PRACTICAL MANUAL

TROPICAL & SUB-TROPICAL FRUITS

B.Sc. (Hons.) Horticulture

Semester : III[rd] (New)

Course No.: H/FS-233

Credits : 3 (2+1)




College of Horticulture

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This is to certify that Mr./Miss._____

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DESCRIPTION AND IDENTIFICATION OF VARIETIES BASED ON FLOWER AND FRUIT MORPHOLOGY IN TROPICAL AND SUBTROPICAL CROPS

Classification of fruit crops: Classification is a system of placing an individual or a number in various groups, or to categories them according to a particular plan or sequence which is in conformity with the nomenclature. Knowledge of classification of fruits/fruit plants is very useful to the horticulturists because it serves.

1. To identify and name them.
2. To afford at least some idea of the closeness of their relationship.
3. To suggest with what other kind they possibly may or may not be interbred or crossed.
4. To suggest the kinds with which they possibly may or may not be inter grafted.
5. Often to suggest certain soil, cultural requirements and climatic adaptations.

However, the classification of fruit trees or fruits on the basis of consumers rating e.g. based on size, shape, nutritive value, marketability has also gained attention in recent years. Basically, the fruit trees have been classified on the basis of their botany comprising of taxonomic ancestry, morphologic features, physiological functions, adaptability etc. or on the basis of agricultural and horticultural requirements.

Classification based on fruit morphology:

Depending on number of ovaries involved in fruit formation, fruits are classified into

A. Simple fruits: Simple fruits are derived from a single ovary of one flower. Simple fruits are of different types with their class names are presented below:

i) Berry : e.g. Banana, papaya, grape, sapota etc.
ii) Modified berry:
iii) Balausta : Pomegranate.
iv) Amphisarca : Elephant apple, wood apple etc.
v) Pepo : e.g. Melon, water-melon etc.
vi) Pome : e.g. Apple, pear, quince.
vii) Drupe (stone) : e.g. Mango, peach, plum, ber etc.
viii) Hesperidium : e.g. Citrus

B. Aggregate fruits : Aggregate fruits develop from numerous ovaries of the same flower. Aggregate fruits are also of many types.

i) Etaerio of berries : e.g. Custard apple
ii) Etaerio of druplets : e.g. Black berry, longan berry.

C. Multiple fruits : Multiple or composite fruits are produced from the ripened ovaries of several flowers crowded on the same inflorescence. These are also seen to be different.

i) Syconus : e.g. Fig.
ii) Sorosis : e.g. Jackfruit, pineapple, breadfruit, mulberry

Classification on the basis of flowering habit:

Fruit plants are classified on the basis of their season of flowering.This is presumed to the response of the fruit plants to varying photo-thermal conditions.

a. **Ever flowering species:** In this group of plant, flowering continues throughout the year irrespective of photo-thermal reaction. Fig and papaya may be cited as example in this group.
b. **Non-seasonal flowering species:** Variation in flowering from plant to plant and from branch to branch is noticed in the plants in this group. The variation is more prominent around equator and the plants become seasonal, as they are grown away from the equator. Mango, coconut etc. are examples of fruit plants in this group.
c. **Gregarious flowering species:** Flowering indefinite times in a year areimpulsed by the atmospheric cues like rainfall in drier period or chilling induces indefinite flowering. Differentiation, formation may take place but flower opening and anthesis require an impulse due to temperature. Precocity at long interval may also be attributed as gregarious flowering e.g. Quince.
d. **Seasonal flowering species:** Many plants flower during the suitable season. Any variation in atmospheric factor during the favourable seasons leads to continuous of vegetative phase in this group of plants. Guava, litchi, apple, pear are good examples of fruit plants in this group which flower during the specific season.

Description and identification of tropical and subtropical fruits based on flower and fruit morphology

Sr. No.	Common name	Botanical name	Family	Chromo some no.	Origin	Type of fruit	Edible portion
1.	Mango	*Mangifera indica*	Anacardiaceae	40	Indo Burma	Drupe	Mesocarp
2.	Banana	*Musa acuminata x Musa balbisiana*	Musaceae	24, 33, 44	South East Asia	Berry	Mesocarp and Endocarp
3.	Sweet orange	*Citrus sinensis*	Rutaceae	18	China	Hesperidium	Juicy Placental Hairs
4.	Mandarin	*Citrus reticulata*	Rutaceae	18	China	Hesperidium	Juicy Placental Hairs
5.	Kagzi Lime	*Citrus aurantifolia*	Rutaceae	18	China	Hesperidium	Juicy Placental Hairs
6.	Lemon	*Citrus limon*	Rutaceae	18	East Indies	Hesperidium	Juicy Placental Hairs
7.	Grape	*Vitisvinifera*	Vitaceae	38	Black Sea to Caspian Sea	Berry	Pericarp and placentae
8.	Papaya	*Carica papaya*	Caricaceae	18, 36	Tropical America	Berry	Mesocarp
9.	Pineapple	*Ananascomosus*	Bromeliaceae	50, 75, 100	Brazil	Sorosis	Bracts and Perianth
10.	Sapota	*Manilcaraachrus*	Sapotaceae	26	Mexico	Berry	Mesocarp
11.	Guava	*Psidiumguajava*	Myrtaceae	22,33	West Indies	Berry	Thalamus and Pericarp
12.	Fig	*Ficuscarica*	Moraceae	26	West Asia	Syconus	Fleshy receptacal
13.	Pomegranate	*Punicagranatum*	Punicaceae	16, 18	Iran	Balusta	Arils
14.	Litchi	*Litchi chinensis*	Sapindaceaae	30	China	Pome	Fleshy thalamus

EXERCISE - 3

SELECTION OF SITE AND PLANTING SYSTEM

Selection of site: Proper selection of site is very important. Selection of site should be based on the following factors:

i) The site should be in a recognized fruit region, because (a) one could get benefit of experience of other growers and (b) benefit of selling of produce through co-operative organizations with other fruit-growers.
ii) The site should be close to market.
iii) The climate should be suitable for the fruit crops chosen.
iv) Sufficient supply of water should be available.

The following factors are to be determined before a grower selects a site:

i) Suitability of soil, its fertility, the nature of sub-soil and soil depth.
ii) Drainage and freedom from stagnation during rains.
iii) Adequate supply of good, sweet water all the year round, mostly in summer.
iv) The site is near to a market or city with proper transport facilities.
v) The site is free from cyclone, frost, hail-storms and strong hot winds.
vi) Is there seasonal gluts/over-production in any particular period of the year?
vii) Whether there is assured demand in the market for the fruits to be grown.
viii) Whether orchard is a new venture or there are already other growers.
ix) Availability of labour
x) Medical and educational facilities
xi) Cost of land
xii) Air-drainage: It is the name applied to the setting of cold air to the lower level in any given local area. Cold air being heavier than warmer air on still cool-nights, gradually flows from the higher land to the lower. For this reason, sites for locating or selecting orchards are best located on slopes above the surrounding land rather than level land or in valleys.

