Unit-I Introduction

The plant kingdom is made up of a great variety of individual plants ranging from relatively simple, minute, microscopic forms to highly developed and complex seed plants. Angiosperms or the flowering plants form the largest group of plant kingdom, including about 300 families (411 families, Hutchinson 1959), 8000 genera and 300,000 species (Hutchinson 1967). They are considered to be the highest evolved plants on the surface of earth. From cretaceous age, the angiosperms eclipsed all other vegetation and now they form the main part of the vegetation on earth and are dominant. They are found almost everywhere in each possible type of habitat and climate.

The body of seed plants is highly evolved and structurally specialized. There is a considerable division of labour among the organs and each type of organ is so constituted that it carries on one or more particular functions successfully. The primary meristem found on the apices of the root and shoot give rise to complex tissues which form the primary plant body. In most dicotyledons and gymnosperms a layer of procambial cells between the primary phloem and primary xylem matures into fascicular cambium while the cells of pith or medullary rays which lie in between the edges of the fascicular cambium, divide accordingly to form a new layer of cambium across the medullary rays, known as inter fascicular cambium, resulting in the formation of a complete ring of cambium. In this way a new lateral meristem, the vascular cambium, which is responsible for “growth in thickness by the formation of secondary vascular tissues (radial growth)”, is formed and adds
secondary phloem towards the outer side and secondary xylem towards the inner side.

I | Cambium

In three dimensional view, the cambium is a continuous cylindrical sheath about the xylem. In most of the plants the vascular cambium is reported to exhibit successive active and dormant phases during a calendar year with a few exceptions of tropical species in which meristematic activity continues throughout the year. This behaviour of cambium is believed to be regulated by several internal and external factors which include heredity constitution, physiological phenomenon and environmental conditions of the habitat (Philipson et al. 1971). Therefore, there is further need to investigate the influence of different physical and climatic factors on cambial makeup and its activity and then to suggest measures for the maintenance of desirable growth pattern to ensure a vigorous production of derivative tissues and their content, although in the recent past several workers have conducted such type studies in different species growing in tropical and sub-tropical regions (Iqbal & Ghouse 1990; Catesson 1994; Larson 1994; Rao et al. 1996a; Chaffey 1999; Lachaud et al. 1999; Kitin et al. 1999, 2000; Khan 2001; Mahmood 2001; Khan & Siddiqui 2007a).

There are two conceptually different views regarding the nature of cambium. One school of thought postulates a multiseriate zone in which all the cells are equally endowed with multiplication capacity. This view, proposed by Raatz (1892) has been strongly supported by Catesson (1964). She defines the cambial zone as those cell layers which are characterized by the greatest R.N.A. contents, are the site of most
abundant mitosis and are distinguished in section by radially narrow cells with thin walls. The other school pleads for the uniseriate nature of cambium. There are two interpretations of this uniseriate concept based on terminological differences. According to one, there exists single initial cells which in each radial file of cambial cells lies somewhere between the phloem and xylem mother cells and is responsible for the production of cambial derivatives on both outer and inner sides. This view is mainly advocated by Bannan (1955, 1968) and Newman (1956), has been supported by ultra-structure studies of Mahmood (1968) and Murmanis (1970) pertaining to tangential wall characteristics. According to another group of workers Wilson et al. (1966), Zimmermann & Brown (1971) the term cambium is applicable only to the initial cells, not the immediate derivatives. This, admittance of a single initiating layer is common in both the interpretations, the only difference being that one group of worker applies the term cambium to the entire meristematic zone consisting of the initial layers as well as the tissue mother cells, i.e., the zone of periclinal division, while the other group restricts it to the initiating layer only (Iqbal & Ghouse 1985a, 1987 and Iqbal 1990).

