.5	24.1	67.0	48.0	7.7	0.0
21	32.6	23.9	82.0	64.0	3.1	23.1
22	31.1	20.8	86.0	60.0	6.2	5.4
23	31.1	23.3	69.0	53.0	8.5	0.0
24	31.1	21.2	65.0	36.0	9.7	0.0
25	31.5	22.6	67.0	43.0	7.3	0.0
26	30.7	21.4	75.0	55.0	6.8	8.0
27	32.1	23.1	80.0	49.0	8.4	0.0

APPENDIX II Contd.

Meteorological week	Max. Temp. ° C	Mini. Temp. ° C	R. H. (%) 07.30 hrs.	R. H. (%) 14.30 hrs.	Bright Sunshine (hrs day $^{-1}$)	Rainfall (mm)
28	37.5	22.9	75.0	40.0	9.0	0.0
29	32.6	23.0	63.0	34.0	8.8	0.0
30	33.5	23.4	69.0	39.0	8.1	0.0
31	31.9	23.3	77.0	52.0	4.3	12.2
32	34.3	22.1	81.0	44.0	7.7	0.0
33	34.9	22.4	82.0	37.0	9.1	0.0
34	35.1	23.5	90.0	52.0	8.7	0.0
35	35.2	23.7	85.0	49.0	8.7	0.0
36	35.0	23.5	89.0	57.0	8.1	2.2
37	35.2	23.4	88.0	57.0	8.1	2.2
38	34.3	24.2	85.0	54.0	7.2	0.0
39	34.3	25.2	87.0	54.0	8.0	2.2
40	35.7	25.3	85.0	62.0	6.3	7.1
41	33.1	23.4	90.0	64.0	5.3	190.6
42	33.7	24.8	89.0	65.0	8.4	44.0
43	34.3	25.5	90.0	63.0	6.3	1.4
44	33.5	25.4	78.0	65.0	6.0	13.0

APPENDIX III

Monthly weather parameters from flowering to harvest

	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01
Mean max. temperature (°C)	29.1	30.7	30.7	33.3	30.4	32.6	34.5	34.9	34.2	32.3	28.4	29.0	27.5
Mean mini. temperature (°C)	22.6	23.0	22.7	23.1	22.0	23.2	22.9	24.0	24.7	24.5	23.1	22.7	23.1
Mean RH (%) 07.30 hrs.	94.0	91.0	91.0	77.0	70.0	71.0	86.0	84.0	88.0	89.0	94.0	93.0	97.0
Mean RH (%) 14.30 hrs.	79.0	70.0	68.0	54.0	48.0	41.0	48.0	54.0	63.0	73.0	79.0	77.0	76.0
Rainfall (mm)	518.8	198.1	262.2	41.3	11.2	0.0	12.2	4.4	243.1	192.6	676.2	477.7	253.2
Sunshine (hrs day $^{-1}$)	96.0	178.0	174.1	202.3	244.3	249.4	223.4	252.8	193.7	198.4	57.0	73.5	112.3
Wind speed (kmh^{-1})	3.4	3.2	2.7	5.7	7.8	8.0	4.2	4.1	3.5	3.3	3.4	3.5	3.6
Soil temperature(°C)	31.8	33.2	32.7	34.4	32.9	35.6	37.8	40.7	38.9	35.7	30.5	31.5	

PERFORMANCE STUDIES IN SELECTED VARIETIES AND HYBRIDS OF MANGO *(Mangifera indica* L.*)*

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

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ABSTRACT

The study entitled "Performance studies in selected varieties and hybrids of mango (*Mangifera indica* L.)" was conducted at the College of Horticulture, Vellanikkara utilising the trees in the germplasm collection attached to the Department of Pomology and Floriculture. The objective of the experiment was to gather basic information about the morphological and biochemical aspects of flushing, flowering and fruiting in five varieties namely Alphonso, Prior, Muvandan, Neelum and Kalapady and two hybrids Ratna and H-151 under the humid tropical conditions of Kerala. The study was conducted under three heads, namely, growth characters, flowering characters and fruit set and development.

Flushing pattern in the varieties revealed that Alphonso, Prior, H-151 and Ratna exhibited single extended flushing for a period of two to three months whereas Neelum, Kalapady and Muvandan showed two distinct flushing. About 90 per cent of the shoot growth in terms of length and leaf number occurred during the first week. The cessation in shoot growth took place by fourth week. Varieties exhibited wide variation in the physical and morphological characters of leaf.

Flowering occurred during the month of December – January in all the varieties, except in Neelum, in which flowering was during April – May. The maximum hermaphrodite flowers were noted in Alphonso (44.39%) and least in Muvandan (15.77%). Inflorescence characters such as length, breadth, shape, colour etc. were recorded. In all the varieties the first 15 days was found to be crucial during which fruit drop to the tune of 90 per cent occurred. Retention of fruits varied from 10.07 per cent in Alphonso to 20.34 per cent in H-151.

Morphological, physical and biochemical characters of fruits from set to fruit ripening was recorded. Changes in length, breadth, circumference, weight, volume, specific gravity, acidity, sugar, TSS, ascorbic acid and chlorophyll content were noted. Maximum increment in length occurred between 30 and 45 days after flowering in most of the varieties. Even though other varieties were having the

maximum fruit weight and volume up to 60 days after flowering Ratna was the topper towards the final stages of development.

Acidity was high in the initial stages of development and later on a decrease was noted towards ripening. Alphonso had the maximum acidity and Prior had the least. Ascorbic acid content was low in the initial stages, gradually a rise was noticed and towards ripening it exhibited a drop. H-151 had the maximum ascorbic acid content and Prior had the least content. Sugar content was found to increase towards ripening. Total chlorophyll content exhibited a progressive increase till 60 DAFS followed by a decrease.

Alphonso, Prior, Muvandan and Neelum took 90 days to reach full maturity whereas Ratna and H-151 took 105 days. The time taken from full maturity to ripening ranged from four to six days in all the varieties. Ratna had superiority in TSS, reducing and total sugars and pulp content, followed by H-151. Prior had the maximum yield followed by Ratna. The overall acceptability was also high for the variety Prior, followed by Ratna.