Planting systems:

Horticultural plants are perennial in habit. Therefore it becomes of immense important to locate them with proper thinking. So accordingly a layout is made and plants are planted to maximize yield in a unit area planting a tree such a way is convinced for interculturing, irrigation, transportation, crop protection, crop sanitation and supervision, distribution of uniform area for crop canopy and root spread, suitability with location occurrence of storm and topography etc.

Commonly the following systems are practiced for above said convinced intercultural practices.

1) Square system :

It is a widely adopted simplest of systems of planting. In this system the plot is divided into squares and trees are planted at the four corners of square; in straight rows running at right angles, while laying out the plot a base line is first drawn parallel to the road, fence or adjacent orchard, at a distance equal to half the spacing to be given between the trees. Pegs are fixed on this line at desired distance. At both ends of the line, right angles are drawn by following simple carpenter's 3, 4, 5 m system and then they are fixed to mark the locations in between the lines at the required spacing. In this system, intercultural operations, spraying, harvesting etc. can be done conveniently and easily. In this system, cultivation and irrigation can be done in two directions.

2) Rectangular system : In this system, plot is divided into rectangles instead of squares and trees are planted at four corners of the rectangle in rows running at right angles. In this systems the between row and plant to plant in row is not the same.

3) Triangular system: In this system trees are planted as in the square system, but the second row are planted midway between the plants in the 1st row. Hence, here the distance between row to row is less than the distance between plant to plant in row. This system is generally not adopted as it is difficult to layout and cultivation also in the plots under this system becomes difficult.

4) Hexagonal system: In this system the trees are planted at the corners of equilateral triangle and thus, six trees form a hexagon with the 7^{th} tree in the center. This system is generally followed where land is very fertile with ample provision of irrigation water. About 15 % more plants can be planted per unit area by adopting this system. However, it is difficult to layout and cultivation in plot cannot be done so easily as in the square system. For layout the plot, a base line is drawn as in the square system. Then an equilateral triangle having ring at each corner and with sides equal to the length of the required distance is made of heavy rings or chain. The two of these rings are then placed on the pegs of the base line and the position of the third ring indicates the position the tree in the second row. The second row is then used as the base line and the pegs are set in the third row. In this way entire plot is laid out.

5) Quincunx system: This system of planting fruit trees is similar to square system, except that 5^{th} tree is planted at the center of the each square. As a result the number in a unit area becomes almost double the number in the square system. The additional tree in the center is known as filler. Usually quick growing early maturing and erect type fruit trees like banana, papaya, pomegranate etc. are planted as filler trees, which removed as soon as the main fruit trees planted at the corners of the square come into bearing. The fillers provide an additional income to the grower in the early life of the orchard.

6) Contour system: This system particularly suits to hills or a land with undulating topography where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve the soil moisture so as to make the slope fit for growing fruits. The trees are planted on the contour lines drawn at equal altitude. The planting distance under this system may not be uniform.

Planting of the fruit crops: For planting the fruit crops, pits are dug at required spacing. The pit size varies from 60 cm^3 to 1 m^3. While digging pits, the top soil up to a depth of 45cm and sub soil below this should be placed separately. After complete digging pits are exposed to sun for disinfection of the pit soil. The pits are then filled up top soil mixed with FYM/compost and SSP, up to at least 10cm above ground level and planting of fruit trees is done with the commencement of rainy season. In areas with heavy rainfall, planting should be done after the heavy rains are received. Planting should be avoided during hot and dry spells of weather.

Points to be considered while planting are given as below:

- Dig out only a small amount of soil in the centre of the pit so as to accommodate root ball of the planting of material.
- Place the planting material erect in the hole and fill it with dug out soil and press gently.
- Apply water immediately after planting without stagnation.
- Do not bury the bud /grafting joint of the planting material in the soil.
- The plants should be staked with bamboo pole to prevent lodging and damage to bud orgraft joints by strong wind.

SN	Crop	Spacing (m)	SN	Crop	Spacing (m)
1	Mango	10 x 10	7	Grapes	3 x 3 or 2 x 2
2	Banana	Tall 3 x 3	8	Papaya	1.8 x1.8
		Semi Tall 2.5 x 2.5	9	Sapota	10 x10
		Dwarf 2.0 to 1.8 x 2.0 to 1.8	10	Fig	5 x 5 or 4.5 x 3
3	Sweet Orange	6 x 6	11	Pomegranate	4.5 x 3 or 5 x 5
4	Mandarin	6 x 6	12	Litchi	10 x 10
5	Acid Lime	5 x 5 or 6 x 6	13	Avocado	5 x 5 or 6 x 6
6	Guava	5 x 5	14	Loquat	6 x 6 or 8 x 8

Assignment:

Calculate the number of trees accommodates in a hectare area, when different fruit crops planted at following spacing.

i) 1.8 x 1.8m
ii) 4.5 x 3 m
iii) 5x5 m
iv) 6 x 6 m
v) 10 x10 m

TRAINING AND PRUNING OF GRAPES, MANGO, GUAVA AND CITRUS

GRAPES:

Training: It may be defined as removal of ample plant part to give proper shape to the plant. The main object of training is to give desired shape that facilitates different operations like cultivation practices, plant protection, pruning, harvesting etc. The important systems of training in grapes are given as below.

1) Head system 2) Kniffin system 3) Overhead system 4) Bower system

The choice of the system depends upon the main factors such as vigour, apical dominance, capacity of owner to invest etc. In South India vine makes vigorous growth and have pronounce apical dominance hence bower system of training is best suited while in North India vines are vigorous hence head system is mainly adopted.

1) Head system: This system is best suited to the varieties producing fruitful shoot from basal bud e.g. Beauty seedless, Perlette, Delight and Gold. It is the cheapest and easiest system of training. The vine is trained like a dwarf bush. The vine is allowed to grow single stem with help of stake after attaining 1.2 m height. It is then cut back to produce side shoots. After retaining 4 side shoots 45 cm above ground in all directions, rest of the shoots are thinned out. These laterals are then cut to 2 buds will produce secondary arms of 20 to 30 cm in length are kept on each lateral. Normally, 1-2 fruiting spurs are kept on each secondary arm. After 3 to 4 years the vine becomes like a dwarf bush and grows without support. In this system, vines are planted at a spacing of 1.8 x 2.4 m. The advantages of this system include inexpensive, easy to train etc.

2) Bower system: It is also known as Arbour or Pergola system. This is the most popular system for Anab-e-Shahi in Andhra Pradesh and for Thompson Seedless in Maharashtra. Though, it is expensive, this system is adopted on a large scale almost in all the grape growing region of India. This system is suitable for vigorous varieties. In this system, *Mandap* is prepared with the help of iron poles or concrete pillars. Wires are stretched horizontally and crisscrossed, about 2.1 to 2.4 m above the ground level. The vines are planted at a distance of 3 x 3 m. The vine is allowed to grow single stem till it reaches the wire network and the vine is supported with a bamboo pole. When the vine reaches the wire, it is pinched off just below the wire net. Then two vigorous shoots in opposite directions are selected at the wire level for training as primary arm. On each primary arm, three laterals at either side at a distance of 60 cm are kept as secondaryarms. Thus, there will be 12 secondary arms on each vine. These secondary arms are allowed to grow and have about 8 to 10 tertiaries, which after maturity form fruiting canes.