Following the former terminology, Butterfield (1975) defines cambium as a "multiseriate zone of periclinally dividing cells lying between the differentiating secondary xylem and phloem, with distinct initials capable of both periclinal and anticlinal divisions lying somewhere within each radial file of cells." The same terminology has been adopted for describing cambium in the present study.
I (ii) Wood

The wood or secondary xylem is the principal water conducting tissue in a vascular plant. The secondary vascular tissues are produced during second major stage of plant development, in which an increase in thickness results from lateral additions of new tissues to the axial part of the plant (i.e. stem and root) and their larger branches. It results from the activity of the vascular cambium.

The primary and secondary xylem has histological differences, but both are complex tissues containing at least water-conducting elements and parenchyma cells and usually also other types of cells, especially supporting cells. The characteristics of these various types of cells and their inter-relations in the tissue may be best introduced by a consideration of the secondary xylem or wood. Woods are usually classified in two main groups, the softwoods and the hardwoods. The term softwood is applied to gymnosperm wood, that of hardwood to dicotyledonous wood. The two kinds of wood show basic structural differences, but they are not necessarily distinct in degree of density and hardness.

The wood of dicotyledons is more varied. The primitive vessel-less dicotyledons have relatively simple wood, but that of vessel-containing species is usually complex. Wood of latter species may have both vessels and tracheids, one or more categories of fibres, axial parenchyma and rays of one or more kinds.

Esau (2002) described that a block of wood reveals the presence of two distinct systems of cells: the axial (longitudinal or vertical) and the radial (transverse or horizontal) or ray system. The axial system contains cells or files of cells with their
long axes oriented vertically in the stem or the root, i.e., parallel to the main or longitudinal, axis of these organs (or their branches); and the radial is composed of files of cells oriented horizontally with regard to the axis of stem or root.

In transverse section, the cells of axial system are cut transversely and reveal their smallest dimensions. The rays, in contrast, are exposed in their longitudinal extent in a cross section. When stem or root is cut lengthwise, strikingly different view of the rays in the two kinds of longitudinal sections are obtained. Radial sections expose the rays as horizontal bands lying across the axial system whereas a tangential section cuts a ray approximately perpendicular to its horizontal extent and reveals its height and width (Fahn 1997).

In transverse sections the secondary xylem shows more or less orderly radial seriation of cells - a result of the origin of cells from tangentially dividing cambial cells. In vessel containing dicotyledons this seriation maybe somewhat obscured by the ontogenetic enlargement of the vessel members and the consequent displacement of adjacent cells. Radial sections also reveal the radial seriation, and they indicate that the radial series of the axial system are superimposed one upon the other in horizontal layers or tiers. The tangential sections in some woods, the cells of one tier unevenly overlap those of another; in others the horizontal layers are clearly displayed in tangential sections. Thus some woods are non-stratified or non-storied while others are stratified or storied. The storied condition is especially pronounced when the height of ray matches that of a horizontal layer of the axial system. Esau (2002) explains that from the evolutionary aspect the storied woods, derived from
vascular cambia with short fusiform initials, are more highly specialized than the
non-storied woods, derived from cambia with long fusiform initials.

Two principal types of woods are recognized on the basis of distribution of
pores in a growth layer: diffuse porous wood with pores rather uniform in size and
distribution throughout a growth ring; ring porous wood with pores distinctly larger
in the early wood than in the late wood. The ring porous condition appears to be an
indication of evolutionary specialization and occurs in comparatively few species. A
pore is called solitary when the vessel is completely surrounded by other type of
cells. A group of two or more pores appearing together form a pore multiple. This
may be a radial pore multiple, with pores in a radial file, or a pore cluster, with an
irregular grouping of pores. Although vessels or vessel groups may appear isolated
in wood transections, in three-dimensional space the vessels are interconnected in
various planes.

The distribution of the axial xylem parenchyma shows many intergrading
patterns. The spatial relation to vessels, as seen in transections, serves for the division
in two main patterns: apotracheal, parenchyma not definitely associated with the
vessels; paratracheal, parenchyma consistently associated with the vessels. The
apotracheal is further sub-divided into: apotracheal diffuse, single parenchyma cells
or parenchyma strands scattered among fibres; apotracheal banded, boundary or
marginal parenchyma with single cells or a band at the end or at the beginning of a
growth layer. The paratracheal parenchyma appears in the following forms: scanty
vasicentric, forming complete sheaths around vessels; aliform vasicentric with wing-
like tangential extensions; and confluent coalesced aliform forming irregular
tangential or diagonal bands. From the evolutionary aspect the apotracheal and
diffuse patterns are primitive (Jane 1970).

