CHAPTER - 1
INTRODUCTION

Mango ‘The King of fruits’ has been acknowledged as an excellent fruit relished by everybody. It has been in cultivation in India, since pre-historic times. This fruit appears to have a strong link with the cultural history of India. It has been portrayed in the paintings and

sculptures, Hindu folklore and mythology, legends and in the sacred Sanskrit scriptures dating back to 2000 BC. Mango fruits had been an esteemed item of diet and the tree a subject of great veneration. This is not due to any blind faith or sentiment, but because of the economic importance of the fruit. The mango tree is part and parcel of rural life. Besides giving shade against the tropical sun, it provides timber, fuel and fodder. Seedling trees can be grown on the sides of the gulleys and streams, thus ensuring soil conservation. Fruits are put to many uses right from the first stage of development to maturity and ripening stage. No other fruit can be put to so many diversified uses in the form of processed products as mango (Singh 1967).

Various travelers have mentioned mango in their memories. Akbar, the great Moghul King (1556-1605), planted a mango orchard of 0.1 million trees near Darbhanga in Bihar. This was the time when mango got royal patronage. Superior varieties were selected and multiplied, and regular mango orchards of grafted varieties were laid out (Singh 1967).

The mango is indigenous to north-east India and north Burma, in the foothills of the Himalayas and is said to have originated in the Indo-Burma region (De Candolle 1904, Popenoe 1920, Mukherjee 1951).The mango was found throughout south-east Asia and the Malaya Archipelago in the early days. The Chinese literature of the seventh century describes it as an important fruit crop in the warmest parts of China and Indo-China. When the Portuguese opened the sea routes to the far-east at the beginning of the sixteenth century, the mango became known in the western world, and its worldwide distribution started. From Indo-China it traveled to the islands of Mindanao and the Sulu of the Philippines through Muslim missionaries about the beginning of the fifteenth century. However, it was not until the end of this century and the early sixteenth century that Spanish voyagers carried the fruit from India to the Philippines (Singh 1967).

The Portuguese introduced the mango from Goa to South Africa and from there to Brazil at the beginning of the eighteenth century. About the middle of this century it was introduced into Barbados in the West Indies, when some plants reached Santo Domingo. During the course of traffic between the Philippines and the western coast of Mexico in the seventeenth and eighteenth centuries, the Spanish people introduced the crop into their tropical American colonies. Jamaica received it from Barbados in 1782 and other West Indian islands in the early part of the nineteenth century. Mango was introduced from Mexico to Hawaii in the 1809 and into California by 1880, whereas the first permanent planting in Florida dates around 1861 (Singh 1967).

Egypt imported budded plants of mango from Bombay first in 1825, and these established themselves successfully (Singh 1960). In Israel the first successful attempt to introduce mixed mango stones from Egypt was made in 1929. From then onwards varieties of mango have been carried there from South Africa, Indonesia, the USA (Florida), India and Egypt. Now there are flourishing orchards of mango in Israel (Singh 1967).

Thus, besides India, mango is now being cultivated commercially in a number of countries. In south-east Asia, mention may be made of the Philippines, Indonesia, Thailand, Burma, Malaysia and Sri Lanka. Other important countries growing mango are Egypt, south-east Africa, South Africa, Israel, tropical Australia, the USA (Hawaii and Florida), Mexico, Brazil, Cuba and the islands of the West Indies (Singh 1967).

India probably has more commercial plantings than the rest of the world (Ochse *et al*. 1961). Perhaps nowhere in the world, it commands the same popularity as in India. The unique taste and flavor 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 great potential as an item of export both as fresh fruit and in its processed form (Singh 1967).

In India the mango is distributed throughout the length and breadth of the country except in hilly regions above 915m from the mean sea level. Systematic surveys have not been conducted to ascertain at regular intervals the total area under this fruit crop, its production and utilization. However, according to a compilation by the Crops Division of Union Ministry of Agriculture for 1978-79, mango occupies 942,560 ha, or 42.6% of the total production of 8.215 million tones (Singh 1967).

The leading mango-growing states in India are Uttar Pradesh, Andhra Pradesh, Bihar, Orrisa and West Bengal. Commercial plantings of the most wanted variety 'Alphonso' for export are located in Maharastra (Ratnagiri) and Gujarat (Bulsar). Likewise top varieties of north India, 'Dasherai','Langra', Bombay green' and 'Chausa', are located mostly in Uttar Pradesh, Important pocket of 'Himsagar' another top-grade variety, are in West Bengal, whereas 'Banganpalli', Neelum', Banglora' and Suvarnarckha' abound in Andhra Pradesh and Tamil Nadu (Singh 1967). Large varieties of mangoes are grown in the different parts of Gujarat. The main native varieties are Kesar, Alphonso, Rajapuri, Jamadar grown in Bulsar, Navsari, Junagadh and Valsad district of Gujarat. The major mango growing states of the country are represented in figure 1.

Botanical aspects

All the cultivated Indian mangoes belong to a single species *Mangifera indica* L., which is the most important member of the family Anacardiaceae. Most of the members of Anacardiaceae are characterized by the presence of resin canals, especially in fruits. Other well-known relatives of *Mangifera* are cashew (*Anacardium occidentale* L.) and Pistachio (*Pistacia vera* L.). A few other edible species of *Mangifera* in the Malaysian region are

M.odorata, *M.foetida* and *M.caesia*, which are cultivated. However, fruits of no other species are as good in quality as those of *M.indica* (Singh 1967).

According to Singh (1959), the tree is described as large, spreading, and evergreen, with a dense rounded or globular crown. The trunk is erect, thick, without furrows or buttresses, when old. The bark is thick, sometimes with longitudinal bursts containing a little yellowing, transparent gum resin like juice. The young plant has a green epidermis like annual herbs, but as it grows larger, the epidermis is stretched out by the bast. It is now necessary for the plant to form a new protective cover. It forms layers of cork which crack as they thicken and flake off. Under the cork layer is the inner bark called the bast and inside it are concentric layers of wood. The wood is reddish grey, often streaked, moderately hard, coarse grained and soft in young trees and is readily eaten by insects. It is somewhat harder and darker brown on the older trees. The tree has the power of healing the wounds by covering it with a rapid growth of the cork. The wood is often divided scantly with fine rays, waves and closes together.

Branches are very numerous, the lower ones spreading horizontally to a great extent, the upper ones gradually ascending till they become nearly erect in the centre; branchlets are rather thick and robust, often with alternating groups of long and short internodes, terete, glabrous,yellowish green when young, with slightly prominent scars on the fallen leaves.

Leaves are simple, alternate, irregulary placed along the branchlets, sometimes remote and at other times (especially at the tips of the flowering branches) crowded, rather long petioled, oblong ovate to oblong lanceolate, base acute to cuneate, narrowed, apex acute to acuminate, entire often with wavy margins, coreaceous, glabrous on both surfaces, leaf blade 10-32 cm, long, 2-9.5 cm, wide with resinous smell when bruised, pinnate nerved, distinctly reticulate veined, costa ronust, lateral secondary nerves numerous (12-13 pairs), conspicuous, yellowish green, prominent beneath and inarching near the margin, alternating with shorter intermediate

nerves, young leaves violet (purplish yellow): petiole is terete, slightly thickened or swollen at the base, round, smooth, glabrous : mature leaves dark green.