3) Kniffin system: This system is evolved by William Kniffin in 1850 in New York as a four cane system. In this system, two trellies of wires are strung supported by vertical posts. In modified

kniffin system three horizontal trellies are made at different height. This is most suitable for moderately vigorous varieties. In this system, two wires are stretched at 90 cm and 60 cm spacing (next at 1.5 m height) supported by irons angles at 4.8 m distance. The two vines spaced at 2.4 m are accommodated between two poles. The vines supported by bamboo sticks grow single stem and one arm is allowed to develop horizontally along each wire on either side. Thus, each vine will have four arms and bearing arms are regulated on these four arms by pruning. This system is suitable for Beauty Seedless, Early Muscat, Perlette, Bhokari and Delight.

4) Overhead trellies or telephone system: This is popularly known as Telephone system. In this system usually 3 to 4 wires are fixed to the crossed angle arm supported by vertical pillars. Then, the vines are planted at a spacing of 3 x 3 m. The wires are stretched as telephone wires. When the vine reaches the wire /height of the telephone, it is pinched off to encourage the side shoots and two side shoots are selected as the primary arms from which 4 vigorous laterals on each side along the wires are allowed to develop as secondary arm and each complete secondary arm can carry 6 to 8 fruiting units. This system is followed for vigorous and medium vigorous varieties *viz*., Thompson Seedless, Anab-e-Shahi etc.

Pruning: Clear understanding about the different terms used in pruning technology is important.

1. **Shoot:** It is young leafy growth of the current season.
2. **Cane:** The shoot after maturity is called cane.
3. **Spur:** The basal portion of the cane left after the pruning on the vine is called spur.
4. **Fruiting spur:** The spur intended to bear fruit with 2 to 4 buds is called fruiting spur.
5. **Fruiting cane:** The basal part of the mature cane with 8 to 12 buds left after pruning.
6. **Arms:** The branches older than one year are called arms.
7. **Trunk:** The undivided main stem is called trunk.

Pruning is done once in a year in North India during January, while in South India; it is done twice in a year i.e. once in summer and again in winter. Pruning mainly consists of thinning out and heading back. All the mature shoots, whether those have given fruits or only made vegetative growth are to be headed back at a certain level depending upon the variety. Some of the canes are headed back severely to retain 1 or 2 buds; it is termed as thinning out. The varieties like Gulabi, Gold, Pusa Seedless are less vigorous and they produce fruits on basal 3 to 4 buds and hence should be pruned heavily retaining only 4 to 5 buds. These are known as spur pruned varieties. The varieties like Thompson Seedless, Kishmish, Muskat etc produce fruits on initial 8 to 12 buds; hence they should be pruned by retaining 13 to 14 buds. These are called cane pruned varieties. All the diseased and damaged canes are to be removed completely while carrying out the pruning operation.

MANGO: Training is an important practice during the first few years after planting. It is essential to space the branches properly and to help in intercultural operations. Mango needs no regular pruning except removal of dead and diseased branches.

GUAVA: Traditionally, no pruning is done in guava because the plant bears heavily even without it. But no pruning results in the formation of narrow crotches, limb breakage due to heavy fruit load and overcrowding. Therefore, training of plants in young stage to build strong framework and to avoid weak crotches is necessary, whereas fruiting trees should be pruned to check overcrowding in the orchard. The plants should be trained as low headed trees to facilitate multiple hand pickings. The open centre or delayed open centre system may be adopted. The scaffold branches in young plants are to be tipped back to encourage secondary branching. The root suckers, water sprouts and criss-cross branches are to be removed altogether. In Maharashtra, bending of horizontal branches is practiced to some extent by tying the branches of two adjoining plants to increase fruiting in young plants but it is labour-intensive and creates hindrances in cultural operations. In every growing season, a large number of new shoots emerge in guava a majority of which are lateral and a few are terminal. These shoots produce fruits. After 1 year most of the lateral shoots dry out, while terminal shoots put forth the extension growth. Hence, to check the overcrowding and to control the plant height, the terminal shoots on the periphery may be headed back at about 40cm level in alternate years. Pruning also takes place during harvesting as the fruit is plucked along with the shoot on which it is borne. Pruning is usually recommended after harvesting or in spring. Summer pruning may damage the plant by sun burning.

CITRUS:

Limes: Young acid lime plants may be trained to modified central leader system, with a smooth trunk up to 75–100cm height from the ground level and 4–5 well-spaced and well-spread branches, as scaffolding branches. All sprouts appearing on the trunk up to a height of 75–100cm should be removed. Similarly on grown-up trees, the water suckers appearing on the main trunk and scaffolding branches should be removed promptly. Once a young plant is trained to a desired shape, it requires very little pruning. Light pruning may be given during later years. Lightly-pruned young trees make greater development of roots and shoots, producing fruits earlier than those pruned heavily. Pruning of bearing citrus trees though differs with the variety, chiefly consists of removal of dead, dried, diseased and broken, criss-cross branches, whose existence is detrimental to the health of the tree. Removal of water suckers is also essential. Pruning may be done just after harvesting. Soon after pruning, the cut ends may be smeared with Bordeaux paste or Copper oxychloride.

Lemons: The lemon trees differ from that of lime, needing a little different training and pruning. Young lemon trees have tendency to produce long, rambling branches and bear fruits at the tip of the laterals, resulting in the drooping of the branches, except a few, which are necessary for the framework of the tree. The rest, particularly those in the centre, should be removed. Mature lemon trees require more pruning. The long shoot which had already fruited at the tips, are to be headed back to the lower secondary shoots to develop the bearing region close to the ground. Annual light pruning of shoots which have fruited for a few years is essential to stimulate new shoots and to maintain production of high-quality fruits.

Mandarin orange: An ideal mandarin tree should be low headed with a dome like crown. This can be achieved by pruning young trees. Pruning of young trees to give them proper shape and size is known as training. To give a desirable shape to the plant, pruning is resorted to during initial years of planting. Trees are trained to single stem with 4–6 well-spaced branches for making the basic framework. Further, the lowermost branches should be allowed not to grow below the height of 50cm from the soil surface. The bearing trees require little or no pruning. Main objective of pruning the bearing trees is to maintain the framework and to secure higher yields with better-quality fruits. Pruning of bearing trees though differs with variety but chiefly consists of removal of dead, diseased, criss-cross and weak branches. Removal of water sprouts and suckers of rootstocks is also highly essential. Pruning of non-bearing trees can be done at any time of the year, but for bearing trees the best time is after harvesting, during late winter or early spring when these are in somewhat dormant stage. Root pruning is also practiced in some parts of central and southern India to regulate flowering season. However, such pruning are not beneficial in the long run.