The ray of dicotyledons maybe one to many cells wide, i.e., they maybe
uniseriate or multiseriate and range in height from one to many cells. The
multiserate rays frequently have uniseriate margins. Individual rays maybe
homocellular, i.e., composed of cells of one form only, either procumbent or upright,
or heterocellular, i.e., having two morphological cell types, procumbent and upright.
The entire ray system of a wood may consist of either homocellular or heterocellular
rays or of combinations of the two types of rays. On this basis the ray tissue system is
classified into homogenous, rays all homocellular (procumbent cells only), or
heterogeneous, rays all heterocellular or combinations of homocellular and
heterocellular. Further variations between homogenous and heterogeneous ray
tissues result from combinations of uniseriate and multiserate rays or absence of
multiserate rays (Jane 1970).

I [iii] Bark

The term bark is defined as the tissues lying between the epidermis and the
vascular cambium of an axis, either in primary or secondary state of growth; it
includes the primary phloem, the cortex and the epidermis. The old shoots running
in secondary state of growth, the bark includes, the secondary phloem, the primary
tissues that may still be present outside the secondary phloem, the periderm and the
dead tissue outside the periderm. Whitmore (1962) classified the tissues lying outside
the vascular cambium into two separate zones and named them as the living 'inner bark' and the dead 'outer bark', which are distinct in colour and texture to the unaided eye. According to Whitmore (1962) the outer bark is the 'rhytidome' which is composed of one or more layers, each consisting of a 'periderm' and a zone of tissues it has cut off from the axis. The layers of the rhytidome may be of various shapes and sizes. The inner bark tissues cut off by the periderm sooner or later die, alter in colour and start to decay. Typically the outer bark is composed largely of successive layers of dead inner bark tissue and the periderms themselves are only thin sheets making up a small fraction of the whole outer bark.

It is important in the first instance to study the bark of a group of related species. Minor variations in the bark can then be followed. My intention is to study the developmental and environmental variations. The bark tissue may be analyzed into four components which interact and produce various features of the surface. These are - secondary phloem laid down at the cambium; expansion tissue developed mainly from the phloem rays; phloem proliferation tissue developed from the parenchyma of the conducting phloem and periderm. The secondary phloem doesn't vary as the other components do. The outer bark is acted upon by external weathering processes and tangential strain to produce the fissures and ridges of the surface. The periderms and weathering processes control the sloughing of the bark and hence also its surface texture and colour. The surface pattern of the bark is a visual summation of the surface configurations, the sloughing pattern, the texture and the colour. The splash appearance (oblique tangential section through the
bark) is a visual summation of the inner and outer bark. Barks are recognized in the forests from the subjective, unanalyzed appearance of surface pattern and slash (Whitmore 1962).

Inspite of the fact that Indian sub-continent is one of the richest tropical tree flora on earth, the studies on the radial growth of these trees, i.e., the activity of cambium, its structure and behaviour are still meager. Much, therefore, remains to be known about the growth phenomenon of Indian tropical trees, particularly the vascular cambium and its derivative tissues, xylem and phloem, their cellular organization with age and varying climatic conditions.

The tropical trees in general exhibit a continuous growth unlike temperate ones where the growth phenomenon is sharply rhythmic. A majority of tropical trees grow in multiple flushes or in an intermittent manner due to the prolonged favourable climatic conditions which prevails in the tropical belt. Keeping in view the aforesaid, the present anatomical studies are an attempt to elaborate the structure and behaviour of vascular cambium and its derivative tissues in some Rutaceae members in relation to various seasonal conditions of the study-site and age of the trees. My study includes the following aspects:-

2. The effect of climate and age on the activity and structure of vascular cambium.

5. Production of xylem and its derivatives.


7. Quantitative estimation of tissue.

In fact no information is available with regard to the cambial activity and formation of its derivative tissues in Citrus species of Rutaceae family. It is noteworthy that Citrus is of immense medicinal importance as well as economic value.