The inflorescence is a large terminal panicle, almost 6-40 cm long ; rigid, erect or ascending, widely branched, rachis sometimes pink or purple, but often in different shades of green, terete, densely or sparingly tomentose, or thinly pubescent : terminal panicle with somewhat disagreeable flavor, tinged with red and with a little downy pubescence, bracts oval to elliptic, oblong lanceolate or ovate oblong, deciduous with downy pubescence, concave, soon withering and falling off, 0.3-0.5 cm, long : bracteoles ovate and small.

Flowers are small, polygamous, monoecious, yellowish green, deciduos, in dense cymes on the ultimate branchlets, 4-5 merous, nearly sessile, scented, male and bisexual on the same panicle, pedicel terete, short, thick and rigid, densely pubescent, jointed in or above the middle, pink at the base or yellowish green throughout its length, 0.2-0.4 cm, long, 0.5-0.7 cms when expanded, stipules none.

Sepals 4-5, free, deciduous, shorter than petals, ovate oblong, rather acute or obtuse, yellowish green or light yellow, concave or both surfaces, but especially on the outside, densely covered with short hairs, ciliate in the upper half segments, imbricate, 0.2-0.3 cms, long 0.1-0.15 cms, wide.

Petals 4-5, deciduous, spreading, free from the disc or adnate to it, with recurved tips, imbricate, twice the length of the calyx lobes, on the inside having a lobed granular scale or crust, oblong to ovoid to lanceolate, sub-acute, reflexed, thinly oubescent or glaborous, yellowish white with purplish veins at the base of the inner side with 3-5 ochraceous orange coloured ridges often with pink margins, 0.3-0.5 cm, long, 0.12-0.15 cm wide.

Disc large, fleshy, seated above the base of the petals, distintly 4-5 lobed, grooved, spongy, citrine, afterwards white as frosted glass, very much broader than the ovary during anthesis,

0.1-0.15 cm, high; nectar 5, large, yellow, fleshy, surrounding the base of the germ forming an excavated 5 lobed receptacle.

Stamens 4-5, very unequal, 1 or 2 of them longer and fertile, the rest reduced to sterile or abortive staminodes, inserted inside or on the disc, slender tipped with a small gland. Besides these, there are generally 2-3 more minute sterile filament like bodies issuing from the apices of the lobes of the nectar; staminodes minute, purpled or yellowish white, hardly 0.1 cm, long; perfect stamens 0.2-0.3 cms. long, filament white or yellowish white terete, glaborous, violet, sterile, 0.1 cm, long, male flowers without a rudimentary ovary; stamens central, closely embraced by the lobes of the disc.

Ovary in the bisexual flowers conspicuous, globose, glabrous, citrine or yellowish white, 0.1-0.15 cms, in diameter, sessile, one-celled, usually obliquely ovoid; style lateral, curved upwards, glabrous, citrine or yellowish white, 0.15-0.2 cms, long ; stigma simple, small and terminal; ovule solitary, one-celled, usually pendulous from the basal or lateral or sun-basal funicle.

Drupe fleshy, resinous, very variable in respect of shape and dimensions, yellowish green or yellow to reddish when ripe, fruit size 4-25 cm, long and 1.5-10 cm, wide, very unequalized, ovoid oblong, obliquely oblong, pyriform, sub-ovoid, rounded or obtuse, peel rather thick, coreaceous, flesh yellow or orange coloured, juicy, savoury; stone solitary, rather thick, woody, with fibrous outer layer containing one flat seed. Seed large, ovoid oblong, compressed testa thin, papery, cotyledons plano-convex, often unequal and lobed, radical slightly curved upwards.

The genus *Mangifera* consists of 41 valid species (Mukherjee 1949), distributed throughout Malaysia from India and Sri lanka in the west to the Philippines and new Guinea in the east. Most of them are wild and economically unimportant but some (Mukherjee 1949) are

cultivated for their edible fruits. They have been classified into 2 groups by Mukherjee (1953), who also described their important characters.

According to Mukherjee (1950), cytology of only 5 species, i.e. *Mangifera indica, M.caloneura, M.sylvatica, M.foetida* and *M.caesia,* has so far been studied. It has been observed that all the 5 species and 23 wild and horticultural varieties of *M.indica* have the same chromosome number 2n=40 and n=20. Meiotic behavior is regular, showing regular pairing and disjunction into 20 bivalents. The chromosomes are small in size, varying from 0.4 to2.0 µm, but they can be morphologically distinguished into 8 types according to size, presence or absence of primary and secondary constriction and satellites. From cytological evidences, Mukherjee (1950) concluded that the primitive type which subsequently gave rise to the mango varieities originated through allopolyploidy, most propably through amphidiploidy. Further differentiation of the various varieities of mango then took place primarily through gene mutation and intervarietal hybridization; selected varieties being retained through vegetative propagation.

In Jamnagar (India), a project has been planted by Reliance industries which would give mangoes 'round the year'. Bajrang and Niranjan are the varieties which flowers in May-June and fruiting takes place by October. In Kesar and other varieties flowering takes place in January- February and thus fruiting is seen in May-June. Similarly, some varieties such as Dasahri get flowers after the monsoon and fruits are available after three-four months. The varieties which can be consumed without any processing is called table varieties.

Almost all varieties of mango have been selected from naturally occurring superior chance seedlings, having in view their earliness or lateness and superior fruit quality. Some of these are still confined to the orchards of a few mango lovers and need to be utilized both commercially as well as in breeding work. All these varieties have a wide range of adaptability under north Indian conditions. For instance there is no difference in the

performance of the variety ‘Langra’ when grown at Varanasi or Saharanpur or Bulsar (Gujarat), although the 3 situations differ significantly in climatic and soil factors. However, the performance of the north Indian varieties undergoes a marked change when grown under south Indian conditions. For instance, if ‘Langra’ and ‘Dasheri’ varieties of northern India are grown under south Indian conditions, the trees would flower and fruit very sparsely. However, south Indian varieties do flower and fruit under north Indian conditions, but some of their characteristics might undergo a change (Singh 1967). For example, ‘Neelum’ (South Indian variety) trees tend to be sufficiently dwarfed under north Indian conditions. Although the trees tend to bear every year, fruit size is markedly reduced, accompanied by delaying ripening. Likewise, ‘Rumani’ variety of southern Indian undergoes a change in sex ratio of flowers, resulting in sparse fruiting under north Indian conditions. ‘Alphonso’ of Ratnagiri cannot be duplicated away from the coastal region in regard to its fruit quality. Thus, commercial varieties of mango, although having a wide range of adaptability, are specific to different regions of the country (Singh 1967).