PRE-TREATMENT OF BANANA SUCKERS AND DE-SUCKERING IN BANANA

Two types of suckers arise from the rhizome. One is the water sucker with large leaves and the other is the sword sucker with thin leaves and a pseudostem with thin base and pointed top. The latter is used for planting. They take a little longer to bear fruit, but the bunches are large and the yield higher. The suckers are detached along with their bulbous base from the parent-rhizome. The suckers should be less than three feet in height. Larger suckers will bear fruit earlier, but their yield is lowers. All their leaves and roots are removed and generally two-thirds of their pseudostem is cut off. New roots appear in about a week after planting. In South India the suckers are often kept in the sun till they wither and harden. In Western India they are dipped in diluted cow dung and then smeared with wood ash. These practices are followed to protect them from drying out in the field. In the variety Basarai in East Khandesh the pseudostems are cut off after harvesting. Many suckers arise from the rhizome after this. The suckers are dug out along with their new bulbous rhizomes. The pseudostem of the suckers is cut off close to the bulb. These bulbs weighing about one to two pounds are stored in a cool dry place for about two months. During this period the leaf bases of the pseudostem drop off, exposing a raised heart bud. In some countries, pieces of the parent-rhizome are also used for propagation, but this practice is not followed in India.

Desuckering: Surplus and unwanted suckers should be kept under control for better growth and yield of the mother plant. Desuckering once in 45 days is a common practice in banana plantation. In a young plantation of up to 2–3 months, emerging small suckers are simply headed back with a sharp knife. In later stages, removal along with their rhizomes is a must. For that a crow bar of 1 m with a flattened, spoon-like edge is used and care is taken not to damage the mother plant. Cutting back the sucker and pouring kerosene (4ml) into the small gouged cavity made in the center or injection of kerosene from the side of the sucker just above the meristem can also be adopted.

SEX FORMS IN PAPAYA, SEED PRODUCTION IN PAPAYA, LATEX EXTRACTION AND PREPARATION OF CRUDE PAPAIN

SEX FORMS IN PAPAYA

Linnaeus (1953) classified papaya as a dioecious species. Gammie and Patwardhan (1908) recognized several sex types, such as dioecious pistillate, dioecious staminate, andromonoecious, polygamous, staminate and hermaphrodite flowers. Higgins and Holt (1914) recorded 13 sex forms of flowers, while Pope (1930) and Cheema and Dani (1930) recognized 3 and 11 different sex forms, respectively. Storey (1937) reported 4 types of flowers in papaya and classified them as typical female or pistillate, typical male or staminate, hermaphrodite and intermediate. Hofmeyr (1938) in his work on papaya, reported 9 different sex forms as female, male, elongata sterile, hermaphrodite, coenomonoedious, pentandria, coexistance of elongata and pentandria, pistillate, hermaphrodite and pistillate and staminate flowers on the same plant. Agnew (1948) described three main types of flowers namely, pistillate, staminate and hermaphrodite or bisexual flowers. Further, he classified hermaphrodite flowers into 3 forms as pentandria, intermediate and elongata according to the nature of their structural modification. Variation in sex was also reported by Sen (1940) and Kumar (1952). Storey (1958) identified 8 working categories as staminate, teratological staminate, reduced elongata, elongata, carpelloid elongata, pentandria, carpelloid pentandra and pistillate. According to him, *Carica papaya* has 3 basic sex forms viz., staminate, pistillate and andromonoecious. The pistillate plant is stable, while staminate and andromonoecious plants may be either phenotypically stable or phenotypically ambivalent going through seasonal sex reversals during which they produce varying proportions of staminate, perfect and pistillate flowers.

Assignment:

1. Write the examples of papaya dioecious, andromonoecious and hermaphrodite varieties of papaya.
2. Write the definitions of the flower types mentioned in this exercise.

SEED PRODUCTION IN PAPAYA:

Papaya is commercially propagated by seed. Gynodioecious varieties breed true-to-type and are preferred by commercial growers. Therefore, production of quality seed is most important for successful production and establishing papaya-based industries.

Papaya seeds are produced by controlled cross pollination and maintaining isolation distance. Pollens from male parent are collected and hand pollinated on flowers of female plants of the same cultivar. The female flower is then prevented from foreign pollens by bagging. The bag is removed once the fruit is set. Fruits are harvested semi ripe and ripened in the shade. The seeds are extracted from the pulp, washed, dried and stored. The controlled cross

pollination was reported to be the best carried out in August-September to maximize seed production. It is suggested that foundation seed production on a commercial scale may be produced on isolated fields to meet the increasing the seed demands, however breeders seed should be produced under strictly controlled pollination to maintain genetic purity. A ratio of 2:1 bisexual:female plants is recommended for seed production of papaya.

MANUFACTURE OF PAPAIN:

The latex or milky juice of the unripe, green papaya fruit contains a large amount of a digestive enzyme called papain, which is able to digest the protein in our foods. The papain is valued as an industrial product in preparing various digestive medicines and foods. The production of papain has long been an important industry in Ceylon which exports large quantities of the product annually to Europe and America. In India, papaya is chiefly used as a dessert fruit and no papain is extracted from it for commercial purposes. However, with the increase in the cultivation of this popular fruit in various parts of India, it may be profitable to manufacture papain where fruit production is over-abundant and it is not possible to dispose of the entire produce in its fresh state in the local markets. It is also profitable to grow papaya solely for the purpose of papain extraction.

Tapping and collection of latex:

Papain is nothing but the dried latex or the milky juice of the papaya fruit. In Kerala, leaf-sheaths of areca palms would very well serve as containers for collecting the latex. In the Tamil Nadu Agricultural University, Coimbatore, large aluminium trays are fixed to the tree trunk and the latex flows into the trays. For collecting the latex aluminium trays seem to be satisfactory as no adverse reactions were noticed as in the case of other metals. After about 2 to 4 hours, the latex is scraped out from the tray and dried in the sun.

The fruits abound in latex, particularly when the tree is young. Warm weather after a rain also helps production of latex in large quantities. In the early morning, the flow is abundant. The work of tapping should be undertaken very early in the morning so that drying in the sun can be done before mid-day. This makes the material sufficiently dry by the evening. It keeps without deterioration until the next morning when the drying can be completed.

Preparation of crude papain:

Drying in the sun can be hastened if the coagulated latex is pressed through a cullender so as to come out in the form of small threads resembling vermicelli. The drying must be done in the dry weather at low temperatures, as at high temperatures the active principle of papain is destroyed. Temperatures below 100°F are preferred. The coagulated latex may be placed upon sheets of glass or porcelain or enamelled vessels for drying. When thoroughly dried, the latex becomes crisp and flaky. It may then be ground into a powder, preferably while still warm. The sun dried papain results in a white or cream coloured powder which should be placed in air-tight bottles. Incubators can also be used for drying. Experiments at Coimbatore showed no difference in quality between sun-dried and incubator-dried product.

Papain yield:

The annual yield of papain per plant varies greatly according to the variety, its fruiting vigour and the culture adopted in different climatic conditions. It is estimated that a good yield is 196 kg/ha/year for the first year after coming into bearing. In the second year, the yield should roughly be one-half of that of the first year. In the third year, the yield will be uneconomical to warrant keeping the plantation for tapping papain.