I [iv] About Family Rutaceae

The family Rutaceae commonly called as Boronia Family consists of about 140 genera and 1,300 species (Lawrence 1951) of aromatic trees, shrubs and a few herbs, distributed throughout the warm and temperate regions on the earth, being most abundant in South Africa and Australia. Engler (1895) regarded 120 genera and 1,200 species; Willies (1966) mentioned 150 genera and 900 species; Cronquist (1981) regarded 1,600 species in this family. In India it is represented by about 75 species belonging to more than 16 genera.

These are cultivated or wild growing trees or shrubs (sometimes climbers), rarely herbs abounding in pellucid glands filled with essential oil. Some of the genera at present included in it are of considerable interest from the point of view of taxonomy, as well as anatomy of the secondary xylem. The wood is somewhat
uniform in structure, usually pale yellowish-white without contrast between heartwood and sapwood. They are fine to moderately coarse textured. The hardness and density vary from rather soft and light to extremely hard and heavy, but, the majority are rather dense and hard. Growth rings are usually distinct due to bands of concentric initial parenchyma occurring at regular to irregular intervals. The Indian Rutaceae woods are mostly diffuse porous. Vessels small to medium sized, often very small, typically in multiples and some times with a distinct radial or oblique pattern, ring porous or semi-ring porous. Parenchyma as a rule scantily developed, but the concentric bands are prominent. Some genera show distinct aliform to aliform confluent parenchyma as in Citrus. Rays are usually fine and generally closely spaced. Some members contain gummy deposits in their vessels and parenchyma cells. Apart from timber, the economic importance of this family is mainly due to genus Citrus Linn. which provides several well known fruits of commerce such as Oranges, Grape-fruits, Tangerines, Lemons, Lime, Pomelo or Shaddock.

I[v] Citrus

A genus of evergreen, usually armed, aromatic shrubs or small trees distributed in the Indo-Malayan region, South-east Asia and China but cultivated throughout the tropical and temperate regions for fruits. Currently, Citrus is commercially grown primarily between the latitudes 40°N to 40°S.

### Hemisphere Countries

**Northern**
- Algeria, China, Cuba, Cyprus, Egypt, Greece, Israel, Italy, Japan,
Brazil is now the largest producer of *Citrus* world wide. The United States is the second largest producer of *Citrus* overall, and the largest producer of grapefruit. China has significantly increased production to become the third largest producer of oranges worldwide. Spain is the fourth largest producer followed by Mexico, Italy, Japan, Egypt, Argentina, Turkey, Israel, Morocco and Greece. Southern hemisphere countries with subtropical climates, such as Argentina, Uruguay and Chile, have developed export industries for the off-season in the northern hemisphere. Although South Africa is one of the smaller producers by world standards, it sets the example for the development and export of *Citrus* amongst the southern hemisphere countries which include the continents of Australia and South America.

All tropical and marginally tropical countries of the world produce some *Citrus*, mostly from backyard plantings or small scale farmers, which are sold locally. Tropical areas have limited production capabilities because of extremely dry or wet climates and/or disease limitations. India still produces a moderate amount of *Citrus* despite these constraints. About 22 species occur in India. There is considerable difficulty in classifying the species of this genus partly because of their close resemblance and partly because of the tendency to hybridize.
### Types of Citrus cultivars and their place of origin:

<table>
<thead>
<tr>
<th>Types of Citrus</th>
<th>Year of origin</th>
<th>Place of origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citron (<em>Citrus medica</em> L.)</td>
<td>330 BC</td>
<td>China and India</td>
</tr>
<tr>
<td>Sour orange (<em>Citrus aurantium</em> L.)</td>
<td>700 BC</td>
<td>South-east Asia</td>
</tr>
<tr>
<td>Limes (<em>Citrus aurantifolia</em> L.)</td>
<td>do-</td>
<td>East India</td>
</tr>
<tr>
<td>Lemon (<em>Citrus limon</em> L.)</td>
<td>do-</td>
<td>do-</td>
</tr>
<tr>
<td>Sweet orange (<em>Citrus sinensis</em> L.)</td>
<td>do-</td>
<td>South-east Asia</td>
</tr>
<tr>
<td>Shaddock (<em>Citrus grandis</em> L.)</td>
<td>do-</td>
<td>Malaysia and India</td>
</tr>
<tr>
<td>Grapefruit (<em>Citrus paradisi</em> L.)</td>
<td>do-</td>
<td>West Indies</td>
</tr>
<tr>
<td>Mandarin (<em>Citrus reticulata</em> L.)</td>
<td>do-</td>
<td>Indo-China</td>
</tr>
</tbody>
</table>

It is believed to be a native of south China, Malaysia and the sub-Himalayan parts of the erstwhile Assam. *Citrus* originated in the Malay Archipelago and in Southeast Asia. However, more recent evidence suggests that Yunnan province in south-central China may be the center of origin due to the diversity of species found, and the network of rivers in this area which could have provided "on route dispersal" to the south. Movement of *Citrus* to Africa from India probably occurred during 700-1400 AD. Limes and oranges were introduced to the Americas by the Mediterranean explorers and settlers centered in Hispaniola, also to the Caribbean by the Spanish, and to Bahia and Brazil by the Portuguese. The movement of *Citrus* through the
Americas was aided by the development of missions by the Roman Catholic Church who established plantings of various fruits including citrus.

It occupies a place of considerable importance in the fruit economy of the country. It comprises the third largest fruit industry after mango and banana and occupies about 7.5% of the land under fruits. Among the Citrus fruits of commerce, oranges are the most important as fresh fruit and they contribute to roughly 80% of the world's Citrus fruit production. They belong to three species, C. sinensis (Linn.) Osbeck, the sweet orange; C. reticulata Blanco, the mandarin or tangerine orange with its hybrids; and C. aurantium Linn., the bitter or sour orange. Sweet oranges are by far the most important species elsewhere but in India they constitute only 23% of area under Citrus and include the common dessert and juice oranges.

Four species of genus Citrus; available in and around district Aligarh, Uttar Pradesh, India; have been selected for a comparative anatomical studies on the aspects as described earlier-

1 - Citrus limon (Linn.) Burm.f.

Classification (Hutchinson 1959) -

<table>
<thead>
<tr>
<th>Class</th>
<th>Dicotyledons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>Lignosae</td>
</tr>
<tr>
<td>Order</td>
<td>Rutales</td>
</tr>
<tr>
<td>Family</td>
<td>Rutaceae</td>
</tr>
<tr>
<td>Genus</td>
<td>Citrus</td>
</tr>
<tr>
<td>Species</td>
<td>Limon</td>
</tr>
</tbody>
</table>
Hindi - Baranibu, Jambira, Paharikaghzi, Paharinimbu, Kinnanibu.

Distribution: The true home of the lemon is unknown, though some have linked it to northwestern India. It is supposed to have been introduced into southern Italy in 200 A.D. and to have been cultivated in Iraq and Egypt by 700 A.D. It reached Sicily before 1000 and China between 760 and 1297 A.D. Arabs distributed it widely in the Mediterranean region between 1000 and 1150 A.D. Christopher Columbus carried lemon seeds to Hispaniola in 1493. The Spaniards may have included lemons among the fruits they introduced to St. Augustine. They were grown in California in the years 1751-1768. Lemons were reported to be increasingly planted in northeastern Florida in 1839.

Guatemala has in the past 2 decades developed commercial lemon culture. Southern Mexico, too, is now a major grower of lemons, also primarily for lemon peel oil. Lemons are rarely grown for the fresh fruit market in Latin America. In South America, Argentina leads in lemon culture with Chile a distant second. Among the world's leading lemon growers and exporters are Italy, Spain, Greece, Turkey, Cyprus, Lebanon, South Africa and Australia. Lemons can be grown only at medium and high elevations in the Philippines.