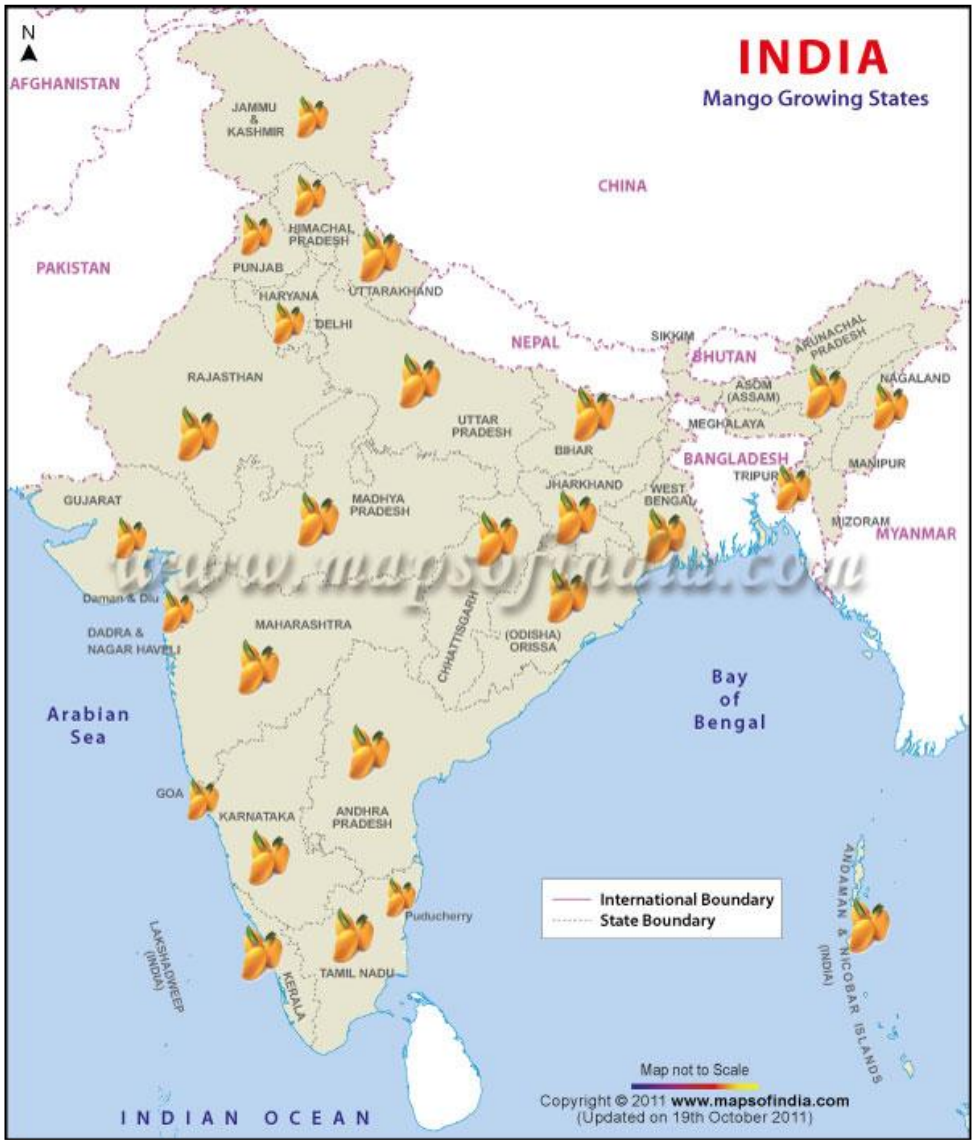

Figure 1: Map of India showing mango growing states

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Classification and Nomenclature

The existence of such a large number of varieties in India, and the attempts of many men of means to build the largest collection of varieties, so as to outdo their rivals in this respect, had led to the creation of an exceedingly large number of fancy and romantic names. In the matter of coining such names the enthusiast have overdone the job to the point of eccentricity (Burns and Prayag 1921). Further the varieties on introduction from one region of the country to another, have been, deliberately or otherwise, given entirely new names by those importing them. And so, many varieties have come to acquire different names in different parts of the country. This has caused a good deal of confusion in the nomenclature of varieties.There is a

considerable confusion in the nomenclature of varieties due to many synonyms of a single cultivar. However, in various monographs on mango published from time to time, correct name of a variety along with its synonym has been furnished. Previously, even one variety found different names in different catalogues. Since most of the varieties of mango have been selected from naturally occurring chance seedling by the interested growers and nurseryman, names signify quality, lateness of earliness, size and shape of fruit, the names of the place, person or king or nawab, colour, etc. for most part names have been taken from the local dialect (Singh 1967).

Synonym used to be many, thus adding to the utter confusion of the grower. Singh and Singh (1956) in their mango monograph have assessed the exact synonyms of the popular varieties of mango by actual observation and also from catalogues. Some of the synonym mentioned in their monograph for 'Langra' are 'Langra Banarasi', 'Langra Hajipur', 'Langarhi, 'Tikari' (Farrukhabad, UP), 'David Ford', Hardil-Aziz (Bhopal), 'Langra Hardoi', 'Langra Patna', 'Sylhet' (Meerut, UP), 'Langra Faquirwala', 'Ruh-e-afza', 'Darbanga' and 'Chhatpa'. Other synonyms are Banglora (Totapuri), Raspuri (Pairi, Peter), Baneshan (Baganpalli), Chowsa (Samarbehist), Badami (Model) and Doodia (Yerrphad) etc. Thus the synonyms multiplied, generally as the grafts changed hands from different persons and places. New names were coined, based often on the person and places from whom or where the grafts were obtained (Singh 1967).

The confusion in the nomenclature and the identification of varieties has been further aggravated by the nursery interest. The desire to coin fancy names with a view to attract and allure the customers has been mispronounced in this sphere. The fancy names given to the varieties ascribe all sorts of imaginary qualities to the fruit. A great chaos exists in the nomenclature of mango varieties. And the buyers of plants after years of careful and laborious nurturing of plants may sometimes find, to their annoyance, that they have been

nourishing something entirely different from what they ordered. The fact that identification of varieties by vegetative characters alone at the time of purchase is not possible, and the long time taken by the trees to come into bearing before their identity is established further complicates the situation. It is. Therefore, necessary to describe and catalogue the existing varieties, so that the fruit grower is enabled to choose correctly the material suitable for his conditions. The first systematic record of the good and bad varieties available is from the account of this fruit tree in *Ain-i-Akbari*, AD 1590. Maries (1901-02) made the first attempt to describe mango varieties scientifically and collected many varieties from India. Woodhouse (1909a) described the mango varieties of Bhagalpur (Bihar) and suggested a system based mainly on fruit characters. Rolphs (1915) attached special importance to fruit characters, particularly shape, while classifying the mango varieties grown in Florida. Wester (1920) gave a descriptive list of mango varieties in India. Burns and Prayag (1921), while describing 89 varieties of the Bombay Presidency, based their classification practically on the same line as of Woodhouse (1909a). Sturrock (1951) used an artificial key for the identification of mango varieties commonly frown in Florida, using the characters of the fruit alone.