In India, at the Harcourt Butler Technological Institute, Kanpur, the yield per plant was found to vary from 112 g to 450 g in the same variety. The market price of papain usually fluctuates between Rs.40 to 80/-per kg according to its quality. It may not be economical to prepare papain in localities where papayas are sold as fresh fruit at high prices, but the papain industry will be a highly paying one where the papaya can be grown as a rainfed crop and with the least expenditure on its cultivation and manuring.

USE OF PLASTICS IN FRUIT PRODUCTION

Plasticulture: The term plasticulture is used to describe the broad and general use of plastics in agriculture. Plasticulture can extend the growing season and improve crop health and growth.
Mulching: It is a technique of covering the upper surface layer of soil by natural crop leftover or plastic films for soil and water conservation is called as mulching. Plastic mulch is commonly used to control weeds in the crop row, moderate soil temperature and conserve water in the plant root zone. There are many different colours and qualities of plastic mulch and use varies depending on the season and crop being grown. There are also degradable mulches made of cornstarch and paper and plastic mulches that are heat and/or light degradable. The plastic film mulches are generally made from low density polyethylene (LDPE) and linear low density polyethylene (LLDP).

Advantages:
1. Increases soil temperature under black and clear much.
2. Reduces soil compaction: Soil under plastic mulch remains loose friable and well aerated. Roots have access to adequate oxygen and microbial activity is excellent.
3. Reduces fertilizer leaching
4. Reduces drawing of crops
5. Reduces evaporation
6. Act as a cleaner product
7. Eliminates root pruning
8. Reduces weed problem
9. Helps in earlier crop harvesting
10. Increases crop growth

Disadvantages:
1. Costly to remove
2. Greater initial costs
3. Increases management
4. Increases soil erosion

Recommended thickness of plastic film for different crops.

1	Annual crops	Vegetable crops, strawberry etc.	25 microns
2	Biennial crops	Papaya, Banana	50 microns
3	Perennial crops	Fruit crops, Plantation crops etc.	100 microns

Types of plastic mulching:

1) **Photo degradable plastic mulching:** This type of plastic mulch film gets destroyed by the light of Sun in a short period.
2) **Bio degradable plastic mulching:** This type of plastic mulch film which gets absolve in the mud in an organic condition.

Colour of plastic mulching films: By a proper selection of plastic mulch composition, colour and thickness, it is possible to very precisely control the soil environment. Following types of plastic mulch films are used in horticultural crops**:**

1. **Black plastic mulch film**: These helpful in conserving moisture, controlling weed problem and reduces outgoing radiation.
2. **Reflective silver film:** It generally maintains the cooler root zone temperature.
3. **Transparent film:** It increases the soil temperature and is mostly used for solarization of the land.

Structures: Various types of structures are available to lengthen the growing season for the crop and improve overall crop health and quality. The high tunnels, low tunnels, loop houses, and greenhouses. Structures that are used for winter production must be able to withstand heavy rainfall, snow, and wind. Structures that are used for summer production must have good ventilation. Many structures may not be suitable for year-round production.

Irrigation systems: Drip, micro sprinklers, fogging system etc.

Recycling: Recycling is a common issue faced by agricultural plastic users. The cost of removing and disposing of agricultural plastics can be high.

MANURE AND FERTILIZER APPLICATION INCLUDING BIO- FERTILIZER IN FRUIT CROPS

Nutrition management of fruit crops is one of the important cultural practices for improving the productivity of fruit crops. Fruit trees being long-lived with spreading root system, the manure and fertilizer requirement of the fruit trees is much different than the field crops. The various factors such as age of the tree, type of the root stock, varieties, soil type, rainfall etc. should be taken into account while formulating the manurial programme for increasing the fruit production.

Types of manure and their methods of application: The method of application of manure would depend upon the type of manure which is classified into 3 *viz.*, bulky, concentrate and inorganic fertilizers.

1) Bulky manure: Bulky manure such as FYM, compost, etc. should be broadcasted over the entire area or near the feeding root zone and well with the soil. The season of application should be such that it should not leached out. In heavy rainfall areas manure may be applied after heavy rains are received whereas in low rainfall areas it should be applied just before the monsoon.

2) Concentrate manure: It includes organic matter such oil cakes, blood meal, bone meal, etc. The nutrients in this manure are not available quickly as they have to be broken down by the action of the soil born micro-organism and made available to the plant. Hence, this manure should be used well in advance before they are required by the trees.

3) Inorganic fertilizers or artificial manure: These are of three types.

a) Nitrogenous fertilizers: These include Urea, Ammonium sulphate, Ammonium nitrate, Sodium nitrate, etc. The nitrogen in nitrate form is easily available to the plant. These fertilizers are applied in round strip under the canopy of the tree. A light irrigation is given to dissolve the fertilizers after their application.

b) Phosphatic fertilizers : The phosphorous when applied to the soil gets fixed up at the spot where it is applied even if the plenty of water is present in the soil and application of phosphorous should be done near the root system so as to make it readily available to the plant. In plants with superficial root system, the phosphastic fertilizers may be applied in top 5 to 7.5 cm layer where the plants having deep root system like mango these are applied 1.5 to 5cm deep in trench dug under the canopy of the tree.

c) Potassic fertilizers: The potash like nitrogen is readily soluble and easily available to the plants and its method of application is similar to that of nitrogen application.

PREPARATION AND APPLICATION OF GROWTH REGULATORS IN BANANA, GRAPES AND MANGO

Growth regulators are the organic chemical compounds, other than plant nutrients and their application in minute quantity/concentration enhance, inhibit or alter the physiological processes of plants in the appreciable measure. They are produced naturally in the plants (phytohormones) and other growth substance/hormone compounds. They are readily absorbed and move rapidly through tissues when applied to different parts of the plant. These compounds are specific in their action and the response of plants to their application depends on their concentration.

Plant Bio-regulators: Plant Growth Regulators are broadly classified as

1. Auxins - IAA, IBA, NAA
2. Gibberellins - more than 100, GA_1 to GA_{100}
3. Cytokinins - Kinetins, BAP, BA
4. Ethylene - Ethephon
5. Growth inhibitors - ABA
6. Growth retardants - CCC, Paclobutrazol, MH – 40

The strength of solution to be used depends on season, species/type of crop, stage of crop, type of bio-regulators use and environmental conditions. For commercial preparation of bio-regulators, the required amount of PGR is taken and dissolved in required quantity of 95% ethyl or methyl alcohol or acetone and final volume is made with water or 50% alcohol or acetone.

Another method of preparation of plant regulators is dissolving the compound either in dilute acid or alkali, neutralize the excess quantity of acid or alkali and make required quantity with water. Acidic compounds like auxins, gibberellins, abscissic acid are initially dissolved in little quantity of dilute NaOH, then little amount of distilled water is added and excess alkali is neutralized with (0.1N) HCl. Final volume is made by adding remaining amount of water. In case of cytokinins or alkaline compounds the desired concentration is prepared by dissolving required amount of PGR in 0.1N HCl (dilute acid) and little quantity of distilled water is added, excess acid is neutralized with little quantity of 0.1N NaOH (dilute alkali) and final volume is made by adding remaining amount of distilled water. The strength of the solution to be used depends upon season, nature of cuttings, species, maturity of cuttings, chemicals used and environmental conditions for propagation of plants through cutting. Different workers with varying degrees of success have tried the following methods of application.