Commonly cultivated in gardens and plantations throughout India but grown commercially in Assam, Bihar, West Bengal, Punjab, Orrisa, Rajasthan and Tripura. Lemons occupy about 5,663 ha which accounts for 5.4% of total area under citrus with an annual production of 64,406 tonnes (Phondke 1992).
Description:- A tree up to 6m in height, of spreading habit, thought to be native to India but not found growing wild anywhere. Spines small, stout; leaves light green, oblong to elliptic ovate, lanceolate, sharp-pointed, sub-serrate, petioles narrowly winged; flowers purple in the bud, large; fruits ovoid or oblong 7.5-12.5 cm long with a terminal nipple, very acid; seeds few, small (Phondke 1992).

Uses:- It is widely used in the preparation of lemonade, squash and home made sherbet. It is used as a garnish for fish and meat, for various culinary preparations, e.g. lemon pies, lemon cakes and lemon ices and as flavouring for candies, jellies, jams and marmalades. The expressed juice of the ripe fruit is largely used in the preparation of cooling beverages and effervescent draughts. It is employed as a stain remover and as a bleaching agent. Lemon peels are preserved in brine and candied. They are also used for the preparation of lemon oil, lemon syrup, lemon tincture and flavour for medicinal preparations. The waste peel from juice factories, after dehydration and grinding, are used as stock feed. The wood is fine-grained, compact, and easy to work. In Mexico, it is carved into chessmen, toys, small spoons, and other articles. In China the leaves are used as tea substitute, or dried leaves are mixed with tea-leaf to flavour it (Watt & Breyer-Brandwijk 1962; Tanaka’s Cyclopedia 1976).

Medicinal properties:- The fruit, in the form of prickles, is useful in hypertrophy of spleen. Lemon peel is stomachic and carminative. Oil of lemon is stimulant and rubefacient when applied externally. Lemon juice is one of the best remedies for scurvy and serves as a refrigerant in febrile and inflammatory affections, acute rheumatism, dysentery and diarrhoea. The juice diluted with water is used as a
coUyrium. In South Africa the juice is used with salt a ring worm remedy. Lemon juice may be used in preparing effervescent, diaphoretic and diuretic draughts. In Italy, the sweetened juice is given to relieve gingivitis, stomatitis, and inflammation of the tongue. It is a well known French remedy; lemon juice in hot water has been widely advocated as a daily laxative and preventive of the common cold. The juice also possesses bactericidal property (Watt & Breyer-Brandwijk 1962).

2 - *Citrus paradisi* Macf.

Classification (Hutchinson 1959) -

- Class: Dicotyledons
- Series: Lignosae
- Order: Rutales
- Family: Rutaceae
- Genus: *Citrus*
- Species: *paradisi*

Hindi- Chakotra.

Distribution :- It originated in the West Indies and has been commercialized in USA during the past half century. The oldest known mention of grapefruit comes from the 17th century, when this evergreen fruit tree was discovered on the island of Jamaica in 1750 by Griffith Hughes who called it the "forbidden fruit" of Barbados - hence the Latin name "paradisi". In 1789, Patrick Browne reported it as growing in most parts of Jamaica. The English term, "grapefruit" stems from a most inaccurate description. A botanist named John Lunan, writing about the horticulture of the
island in *Hortus Jamaicensis*, claimed the large round yellow fruit tasted like grapes.
The name stuck, regardless of Lunan's faulty characterization, however early varieties of grapefruit did look much like huge clusters of grapes, as the fruit hung in a bunch on a single branch. William C. Cooper, a citrus scientist (USDA, ARS, Orlando, Florida, to 1975), traveled widely observing all kinds of citrus fruits. In his book, *In Search of the Golden Apple*, he tells of the sweet orange and the grapefruit growing wild on several West Indian islands. He says that it was from the nearby Bahamas Islands in 1823 that Count Odette Phillipe took grapefruit seeds to Safety Harbour near Tampa, Florida.