Hartless (1913) was the first worker to emphasize the importance of floral characters in classifying mango varieties. Poponoe (1932) for the first time classified the mango varieties in a natural way on the basis of fruit characters, colouration of panicle axis, laterals and pubescence on the panicle branches and number of embroys in seed. Mukherjee (1948) classified and described 72 varieties of Bengal and divided all the varieities into 3 broad groups, taking fruit shape as the main criterion. Apart from fruit characters, he took in account the colouration of emerging leaves, colouration of panicle branches, nature of bracts and length of inflorescence. Naik and Gangolly (1950) described 335 varieities of south Indian mangoes. Their method of classification seems to be logical, and Singh and Singh

(1956) based their work on the classification of Uttar Pradesh mangoes on almost the same line. In this classification primary, secondary and tertiary characters have been taken according to their stability and importance, in grouping and distinguishing one variety from the other. These characters include fruit shape and beak, venation on the stones, color of the panicles, leaf apex and folding of leaves.

In the improvement of every crop, a stage comes when simple plant introductions and trials, cease to be of any further value. At this stage, the purely empirical techniques have to be replaced by well planned experiments with definite objectives, and a full knowledge of the plant material available in the country along with its characteristics becomes essential. Without such information, no further progress is possible. Such is the case with mango today. Mere introduction of varieties from other region too, is of doubtful value: for varieties thriving in one place usually does not turn out well in another. For example, the varieties Langra and Dusheri of Uttar Pradesh grown in Madras, show little resemblance to the original parent in respect of flavor, size, and other characteristics. A thorough survey and descriptions of the existing varieties becomes imperative for further progress and must form the basis of all future work. If we look for a high yielding, disease resistant, choice variety of a regular bearing habit, the chances of coming across a variety possessing all the attributes in nature are remote. We might, however, find varieties with one or more of these characters and then try to combine these through hybridization. And in some cases we may even have to go to the wild species of *Mangifera* in search of a particular character. Hence, the importance of a thorough knowledge of the characteristics of our existing varieties.

Hedrick (1935) has stressed the importance of systematic study of varieties in breeding work. Not only do we need to study the fruit qualities and yielding abilities of our commercial varieties, we also require information on other specific characters such as the canning quality of a variety, its rootstock potentialities and disease resistance.

The absence of any information regarding even our best varieties is deplorable. Also we do not have any record of the varieties grown in the Lakh Bagh in Bihar, which was started by Emperor Akbar. In other countries a great deal of work on the varieties of their important fruits, such as apples, pears and grapes has been done. In our country new mango varieties from the seedling trees are constantly springing up and record should be made of such varieties. At the twelfth International Horticultural Congress, held in Berlin in 1938, research workers from rightly regarded the description and classification of varieties as a fundamental aspect of fruit research and it was resolved that a permanent commission be set up in every country to encourage the undertaking of nomenclature work. This was affirmed at the Horticultural Worker's Conference organized by the Indian Council of Agricultural Research in New Delhi, in 1947 (Singh 1967).

Owing to the present confused nomenclature of mango varieties, the Indian orchardist is confronted with the perplexing problem of varietal identification and selection. There is no authentic guide for this purpose. A rational system of standardization of varietal names and their identification should be brought. Such work will help the fruit grower choosing correctly the varieties suitable for his requirements. It will also equip the horticultural research worker with a precise knowledge of the plant material already available, as well as the source of its availability in the country (Singh 1967).

Even though the mango varieties have been well established in India for over 400 years, after the adoption of vegetative methods of propagation the work of varietal descriptions has been limited and isolated in character. In India all the work done so far has only been a regional nature. The earliest descriptions of mango using scientific terminology are by Watt (1891). Maries (1901-1902) collected about 500 varieties of Indian mango and described them with botanical terminology. The first attempt to suggest the distinguishing characters of varieties was made by Woodhouse (1909b). He described 40 mango varieties of Bihar. Burns and

Prayg (1921) described 89 varieties in Bombay Presidency and used similar characters. They grouped these varieties of Bombay Presidency and used similar characters. They grouped these varieties under three cohorts on the basis of the shape of fruit, i.e. round fruited and indefinitely. They have themselves mentioned that this is an arbitrary classification and aims only at cataloguing varieties. Popenoe (1932) has described 300 varieties from all parts of the world including India, suggesting some methods of grouping them. Subsequently he classified them into four groups: Mulgoba; Alphonso; Sandershah; and Cambodiaba. This was based on fruit characters, the color of the axis and laterals of the panicle, pubescence on panicle branches and the number of embryos per seed. This was the first attempt at including the panicle characters in the descriptions.

The first key for the identification of mango varieties, based upon fruit characters only, was published in 1944 by Sturrock and Wolfe, who described 38 mango varieties from Florida. The descriptions adopted so far had not included the vegetative characters. But, recent work includes Mukherjee (1948) has described 72 varieties of Bengal, Bihar and Uttar Pradesh. He has studied the range in the variability of the following characters and has also given a key for the identification of these varieties.

Simultaneously, Naik and Gangolly (1950) have described 335 varieties of South India. Apart from the fruit characters, they have also laid great stress on the vegetative characters. They found that the apex of the leaf and the inrolling of mature leaf are very important in the identification of varieties. They have classified these varieties into three groups, i.e. fruits roundish, fruits intermediate, and fruits markedly long. These three groups are similar to the groups followed by Mukherjee. They have further divided each of these groups followed by Mukherjee. They have further divided each of these groups into cohorts, depending upon whether the fruit had a prominent beak or not.

Studies on the post harvesting and post fertilization biochemical changes are plenty but anatomical and biochemical changes leading to the development in the fruit and its variation in the same varieties growing in different regions in meager (Singh 1960). In the present study three varieties growing in two different regions Junagadh and Navsari of Gujarat were studied. The varieties Alphonso, Kesar and Rajapuri were studied in detail. Alphonso (Junagadh) possesses a medium sized fruit, oval shaped, excellent keeping quality, mild sweet taste while Alphonso (Navsari) had medium sized fruit and sweeter taste than in Junagadh variety. In Kesar (Junagadh), the fruit is ovate oblong shape, sweet flavored, fibreless mango with good keeping quality but in Kesar (Navsari), fruit shape was oblong and less sweet. Rajapuri (Junagadh and Navsari) possess ovate, oblong shaped large sized fruit with the sour and sweet taste, mainly used in making pickles.

Varieties of *M.indica*

There are hundrEds of varieties of mango, out of which only a few happen to be of commercial importance. Different regions of the country have their own commercial varieties because, as has already been indicated in the beginning, a particular variety of mango is not expected to perform equally well under different sets of climatic factors prevailing in various parts of the country. The most well-known varieties throughout the country are ‘Langra’, ‘Alphonso’ ‘Dashehari’ and ‘Banganpalli’. Thus the choice of a commercial grower in north India is mostly confined to ‘Bombay Green’ (early), ‘Langra’, ‘Dashehari’ and ‘Samar Behisht Chausa’; in the eastern part of ‘Fazli’, ‘Kishebhog’, ‘Himsagar’, ‘Langra’, Gulabkhas and Zardalu; in the western part to ‘Alphonso, Pairi, Malkurad (Goa), Kesar, Rajapuri and Jamadar (Gujarat); and in the southern part, Beneshan (Banganpalli) Neelum, Banglora, Rumani, Suvarnarekha, Mulgoa, Rspuri and Badami. Although the most delicious mangoes of the south are Allampur Beneshan, Himayuddin and Jehangir, these are not commercial

types due to their shy bearing. Among these Neelum and Banglora happen to be the most consistent bearers (regular) and Dasheri by far the most delicious variety (Singh 1967).