Solution immersion / prolonged soaking in dilute solutions:

The cuttings held in bundles with rubber bands are set with basal ends of about an inch in the solution of the root inducing substance, which should not be kept in metal containers. Solutions of IBA and NAA can be used three times if used within a week of preparation and if evaporation is reduced to minimum, while solution of IAA deteriorates more rapidly. During treatment, cuttings should be out of direct sunlight, but in good light. At night or in very dark weather, the length of treatment may be somewhat longer. Temperature also affects the time for treatment of cuttings. Higher the temperature, shorter is the duration of treatment. The concentration used varies from 20 ppm for easy to root species to about 200 ppm or even more for difficult to root species and about 24 hours immersion just before the cutting are inserted in to the rooting medium.

Quick dip in concentrated solutions: The basal ½ inch of the cutting is dipped in concentrated solutions (500-1000 ppm). This method reduces the time of treatment to a few seconds (5 seconds) and is found effective as there is optimum auxin concentration in the solution immersion method. This method is particularly useful in case of cuttings, which may be injured by a prolonged soaking in water or even in solution. Concentrated solution method of treatment is quite effective and more convenient than the dilute solution method.

Spraying the plants: Spraying the solution of 2,4,5-T in concentrations varying from 25-100 ppm on parent trees of certain species from which cuttings were taken 9-40 days after the spraying and set in the rooting medium. The results were as good as the responses obtained when the severed cuttings were treated in the usual way. The PGR solutions in desired concentration are also sprayed on various horticultural crops for higher flower production, fruit set, yield, better fruit/flower quality, male sterility, sex modification etc.

Material required: PGR (IBA/NAA/IAA/GA_3), distilled water, measuring cylinder, volumetric flasks, 95% ethyl alcohol.

Procedure :

1) Accurately weigh the required quantity of PGR crystals on electronic balance.
2) Take the weighed PGR in volumetric flask.
3) Add 95% ethyl alcohol slowly till complete PGR crystals/powder is dissolved.
4) Add distilled water and make the required volume.

The unit for concentration is ppm i.e. parts per million. To prepare 1 ppm solution 1 mg of crystals of PGR should be dissolved in 1 litre of distilled water. Solutions of most of the PGR are made by dissolving previously weighed quantity of crystals in a 20-50 ml of 95% ethyl alcohol, which is then diluted, with required quantity of distilled water. Salts of many of the acidic PGR are readily soluble in water and can be dissolved directly in water. For convenience in calculations, the stock solutions having higher concentration can be prepared and kept without deterioration for some weeks, if stored in a cool dark place.

From the stock solutions, the required volume is calculated by the following formula:

$N_1V_1 = N_2V_2$

Where,

N1 = Normality of stock solution (ppm)
V1 = Volume of stock solution (ml)
N2 = Normality of required solution (ppm)
V2 = Volume of the required solution (ml)
(Note: 1% solution means 10,000 ppm concentration)
i.e. 1 g in 100 ml - 1% solution
10 g in 1000 ml
10,000 mg in 1 litre - 10,000 ppm solution

Application of growth regulators in banana, grapes and mango

Banana – Spraying of NAA @ 100 ppm after 5 and 7 months of planting markedly increases fruit size and yield in banana. Spraying of 2,4-D @ 20 ppm increased the quality of fruits. Application of GA_3 (50 ppm) resulted in maximum yield and required less number of days for fruit maturity in Giant Governor Banana.

Grapes –PGR has significant role in determining yield and quality of grapes. Among growth regulators, gibberellic acid is the most significant one in improving berry yield, size and quality. Varieties including Thompson Seedless, Anab-e-Shahi, Perlette, Pusa Seedless, Tas-A-Ganesh, Bhokri, Cheema Sahebi, Banglore Blue and Muscat show positive response in terms of increased berry size, total yield and early ripening towards GA (25 ppm) application. In seedless varieties, dipping of bunches in GA_3 solution results in increased fruit set and berry size mainly due to elongation. Quality improvement and early ripening are resulted through application of ethrel (250 ppm) at two months after fruit set in Bangalore Blue, Muscat and in Pusa Seedless.

Mango - Application of Paclobutrazol (3 ml/m average canopy diameter) helps for induction of profuse flowering in mango. Foliar applications of 20 ppm NAA or 2,4-D are marginally effective in reducing fruit drop in mango. Dipping of fruits in GA (200 ppm) or cycocel (400 ppm) also resulted in delay of ripening. Gibberellic acid and Kinetin delay the ripening process in mango due to inhibition of chlorophyll degradation and carotenoid biosynthesis and retardation activities of hydrolytic enzymes.

Assignment:

1. How will you prepare 100 ppm solution of NAA.
2. A stock solution of 10,000 ppm of 2,4-D is available. How will you prepare solution of 20 ppm and 500 ppm strength from the available stock solution.
3. Write the long forms of GA, NAA, IBA, TIBA, 2,4-D and 2,4,5-T

RIPENING OF FRUITS, GRADING AND PACKAGING

RIPENING OF FRUITS:'Ripening is a terminal period of maturation when fruits attain maximum aesthetic and edible quality.' Ripening marks the completion of development and commencement of senescence with life of a fruit and is normally an irreversible event. In case of non-climacteric fruits ripening take place naturally on the tree whereas in climacteric fruits artificial ripening can be achieved by the application of ethylene. The accurate quantity of ethylene should be used in the ripening room at regular intervals. A concentration of CO_2 above 1% delays ripening. Hence thorough ventilation is essential. The information regarding ripening, grading and packaging of different fruit crops is given as under.

1) Mango: It takes about 95 to 115 days to mature after flowering. At maturity the colour of fruit changes from green to pale green and red blush develops on fruits surface. In case of Alphonso mango, the shoulders develop and slight depression develops near the stalk end which indicates the maturity of the fruit. At maturity, fruits have specific gravity ranging from 1.00 to 1.02. One or two-three ripe fruits known as Pad/ Tapka, drop down indicate the maturity of the other fruits. The fruits are harvested with stalk intact with Nutan mango harvester developed by BSKKV Dapoli. Based on the size the fruits graded as small, medium and big and are then packed in ventilated wooden crates with paddy straw or CFB boxes with honey comb partitions for the distant market.

2) Banana: The dwarf bananas are ready for harvesting within 11 to 14 months after planting, while tall varieties take about 14 to 16 months to harvest. A bunch usually takes about 120 to 140 days to mature after flowering. The bunch is harvested when the ridges on the surface of the skin change from angular to round. At maturity, the topmost leaf begins to dry and colour of the fingers changes from green to pale green. Banana fruits are not generally graded. In some places, banana bunches are wrapped in banana leaves after harvesting and then, transported to the distant market.