Today it's the second most important citrus worldwide and a key commercial crop in the U.S. states of Texas, Arizona, California and Florida. In Florida alone, more than 2.5 million tonnes of grapefruit are harvested annually. The U.S. now produces 60% of the world's grapefruit crop. Cultivation has reached commercial proportions in Jamaica and Trinidad and spread to Brazil, Spain, Jordan, South Africa, South America, Israel and Asia. Other countries which had entered the grapefruit industry are Mexico, Argentina, Cyprus, Morocco and some areas of South America which raise grapefruit for local markets. In recent years, the grapefruit has become established in India in hot regions where the sweet orange and the mandarin are prone to sunburn.

Though grown in India in the arid, irrigated regions of Punjab and Haryana, it has not attained any commercial importance (Phondke 1992).
Description: It is known to be an apomictically stabilized hybrid between C. grandis and C. sinensis. A large spreading round-topped tree with dense foliage, few and relatively small thorn or almost thornless. Leaves large with winged petiole; flowers in clusters; fruits in clusters (like grapes), around 250 fruits of medium size per plant, sub-globose, light yellow, rind medium thick, yellow and smooth, flesh pink, sweet with bitter after taste; seeds white, smooth (Phondke 1992).

Uses: It is occasionally used as a root stock outside India. Trees of grape fruit are shy bearers; yields are less but the fruit quality is high. It is used mainly as a breakfast fruit served in halves, in section, or as juice because of its refreshing flavour and mild bitterness. It is also canned and the peel is candied. The bitter principle is a tonic. Dry and fortified wines, brandies and cordials are prepared from the fruit. The peels are rich in pectin and may be employed in making jellies. Peels and seeds are fed to cattle. Old grapefruit trees can be salvaged for their wood. The sapwood is pale-yellow or nearly white, the heartwood yellow to brownish, hard, fine-grained, and useful for domestic purposes. Mainly, pruned branches and felled trees are cut up for firewood (Kumamoto et al. 1987; Singh et al. 1964; Dhillon et al. 1982-83; Rajput & Haribabu 1985; Tanaka’s Cyclopedia 1976; Aiyappa & Srivastava 1965).

Medicinal properties: The limonoids present in the seeds are: limonol, deoxylimonol, obacunol, isolimonic acid and deoxylimonic acid. An enzyme, deoxylimonic acid A-ring lactone hydrolase has also been reported in the seeds which catalyses the conversion of deoxylimonic acid to limonic acid D-ring lactone.

The presence of coumarins and flavonoids in the fruit is reported.
Grape fruit is rich in vitamins C, A and B and minerals (calcium, iron and phosphorus), which balance the acid reaction in the stomach and keep the digestive tract clean and healthy and stimulate appetite. An essence prepared from the flowers is taken to overcome insomnia, also as a stomachic and cardiac tonic. The pulp is considered an effective aid in the treatment of urinary disorders. Leaf extractions have shown antibiotic activity (Kumamoto et al. 1987; Singh et al. 1964; Dhillon et al. 1982-83; Rajput & Haribabu 1985; Tanaka’s Cyclopedia 1976; Aiyappa & Srivastava 1965).

3 - *Citrus reticulata* var. *kinnow*

Classification (Hutchinson 1959) -

- **Class** - Dicotyledons
- **Series** - Lignosae
- **Order** - Rutales
- **Family** - Rutaceae
- **Genus** - *Citrus*
- **Species** - *reticulata* var. *kinnow*

Hindi- Kinnow.

Distribution : - It has originated in India and performs well in Punjab and Karnataka. Kinnows are also cultivated in the lowers hills of Rajasthan, Uttar Pradesh, Kodaikanal region of Tamil Nadu and Coorg (Phondke 1992).