Apart from table varieties, there are quite a few sucking types characterized by juicy and soft flesh with fibres. These are not yet cultivated on commercial scale but grafted trees are grown in the orchards of big mango growers. Some such varieties are 'Raspoonia', 'Mithwa Sundar Shah', Mithwa Ghazipur', 'Taimuriya', 'Sharbati' Begrain', 'Gilas', 'Nauras', Rasgola', 'Hardil-aziz', 'Cherukurasan' and 'Peddarasam',. Detailed description of the first 9 varieties is represented in the mango monograph by Singh and Singh (1956), and the later 2 vareities have been described in the monograph by Naik and Gangolly (1950).

Fruits of all these varieties except the south Indian ones range in size from small to medium. Further, these varieties are mostly biennial in habit. This germplasm of juicy mangoes may get extinct unless propagated and multiplied by nurseries and popularized for commercial cultivation to cater of the mango industry.

Among the varieties of *M.indica*, there are a few lesser known superior varieties having sweet taste and texture. Extensive surveys have revealed a number of superior varieties which, however, still remain confined to the orchards of a few individuals only; as a result these lack popularity. Among such varieities are 'Fajari Zafrani', 'Amankhurd Buland Bagh', 'Zamurrad', Sona tol', 'Nisar Pasand' and 'Aziz pasand'(Singh 1967).

Additional to these varieties a few of them are designated as polyembryonic varieties. The phenomenon of polyembryony, characterized by the formation of more than one embryo in the seed, is known to occur in a number of mango varieties growing under different conditions of climate and soil. The seedlings arising from the adventive embryos of nucellar origin are highly uniform. These can therefore be used as such for the vegetative multiplication of a polyembryonic variety. If found suitable, they can also be utilized as standard rootstocks for some of the monoembryonic varieties (Singh 1967).

In India almost all the commercial varieties are monoembryonic. A few that are polyembryonic are comparatively of little economic value. Some of these are 'Bappakai', 'Bellary', 'Chandrakaran', 'Goa', 'Goa Kasargod', 'Kurukkan', 'Mylepalium', 'Olour', 'Nileswar Dwarf' and 'Salem'. Some of the important polyembryonic varieties grown in the Philippines are 'Cambodiana', Carabao', Corazon', Paho', 'Pahutan', 'Pico', Senora' and 'Strawberry' (Singh 1967).

The exact criterion for distinguishing a nucellar seedling from a gametic seedling in polyembronic varieties of mango is not yet well established. However, Sacgar and Chopra (1957) reported that in polyembryonic seed-stone the zygote usually gets degenerated and the seedling emerges from nucellar embryos alone. Thus there are chances of the sexual embryo development being crowded out by asexual ones in the early stages of embryo development. In that case the seedlings emerging will be all nucellar. However, this may not hold good for all varieties. Juliano (1937) reported that in 'Pico' both the types of embryo develop approximately at the same time and at the same speed. But in 'Olour', 'Carabao' and 'Cambidiana' the egg degenerates and all the embryos in a mature seed are adventive. Uniformity in the color of the emerging leaves of the seedlings may, however, be a a fair indication of their nuclear origin (Singh 1967).

It has been observed that some of the monoembryonic varieties may revert to polyembryony when grown under different sets of soil and climatic conditions. Wester (1924) reported that some of the Indian varieties which were mostly monoembryonic produced more than one seedling in the Philippines. A similar condition was observed with some Indian varieties when grown under Puerto Rico conditions. This may be due to natural crossing of the monoembryonic with the polyembryonic varieties commonly grown in these regions. Sturrock (1951) reported that the hybrids of polyembryonic and monoembryonic types are

polyembryonic under Florida (USA) conditions. However, further breeding studies are needed to ascertain the nature of inheritance of polyembryony in mango.

Sometimes, seedlings with multiple shoots forming lateral branches arising in the axil of the cotyledonary leaves are mistaken for polyembryonic types. However, these can easily be distinguished as monoembryonic or polyembryonic on the basis of the number of tap roots. Single tap root will be a fair indication that it is monoembryonic, whereas more than one tap root with equal number of shoots will mean that the variety is polyembryonic (Singh 1960).

Added to the above mentioned varieties some are also categorized as coloured and unusual varieties. Most of the coloured varieties developed in Florida (USA) are characterized by brilliant red blush on the cheeks giving it a high aesthetic value. It adds to the desirable characteristics of a variety and enhances consumer appeal.The varietal wealth of mango in India is huge and a number of varieties are known to have brilliant red blush on their cheeks. Some well-known varieties having red color are'Gulabkhas Red' ('Sinduriya'), 'Surkha Calcutta', 'Zafran', 'Husnara' (this has a very bright red color), 'Janardhan Pasand', 'Suvarnarekha', 'Lal Mulgoa' and 'Vanraj'. Sensation' from Florida (USA) is the most brilliantly colored variety of mango reported so far. Some of these have a good fruit quality, and it will not be difficult to combine the two qualities i.e. a better fruit quality with desirable color by breeding (Singh 1967). 'Chitla Afaq' and 'Croton' are unusual varieties of mango. The variegated fruits of the former are of an ornamental nature and serve as a sort of curiosity. Fruits are small and oblongish with undulated surface. It is quite juicy, fibrous and sub-sweet in taste. There is also another strain of this variety which bears variegated fruits of smaller size. Nothing is known about the origin of this peculiar variety (Singh 1967).The leaves of 'Croton' resemble those of the croton foliage shrub, and the tree is of ornamental nature. The veins in the leaves are depressed and the surface in between them in raised,

presenting a peculiar leathery appearance. The fruits are small and oval. It has abundant juice and fibers and is sub-sweet in taste (Singh 1967).

FLOWERING AND FRUITING

Flowering in mango is preceded by the differentiation of the flower bud in the shoots. The period of differentiation is reported to be October-December, depending upon the climatic conditions (Sturrock 1934, Sen and Malik 1941, Mustard and Lynch 1945, Singh 1958). Musahib-ud-din (1946), however, had reported August to be the time of flower-bud differentiation in mango under Punjab conditions which appears to be too early a period because there is no dormancy between the fruit-bud differentiation and inflorescence elongation. In 'Baramasi' however, sometimes the critical time of differentiation is twice a year and in certain years it is only once. Differentiation period is generally during May-June and September-October. This appears to be its hereditary character.

According to Singh (1958) the development of different organs in the mango flowers is in the following order.

Calyx, corolla
Stamen
Staminodes
} Carpel and the disc

Apart from the inherent character of the variety, the time of flowering in different regions is mainly governed by the local climatic conditions. Gandhi (1955) stated that flowering nat start as early as November or usually during December in Rayalaseema (Andhra Pradesh) and the south Konkan on the west Coast of India. In Northern India mango flowers from February to March and the period of full bloom may be some time during March. Thus under milder climatic conditions of the southern and western India, mango may start flowering from December itself, whereas under extreme climatic of tge north the flowering time is comparatively more precise and late (February-March). Bloom period in eastern India is

earlier than in north. In the Philippines too the mango flowers during December-January (Burns and Prayg 1921). Bijhouwer (1937) observed that flowering period in Queensland (Australia) and South Africa is during June-July and August-September repectively, and fruits are available from November to January.