3) Citrus: In citrus, flowering and fruiting starts from 4th year onwards after planting. *Ambia bahar* fruits are harvested in the month of October-November, where as *Mrig bahar* fruits are harvested in the month of March-April. Mandarins and Sweet oranges generally take about 210 to 240 days to mature whereas; Kagzi lime requires 150 to 160 days to mature after flowering. Being a non-climacteric fruit, all citrus fruits are harvested at ripe stage. The fruits are harvested manually and graded roughly according to the size and appearance. Citrus fruits are usually packed in wooden boxes for distant market whereas for nearer market, bamboo baskets are used. The chopped straw and dry grasses are mainly used in the packing material.

4) Guava: The seedling guava trees require 4 to 5 years to bear, while grafted, budded or layered plants start bearing at the age of 2 to 3 years. The fruits turn greenish yellow with the advancement of the maturity and it takes about 140 to 160 days from flowering to harvesting. The guava fruits should be handpicked immediately when it is mature because it can be retained on the tree in ripe stage as occasionally ripe fruits are liable to be damaged by the birds. The wooden crates or bamboo baskets of various dimensions with straw are used as packing material. Before packing, fruits are graded on the basis of size, shape, maturity, freedom from diseases and attack of insect-pests

5) Grapes: In Grapes, harvesting starts from 3rd year after planting. The Grape is a non-climacteric fruit which is to be harvested at full ripe stage when it develops proper sugar-acid blend, colour and flavour. It takes about 125 to 135 days from flowering to harvesting. All bunches on the vine do not ripe at one and the same time. A bunch is ready for picking after the berries near the tip have the colour and become soft and sweet. Before packing, the broken, decayed or defective berries from the clusters are removed. Bunches are then packed in CFB boxes along with grape guard for distant market. Grape guard is a paper impregnated with KMS. The use of grape guard in packing reduces the spoilage to a great extent.

6) Papaya: Harvesting of papaya starts from 10 to 14 months after transplanting. The mature fruits are harvested when the colour changes from green to yellowish green. About 125 to 140 days are required from flowering to harvesting. When latex of the fruit becomes watery, the fruit is considered ready for harvest. The fruit is harvested individually with hand taking care to avoid all possible injuries. The harvesting is continuous during the life of the plant. The papaya fruits are generally not graded for market. For distant market, fruits are packed in bamboo baskets with paddy straw to avoid bruising.

7) Sapota: It is a climacteric fruit and its quality is improved after harvesting. Hence, only mature fruits are harvested. It takes about 240 to 270 days from flowering to harvesting. Fruits at maturity develop dull orange colour or potato colour. A mature fruit when scratched with nail shows a yellow streak instead of green streak which is a sign of immature condition. The brown scaly material disappears from the fruits surface as the approaches the maturity and milky latex content also gets reduced. The dried spine like stigma at the tip of the fruits surface drops off easily when touched. The fully mature fruits are harvested by hand with stalk intact. Atul sapota harvester can be used for harvesting the sapota fruits. The fruits are graded as small, medium and large based on their size. The fruits are then packed in bamboo baskets with straw and banana leaves as cushioning material and transported to the distant market.

8) Pineapple: The pineapple generally flowers in about 18 to 24 months after planting. The fruits require about 115 to 130 days maturing from flowering. The main harvesting season is June to September. At maturity, the basal portion of the fruit turns yellow; the eye bracts on the fruits surface become loose and turn brown in colour. Harvesting is done with a sharp knife by severing the fruit stalk with a clean cut and retaining 5-7 cm of fruit stalk. The cut end of the fruit stalk is then dipped in a 10 % solution of benzoic acid in order to check the attack of fungus. For

marketing, grading of the fruits is done on the basis of size, shape, maturity and freedom from blemishes. The crowns are trimmed less than 10 cm and packed either in wooden crates or bamboo basket with paddy straw then transported to distant market.

9) Fig: Harvesting of fig may start from February and continued till June. The fully mature and ripe fruits are harvested. For best flavour and quality fruits are picked when they are soft and at neck and down due to their own weight. The milky latex exuding from the stem when the fruit is pulled of indicates that the fruit is still immature. The fruits are harvested by twisting or by cutting the fruit neck or they are gathered when dropped down on the ground and then, are packed in bamboo baskets for distant market.

10) Pomegranate: The fruits are ready to harvest in about 5 to 6 months after flowering. The fruits are harvested when the skin turns slightly yellow and fruits give metallic sound when tapped. After harvesting, fruits can be cured in shade for a week so that the skin becomes hard and fruits can stand transportation better. The fruits are then graded according to their size like Super, King, Queen and Prince and packed in bamboo baskets or ventilated wooden crates or CFB boxes with dry grass as cushioning material.

ARTIFICIAL RIPENING OF FRUITS:

The flavour, storage life and market demand of all the fruits are affected by the stage of maturity at which they are harvested. Induction of early and uniform ripening in fruits is ideal for getting premium prices in the market. Ethephon or Ethrel (2-chloroethyl-phosphonic acid) i.e. CEPA, an ethylene releasing chemical, is recommended for fruit ripening. About half to a litre Ethephon is enough for pre-harvest spraying of one hectare crop and fruits may be treated with 500 ppm of Ethephon.

PRODUCTION ECONOMICS FOR TROPICAL AND SUB-TROPICAL FRUITS

Farm production economics is a broad division or field of specialization within the subject of agricultural economics. It is concerned with the choice of production patterns and resources use in order to maximize the objective function of the farm operator, their families, the society or the nation, within a frame work of limited resources. It is concerned with choosing the available alternatives or their combinations with a view to maximizing the returns and/or minimizing the costs.

Farm production decisions involve application of the principles of production economics. It is therefore essential for a farm operator or a planner to understand basic concepts and relationships pertaining to the economics of agricultural production.

Production economics is concerned with two categories of decisions in the production process.

i) How to organize resources in order to maximize the production of a single commodity i.e. to make choices from various alternative ways of using resources.
ii) What combination of different commodities to produce.

Objectives:

The main objectives of production economics are

i) To determine and define the conditions which provide for optimum use of resources.
ii) To determine the extent to which the existing use of resources derivates from the optimum use.
iii) To analyze the factors or forces which are responsible for the existing production patterns and resources use.
iv) To delineate means and methods for charging the existing use of resources to the optimum level.

The principles or laws that help to attain these objectives are same at micro as well as national and regional level.

ESTIMATION OF COST OF CULTIVATION OF PERENNIAL CROPS:

Once tree starts bearing the fruits the growers have to incur expenditure on various items to maintain the orchard every year. The maintenance cost of any orchard include human labour charges (Family and hired), manures, chemicals, fertilizers, plant protection chemicals, interest on working and fixed capital and rental value of land.

The cost of family labour is to be calculated on the basis of average wages paid to hired human labour. For hired human labour, the actual wages paid to male/female in cash and kind is to be considered. The interest on working capital is to be worked out @ 13 per cent for season of the crop, and fixed capital is to be worked out @ 10 per cent per annum. The rental value of land is estimated at $1/6^{th}$ of the gross value of produce.

The annual cost of cultivation of perennial crops comprised of maintenance cost and amortization value.