Description : - It is a hybrid between King Orange and Willow Leaf Mandarin. A small spiny strong growing tree 4-6m in height with a dense top, tall and columnar
with numerous long, slender, ascending and vertically thornless branchlets; leaves medium large, broadly lanceolate with prominent midrib; petioles narrowly winged or slightly margined, articulated; flowers white, single or in unbranched inflorescence; fruits globose to slightly oblate, medium sized, both base and apex slightly depressed, skin attractively orange-coloured, tight, tough and leathery; rind adherent but peels easily, segments 10-12, don’t separate easily; flesh bright golden yellow, fine textured, very juicy, melting, deep yellowish orange, rich and aromatic flavour, with a fine sugar acid blend (Phondke 1992).

Uses :- The rind of the fruit on expression yields oil which is rich in limonene. Petitgrain oil is obtained from the leaves and twigs. Mandarin peels yields 0.84% oil on cold pressing and 2.35% on steam distillation. The peel oil showed fairly good anti-fungal activity against *Aspergillus nidulans* (Eidam) Wingate, *A. niger* van.Tiegh., *Cladosporium herbarum* (Pers.) Link.ex.Fr. and *Fusarium oxysporium* Schlecht.ex.Fr. (Gupta & Singh 1983).

Medicinal properties :- It is considered effective in fevers, coughs, acne, and is said to be an antidote to fish and shellfish poison.

4 - *Citrus sinensis* (Linn.) Osbeck.

Classification (Hutchinson 1959) -

- Class - Dicotyledons  
- Series - Lignosae  
- Order - Rutales  
- Family - Rutaceae
Genus - *Citrus*

Species - *sinensis*

Hindi- Mosammi, Malta.

Distribution :- Origin is obscure, possible Asia in southern China and Vietnam, possibly an introgressed hybrid of *C. maxima* x *C. reticulate* (Huxley 1992). Sweet oranges are cultivated both in the sub-tropical, humid regions of North India and the tropical, humid regions of South India. In the north, cultivation is mostly confined to the irrigated plains of Punjab, northern Rajasthan and western Uttar Pradesh. In the south, sweet oranges of good quality are cultivated in the districts of Rayalaseema and northern Circars in Andhra Pradesh. In the western region, fine quality fruits are grown under irrigation in the dry climate of Pune and Ahmednagar and adjoining regions of Maharashtra (Singh 1969).

Description :- A medium to large pendulous tree upto 9m in height with dense foliage and slender axillary spines. Leaves oval or ovate-oblong, smooth, shinning, entire, petioles narrowly winged; flowers axillary, in clusters of 1-6, white, sweet-scented; fruits globose or oblate, light orange to yellow core solid, rind smooth, lightly adhering, pulp juicy, sub-acid, yellow to orange, segments tightly attached to each other, juice-sacs spindle shaped; seeds few to many; white inside (Phondke 1992).

Uses :- The fruit is juicy and nutritious and has a good flavour. It is highly esteemed as a dessert fruit. A turbid yellow juice with a characteristic odour and taste of fresh oranges is obtained on expression. It is a rich source of anti-scorbutic vitamin. The
fruits are sliced and dehydrated until brittle, ground to powder and extensively used as flavouring material for cakes, pies, cookies and plug tobacco. Orange jam is prepared from the residual pulp, after straining the juice; marmalade is also made with this fruit. The essential oils obtained from the flowers of sweet orange (neroli oil) and from the leaves and young shoots (petitgrain oil) are used in the preparation of essences and perfumes. As a flavouring agent, sweet orange peel is employed in the form of infusion, tincture or syrup. It is used in distilleries for making spiced spirits. The sugars present in the peels may be fermented to produce acetone and butyl alcohol. Sweet orange peel is also candied. Leaves are used to make tea (Phondke 1992).

Medicinal properties :- Sweet orange is reported to purify blood, allay thirst in fevers, cure catarrh and improve appetite. The juice is useful in bilious affections and stops bilious diarrhoea. The inner white peel and the rag if consumed along with juice and pulp are laxative. The rind is carminative. Fresh rind is rubbed on the face as a remedy for acne. The dried outer portion of the rind possesses stomachic and tonic properties. The peels are also used to relieve toothache and earache (Duke 1986; Randhawa & Srivastava 1986; Aiyappa & Srivastava 1965).