Thus flowering in mango is controlled by the climatic factors. There are certain varieties of mango in India such as 'Rumani', 'Banglora', 'Neelum', and 'Alipasand' which put forth flower flushes twice or thrice a year (Naik and Rao 1943). This is observed oparticularly when these varieties are grtown under Kanyakumari conditions. 'Baramasi' is yet another erratic variety which may flower once, twice or thrice a year even udner north Indian conditions.In norther Indian the duration of floweing in mango is for about 20-25 days (Singh 1960)

Fruit set

Mango inflorescence is primarily terminal but axillary and multiple panicles may also arise from axillary buds quite frequently. The panicle consists of a main axis bearing many branched secondary axes. The secondary branches may bear a cyme of 3 flowers, or tertiary branches may again arise on them which bear a cyme of 3 flowers, each flower borne on bracteate pedicels. The flowers are closely clustered towards the apices of each branch or main axis and are either male or hermaphrodite. The total number of flowers in a panicle may vary from 1, 00 to 6,000, also varies in length from a few centimeters to 60cm (Singh 1960).

It is the hermaphrodite flowers that after proper pollination and fertilization set fruit. Therefore, the initial fruit set will depend much on the number of hermaphrodite flowers in a panicle. The percentage of hermaphrodite flowers in panicle are subjected to appreciable varied, depending upon the early or late emergence of the panicle and the variety. Singh (1954) reported that under the north Indian conditions percentage of perfect flower in the panicles of 'Dahseri' and 'langra' is 30.6 and 69.8 respectively. In the south Indian mangoes

it varies from 16.14 in ‘Neelum’ to 3.17 in ‘Allampur Beneshan’ (Naik and Rao 1943). Popenoe (1917) earlier had reported that the percentage of perfect flowers vary from 2 to 70 according to the variety.

The percentage of perfect flowers in the panicles of medium and late flushes in ‘Dasheri’ was respectively 2 and 7 times more than that in the panicles of early flush (Singh, *et al*. 1966). Variation in the number and sex ratio of panicles appears to be existing in the inner and the outer/ peripheral portions of the tree. Panicles in the inner portion of the tree bore 1.5-2 times more perfect flowers than those located on the periphery. The number of hermaphrodite flowers is the least in the upper part of the panicle but the percentage is the highest (Singh 1954). Fruit set and ultimate retention per panicle are much higher in the medium and late emerged panicles tha in the early ones. There appears to be a close association between high temperature and an increased percentage of perfect flowers, and low temperature and a decreased percentage of perfect flowers.

The percentage of perfect flowers in some of the south Indian varieties has been observed to be much less under north Indian condition (Singh *et al*. 1965). This has been attributed to the lower maximum and minimum temperatures obtaining during the period of panicle development at Delhi compared with those obtaining at Kodur (South India). The percentage of perfect flowers ub ‘Janardhan Pasand’ and ‘Beneshan’ is significantly increased with the aid of NAA (200ppm) sprays. The increase in the percentage of perfect flowers by NAA sprays results in much higher fruit set per panicle in ‘Beneshan’, which is shy when grown under north Indian conditions.

Mango is a cross-pollinated crop and pollination is essentail for fuit set. It is primarily accomplished by insect; housefly (*Musa domestica* L.) being the chief agent. Fruit set is avarietal character, depending upon several factors such as time of flowering, sex ratio, efficicent cross-pollination and intensity of drop. Varieties differ from one another in these

repects and this leads to varying fruit set in different varieties. Under Delhi conditions the panicles of the early flush of ‘Dashehari’ emerge rather early in the season and at that time the majority of the varieties are not found in flowreing. The weather is also much cooler at that time and the pollen tranference is also less. Consequently, the mean fruit set is negligible in the early flush of ‘Dahsehari’, on the contrary, show high fruit set and ultimate retention per panicle.

Fruit drop

In mango there is a heavy drop of hermaphrodite flowers and young fruits, amounting to 99% or more (Mukherjee 1949). Sen (1939) from Sabour (Bihar) reported that in the commercial varieties ‘Bombai’, ‘Labgra’ and ‘Fazli’, only 13 to 28% of the bisexual flowers have been found to set fruit, out of which only 0.1 to 0.25% reached maturity. This observation emphasizes the nature of heavy fruit drop in mango. In general, in mango 0.1% or less hermaphrodite flowers develop fruits to maturity (Naik and Rao 1943, Singh 1954). The maximum drop of fruits in ‘Langra’ and ‘Dashehari’ takes place in the first 3 weeks of April and differs significantly from the drops in the following weeks (Singh 1954). Fruit drop is to some extent associated with the variety as the variety ‘Langra’ is more prone to fruit drop than ‘Dashehari’.

Among the external factors affecting mango fruit drop in the initial stages, mention may be made of external biofactors like mango hopper, mango mealy bug, powdery mildew and anthracnose. Deficient nutrition of many developing embryos may be the most important internal factor leading to postfertilization drop in mango (Mukherjee 1953). This results due to competition among over-crowded fruitlets on a panicle. Degeneration of the embryo in the initial stages of its development may yet be another cause of the drop. This occurs invariably if the flowers are self-pollinated.

In some varieties such as ‘Langra’ and ‘Chausa’, natural fruit drop does hardly pose a problem in normal bearing. However, drop due to insect and disease attack must be checked in all the varieties by applying appropriate insecticides and fungicides. Cross-pollination of the varieties ought to be assured by avoiding isolated planting of single variety. Check of natural fruit drop in mango will result in the intensification of alternate bearing habit.

Fruit growth and development

Fruit growth and development can be categorized into different stages. Growth in mango fruit is characterized by sigmoid curve. During the different developmental stages of the fruit both anatomical, biochemical and compositional changes take place. Studies have shown that the period of stone hardening is directly associated with the tremendous decrease in growth rate. Development of fruit in ‘Langra’ and ‘Dashehari’ starts in the last week of March and are completed by the end of second week of June (Singh 1954). The percentage increase in growth in ‘Dashehari’ and ‘Samar Behisht Chausa’ as expressed in terms of length, breadth and thickness is maximum in April, followed by May and March respectively. It is least in June. However, maximum increase in weight and volume of fruits is recorded in May, followed by April and June repectively (Saini *et al*. 1971). It is almost negligible in March. Many characters of the pericarp like cell size, laticiferous canals, intercellular spaces, etc., in different tissues of the fruit contribute to the increase in length, breadth, thickness and volume of the fruit, whereas inctese in weight in the later stages is associated with the accumulation of starch grain in the cells.

Development of the seed is similar to that of the fruit. Peak growth period of fruits is directly associated with the peak growth period of seed. Chacko *et al*. (1970) reported that in mango the period of rapid growth is directly associated with the period of maximum activity of auxin and gibberellin-like substances in the seed. Our observations have shown that the size of seed also contributes to fruit growth.