Amortization Value: The capital cost is incurred in the initial stage (gestation period) of the orchard, it is distributed in equal installments on the whole life of the orchard production starting from 6th year, for mango the average life is considered as 60 years beyond the productive life become uneconomical to mango.

SN	Item of cost	Unit	Quantity	Rate (Rs.)	Amount (Rs.)	Percentage
1	Hired human labour					
	a) Male	Days	63			
	b) Female	Days	30			
2	Bullock (Pair)	Days	10			
3	Seeds	-	-			
4	FYM/ Compost	(C.L.)	6			
5	Fertilizers	Kg				
	N		95			
	P		40			
	K		12			
6	Plant protection chemicals	-	-	-		
7	Depreciation and repairs to implements and machinery			250		
8	Land revenue			50		
9	Interest on working capital @ 13%					
			Cost-A			
10	Interest on fixed capital @ 10%			250		
11	Rental value of land (1/6)					
12	Amortization value			12000		
			Cost-B			
13	Family labour					
	a) Male	Days	29			
	b) Female	Days	29			
			Cost-C			
14	Gross Returns					
	a) Main product	Kgs	2000			
15	Net returns					
16	Cost benefit ratio					
17	Cost per kg					

MAPPING OF ARID AND SEMI-ARID ZONES OF INDIA

The term "arid" normally means a region of the earth's surface where rainfall is nil or inadequate, with the result the vegetation is non-existent or sparse, agriculture difficult or impossible and human living conditions precarious. The hot Indian arid zone lies in the north-west part of the country. The western scarp of the Aravali range, running in a NE-SW direction, is the geomorphic as well as the climatic boundary of the arid zone in east, where as in the west it merges into the Pakistan desert.

State wise areas of arid and semi-arid zones of India:

State	Area (sq.km.)		Percentage area in each state to the total arid zone in India	
	Arid	Semi-arid	Arid	Semi-arid
Hot arid zone				
Rajasthan	196150	121020	62	13
Gujarat	62180	90520	20	9
Punjab	14510	31770	5	3
Haryana	12840	26880	4	3
Uttar Pradesh	--	64230	--	7
Madhya Pradesh	--	59470	--	6
Maharashtra	1290	189580	0.4	19
Karnataka	8570	1339360	3	15
Andhra Pradesh	21550	138670	7	15
Madras	--	95250	--	10
Total area of hot arid zone	3,17,090	956750		
Cold arid zone				
Jammu and Kashmir	70300	13780	--	--

Indian arid and semi zones-

Hot arid zone - West Rajasthan, Punjab, Haryana, Gujarat, Andhra Pradesh, Karnataka and Maharashtra.

Semi arid zone- The semi-arid zone is distributed in the states of Punjab, Haryana, Rajasthan and Uttar Pradesh.

Examples - The major fruit crops which are commercially grown in arid and semi-arid zones of India are ber, pomegranate, custard apple, aonla, date palm. Indian jujube, lasora, bael, karonda, tamarind, wood apple.

EXERCISE - 14-15

Botanical description and identification of

(Ber, Fig, Jamun, Pomegranate, Carissa, Phalsa, Wood Apple, West Indian cherry, Tamarind, Aonla, Bael and Annona)

Sr. No.	Common name	Botanical name	Family	2n	Origin	Type of fruit	Edible portion	Remarks
1.	Ber	*Zizyphus mauritiana*	Rhamnaceae	48	Central Asia	Drupe	Epicarp and Mesocarp	Evergreen tree. The genus *Zizyphus* contains about 40-50 species
2.	Fig	*Ficus carica*	Moraceae	26	West Asia	Syconus	Fleshy receptacle	Deciduous in subtropics but evergreen in tropics. Fig is a multiple fruit
3.	Jamun	*Syzygium cuminii*	Myrtaceae	40	India	Drupe	Epicarp and Mesocarp	Tall and evergreen tree. Flowers are bisexual and light yellow in colour, Fruit is oblong, round in shape, deep purple or bluish coloured with juicy sweep pulp having a single seed.
4.	Pomegranate	*Punica granatum*	Punicaceae	16, 18	Iran	Balusta	Arils	Plant grows as a bushy shrub. Bears male, hermaphrodite and intermediate flowers, bright red to orange in colour. Fruits are large, round or globose.
5.	Carissa	*Carissa carandas*	Apocynaceae.	22	India	Berry	Epicarp and Mesocarp	This is an evergreen hardy shrub. Plant is highly suitable for thorny hedging to provide protection to orchards. Fruits are rich in iron.
6.	Phalsa	*Grewia asiatica* L	Tiliaceae	36	India	Berry	Epicarp and Mesocarp	Phalsa is a small tree grows up to 3 to 4.5 m height, it comprises 18 genera and 400 species.

7.	Wood Apple	*Feronia limonia* Swingle	Rutaceae	18	India	Amphisarca	Mesocarp and Endocarp	Tree flower 4-5 years after planting. Flowering season is Feb to May. Fruiting season is from Oct and Jan., fruits are hard many seeded globose with a woody brown pericarp.
8.	West Indian cherry	*Malpighia emarginata*	Malpighiaceae	20	West Indies	Drupe	Epicarp and Mesocarp	This is a small shrub or small sized tree growing up to 8.0 m height, flowers are rose-coloured in clusters. Fruits are rich in ascorbic acid.
9.	Tamarind	*Tamarindus indica*	Fabaceae	24	Tropical Africa	Berry	Mesocarp	Tamarind is an excellent tree crop for dry land horticulture. It is long lived evergreen tree which grows up to 30 m high. Flowers are pink or reddish in colour, flowering season starts from April and extends to September. Seeds are glossy brown embedded in pulp.
10.	Aonla	*Emblica officinalis*	Euphorbiaceae	28 to 104	Central India	Capsule	Pericarp	Trees are of medium height behaving as evergreen in tropics and deciduous in sub-tropical conditions.

								Unisexual flowers are produced on determinate shoots. Fruits are sour and astringent and not consumed as a table fruit. Fruits have
11.	Bael	*Aegle marmelos*	Rutaceae	18	India	Amphisarca	Mesocarp and Endocarp	Tree is considered a sacred one and is much valued for medicinal values. Fruit contain 'Marmelosin' responsible for medicinal properties as restorative, tonic and laxative. Fruits have hard shell and tunnels in pulp filled with mucilage. Fruits are climacteric and need about 11 months to ripen on tree. Ripe fruits have pleasant aroma and can be used for fresh eating or for processing.
12.	Annona	*Annona squamosa*	Annonaceae	14 and	Central America	Etaerio of berries	Endocarp	Itincludes 40 genera and 120 species out of which 6 have commercial significance. Botanically fruits are aggregate type.

VISIT TO COMMERCIAL ORCHARDS AND DIAGNOSIS OF MALADIES

Identification of some important fruit crops

Litchi

Bael

Avocado

Mangosteen

Carambola

Durian

Rambutan

Loquat

Bilimbi

Rose apple

Breadfruit

Passion fruit

Assignment: Give visit to the progressive farmer's orchard, collect samples of abnormalities and suggest remedial measures to control them.

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