The second period of rapid development of fruit may be due to rapid initiation of development of seed and decrease in the inhibitor content of the pericarp. Further, the slowing of growth after 64 days in 'Dashehari' and 29 days in 'Chausa' may be due to the lignification and development of endocarp, as it resluts in competition for food substances in the formation of the endocarp and the fleshy part of the fruit. In the later stages of the growth and development of mango fruit, the exocarp region develops into a leathery protective skin, the mesocarp in to a fleshy pulp.

The maturity of fruit at harvest determines it quality and postharvest shelf life. Some works correlated maturity of the fruit with various physical characteristics like skin colour, shape and size, sholder growth while others tried it with chemical parameters like soluble solids content, titrable acidity, starch, phenolic compounds and carotenoids (Cheema and Dani 1934, Singh *et al*. 1937, Teaotia *et al*. 1968, Rao *et al*. 1970, 1972). As most of these parameters varied among different varieties, the biochemical aspects have also been included in the present study.

Composition of ripe mango fruits

The composition in general differs with the cultivar and the stage of maturity. Genereal composition of mango is given in table 1. The unripe green mangoes are reported to have 90% moisture, 0.7% protein, 0.1% fat,8.8% carbohydrates, 0.01% calcium, 0.02% phosphorous, 4.5 mg/100g iron, carotene (as vitamin A 150 i.u.), 30 µg/100 g ascorbic acid (Anonymous 1962).

Constituents	**Amount**
Moisture (%)	73-86.7
Carbohydrate (%)	11.6-24.3
Protein (%)	0.5-1.0

Fat (%)	0.1-0.8
Fiber (%)	1.1
Lipid (%)	0.8-1.36
TSS (Brix)	12.0-23.0
Total sugar (%)	8.7-17.93
Acidity (%)	0.12-0.38
Total phenol	1.20-7.83
Vitamin A (µg / 100g- βcarotene)	6375-20750
Vitamin B (mg/ 100g)	40
Nicotinic acid (mg/ 100g)	0.3
Riboflavin (mg/ 100g)	50.0
Ascorbic acid (mg/ 100g)	6.8-38.8
N (%)	0.46
P (%)	0.195
K (%)	0.88
Ca (%)	0.412
Mg (%)	0.082
S (%)	0.542
Cu (ppm)	24.0
Zn (ppm)	11.5
Mn (ppm)	10.0
Fe (ppm)	50.0

Table 1: Composition of ripe mango fruit.
(Pathak and Sarada 1974, Lakshminarayan 1980, Raghupati and Bhargava 1994, Chandra and Chandra 1997)

The sugars in mango comprise of sucrose, glucose, fructose and maltose (Anon 1994). Others that have been reported to be present are xylose, arabinose (Wali and Hassan 1965), sedoheptulose and manoheputlose (Ogata *et al.* 1972). The mineral content (% DW) of all fruit parts of all cultivars was generally lower at harvesting stage than at half-maturity and the mineral content of peel was generally higher than that of other fruit parts at both stages (Singh 1954). Raghupati and Bhargava (1994) obtained maximum N, P, Ca, Mg, Fe, Zn and Cu concentrations in the mesocarp, while S and Mn concentrations were greatest in the endocarp and the kernel respectively. In general, the dorsal part of the fruit was sweeter than the ventral parts and the basal part was sweeter than the middle or apical parts (singh 1960).

The soluble protein content was found to decrease up to 44 days after fruit set and increased thereafter until 96 days (Tandon and Karla 1983). Elahi and Khan (1973) identified 12 amino acids including the essential ones like alanine, aspartic acid, lysine, leucine, cystine, valine, arginine, phenyalanine, and methionine in fruits of 4 mango cultivars grown in Pakistan. The number of amino acids increased from 9 at early stages (1-4 weeks after fruit set) to 13 during the later part of fruit development (10-13 weeks after fruit set). Aspartic acid, glutamic acid, phenylalanine, alanine and histidine were found throughout the development of fruit. Proline and glycine could be observed only during later part of fruit growth, while leucine and threonine only at the intial stage.

The lipid content in peel and pulp of five mango varities ranged from 0.75 to 1.70% and 0.80 to 1.36% respectively (Pathak and Sarada 1974). Total kernel lipids in Alphonso mango amounted to 11.6% of the dry kernel and consisted of 96.1% neutral and 3.9% polar lipids which comprised 2.9% glycolipids and 1.0% phospholipids (Hemavathy *et al.* 1987).

According to Jain (1961), small amount of tannin is also present in the flesh (0.16%) and skin (0.105%) which is responsible for astringency. From the nutritional point of view the mango is a rich source of vitamin A, almost as rich as butter (Singh 1960). The caretenoid pigments, β-carotene (provitamin A) increase with ripening. Also it has a fair amount of vitamin C. The vitamin C content varies with cultivars (Singh 1954). Singh and Chadha (1961) reported higher ascorbic acid content in Langra than in Dasheri; lowest being in Fazli. The smaller fruits had higher amount of ascorbic acid content than larger ones (Palaniswamy *et al.* 1974). The highest concentration of ascorbic acid was observed in fruit just after fruit set and the concentration decreased with fruit development.

Ghosh (1960) reported the presence of folic acid (vitamin B) in green mangoes to an extent of 3.6 µg/100 g fresh weight respectively. A more detailed account of the pre- and post-harvest physiology of mango is given by Krishnamurthy and Subramanyam (1973). Sadhu and Bose

(1976, 1982) studied the chemical composition of fruits of 37 mango cultivars and reported marked variations in the constituents of different cultivars.

Dietary fibre is a mixture of complex organic substances, including hydrophilic compounds, such as soluble and insoluble polysaccharides and non-digestable oligosaccharides as well as a range of of non-swellable, more or less hydrophobic, compounds such as cutins, suberins and lignins. The content of total dietary fiber in the tropical fruits was in the range of 0.54 to 5.6 g/100g of fresh fruit. In a study, it was found that among some tropical fruits, ripe mango, guava and litchi has significant amount of total dietary fiber (Gorinstein 1999). In a study by Larrauri *et al*. (1996) it was found that the mango peels contained high amounts of total extractable polyphenols (70g/kg) and soluble dietary fibre (281 g/kg), indicating mango peel as good source of tropical fruit fibre.

The aroma and flavor vary widely among mango cultivars and there is no one typical formulation of flavor component for mangoes (Wilson *et al*. 1990). The seed kernels contain fat (7.5- 8.8%), protein (6.1-6.8%), crude fibre (1.3-2.4%) and ash (2.2-2.8%). The main fatty acids of the kernels fat are palmitic (6.9-7.3%), stearic acid (44.3-44.4%), oleic (38.9-42.1%) and linoleic (4.5-7.4%) acids (Augustin and Ling 1987). Several carbohydrate hydrolysases, esterases, pectinases, glycanases, galactanases, mannanases, arabinases, catalase, amylase, peroxidase are found in mango. A study (Yashoda 2003) reported cellulose, hemicellulase and amylase showed a steady increase in activity while laminarinase (β- 1, 3 glucanase) exhibited a activity peak around climacteric stage. Hydrolases showed increase activity during ripening whiel pectin methy esterase showed a steady decrease in activity. The major textural changes resulting in the softening of the fruits are due to enzyme- mediated alteration in the structure and composition of cell wall (Tucker and Grierson 1987) and hydrolysis of starch and other storage polysaccharides (Selvaraj *et al*. 1989, Fuchs *et al*. 1980).

Mango can grow and crop on a wide variety of soils. It requires deep, well drained soils of loamy texture. The Gangetic plains of North India and Also the plains on the banks of the rivers of Peninsular India, with deep, well drained, rich and alluvial soils, suit it the most. Soils which are not well drained are unsuitable for the mango. Soils with hard pans, compact layers and alkalinity are considered unfavorable as the root growth is hampered. Subsoil with loose lime concretions wherein the pH is not higher than 7.5 are satisfactory.

The nutrient status of the soils selected for mango cultivation may not be very high, but it is desirable and perhaps also essential that it should be within an optimum range of pH. The soil deficient in nutrient status may be easily corrected by adding the required nutrients, but when it is too acidic or too alkaline at the root zone it may not be possible to effect any improvement. Most of the mango growing soil in India has a low soluble salt content, ranging from 0.04 to 0.05 per cent, and available K_2O from 0.008 to 0.0087 per cent. The pH of soils of most of the well known mango regions varies from 5.5 to 7.5. This pH is considered suitable for mango.

Studies on the variations in anatomical and biochemical changes in the fruit development of same variety of mango from two different regions in meager. In the present study an attempt to identify changes taking place during the fruit development of Kesar, Alphonso and Rajapuri varieties of two different regions differing in the soil and climatic condition has been taken in consideration and studied.

Weather condition during crop seasons strongly influences the crop growth and development. The variation in crop productivity is mainly due to weather fluctuations. Weather and climate are the important factors determining the growth, development and yield of crops. The external environment is the climate which regulates and the weather determines the growth and development and finally the yield of the crop.

Vegetative growth is intimately linked with tree nutrition while fruit-bud differentiation depends upon the biochemical status of the tissues. Increase or decrease of nitrogen in the tissues of the mango tree provides the main cause for favoring growth and flowering. When the nitrogen supply is short, vegetative growth is hampered. Other elements phosphorus and potash are also required to maintain physiological function at optimum level and to encourage rapid development and proper maturity of shoots and fruits. Deficiencies of some micronutrients, such as manganese and zinc have been observed in some parts of India. Leaves become smaller on the new flushes and resetting occurs during zinc deficiency. Manganese deficiency is accompanied with the slackening of growth. The leaves turn yellowish green, with a fine network of green veins (Singh 1967). Optimum biochemical status of tissues is important for fruit-bud differentiation and flowering. Flowering shoots show a higher C: N ratio but it is lower during the period between July and February when non-flowering shoots are actively elaborating reserve food, differentiating buds and blooming. After flowering, the C: N ratio of non flowering shoots drops and thus the cycle goes on. The highest C: N ratio normally coincides with period of fruit bud differentiation. In varieties like Barmasia, a high C: N ratio is not essential for fruit bud differentiation and flowering (Singh 1967).

Studies conducted therefore show that, several elements take part in the growth and development of plants, and those absorbed from the soil are generally known as plant nutrients. In all, 16 elements have been identified and are established to be essential for plant growth. They are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, iron, sulphur, zinc, manganese, copper, boron, molybdenum and chlorine. These elements serve as raw materials for growth and development of plants and the formation of fruits and seEds.

Although plants absorb a large number of elements, all of them are not essential for the growth of crops. The elements taking active part in the growth and developmental processes are called the essential ones. Some are required in large amounts and some in traces. These are classified as major and micro nutrients, and are further classified as follows:

Major nutrients: carbon, hydrogen and oxygen, nitrogen, phosphorus, potassium

Secondary nutrients: calcium, magnesium, sulphur

Micronutrients: iron, manganese, boron, zinc, copper, molybdenum and chlorine.

Studies had revealed that leaves and fruit of *M.indica* contains phenolic acids, flavonols and C-glycosyl xanthone, mangiferin (Andreu *et al*. Andreu *et al*. 2005, Hernandez *et al*. 2007, Ribeiro *et al*. 2008, Ling *et al*. 2009). Mangiferin (2-beta-D-glucopyranosyl-1,3,6,7-tetrahydroxyxanthen-9-one) has significant pharmacological properties including antidiabetic (Garcia *et al*. 2003, Miura *et al*. 2001), antioxidant (Garrido *et al*. 2004, Sanchez *et al*. 2000, Martinez *et al*. 2001), antitumor (Leiro *et al*. 2003, Sarkar *et al*. 2004, Yoshimi *et al*. 2001),vascular modulatory (Beltran *et al*. 2004), immunomodulatory, and antiviral activities (Dar *et al*. 2005, Nong *et al*. 2005, Ribeiro *et al*. 2008). Jutiviboonsuk and Sardsaengjun (2010), isolated mangiferin in leaves of three Thai mango varieties. Other than *M.indica*, mangiferin has been detected in *Anemarrhena asphodeloides, Coffea, Cyclopia, Hypericum rochelli, H. perfoliatum, H. aucheri, H. montanum, Salacia retiulcata* etc (Yoshikawa *et al*. 2001 Campa *et al*. Miura *et al*. 2001). In the present study, all the selected 30 varieties were analyzed for mangiferin content.

The entire study has been categorized into two parts. The first part includes studies on the variations in morphological, anatomical and biochemical characteristics of 30 different varieties of *M. indicia* growing in Junagadh. The second part of the thesis comprises of anatomical and associated biochemical developmental variations in 3 different common varieties of *M.indica* growing in two different regions (Junagadh and Navsari) of Gujarat.

The broad objectives of the present study are as follows:

THIRTY VARIETIES OF *M.INDICA* GROWING IN JUNAGADH, GUJARAT, WERE STUDIED FOR ITS VARIATION IN VEGETATIVE AND REPRODUCTIVE FEATURES OF THE PLANT.

This study includes

1. **The Morphology of:**

   Leaf, inflorescence, flower, fruit.

2. **Micromorphological features:**

   Stomata, Trichome, Venation, Vein islet and Veinlet termination.

3. **The anatomical features of:**

   Leaf: - lamina and petiole

4. **Variation in Mangiferin content:** HPLC analysis

5. **Study of the variation in macro and micronutrients of leaves at different developmental stages.**

   Vegetative phase, flowering phase, fruiting (stage III), and fruit ripening (stage IV).

6. **Soil analysis** of the selected region

THREE DIFFERENT VARIETIES OF *M.INDICA* VIZ., KESAR, ALPHONSO AND RAJAPURI GORWING IN TWO DIFFERENT REGIONS OF GUJARAT, JUNAGADH AND NAVSARI HAS BEEN STUDIED FOR ITS VARIATION IN FRUIT DEVELOPMENT.

1. **Development of fruit -** epicarp, mesocarp and endocarp

2. **Biochemical Analysis of:**

   i) Total sugars

   ii) Proteins

   iii) Enzymes: - Catalase, Amylase, Invertase, peroxidase, cellulose, polygalacturonase, pectinmethylesterase

   iv) Sugars and amino acids

3. **To study the Fiber content:** Total dietary fiber (TDF)