ShedgeMAHARASHTRA COUNCIL OF AGRICULTURAL EDUCATION AND RESEARCH

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PRACTICAL MANUAL

TROPICAL AND SUBTROPICAL FRUITS

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Exercise No. 1
Date:

Description and identification of varieties based on flower and fruit morphology

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 i.e. line of descent to other kinds
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 and the cultural requirements, 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 blow:

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): i.e. Mango, peach, plum, ber etc.
viii) Hesperidium: e.g. Citrus.

B. F: 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.

i) **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.

ii) **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.

iii) **Gregarious flowering species:** Flowering indefinite times in a year is impulsed 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.

iv) **Seasonal flowering species:** Many plants flower during the suitable season. Any variation in atmospheric factor during the favourable seasons leads to continuance 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.

Exercise No. 2
Date:

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

Sr. No.	Common name	Botanical Name	Family	2n	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	*Vitis vinifera*	Vitaceae	38	Black Sea to Caspian Sea	Berry	Pericarp and placentae
8.	Papaya	*Carica papaya*	Caricaceae	18, 36	Tropical America	Berry	Mesocarp
9.	Pineapple	*Ananas comosus*	Bromeliaceae	50, 75, 100	Brazil	Sorosis	Bracts and Perianth
10.	Sapota	*Manilcara achrus*	Sapotaceae	26	Mexico (Tropical America)	Berry	Mesocarp
11.	Guava	*Psidium guajava*	Myrtaceae	22,33	West Indies to Peru	Berry	Thalamus and Pericarp
12.	Fig	*Ficus carica*	Moraceae	26	West Asia	Syconus	Fleshy receptacal
13.	Pomegranate	*Punica granatum*	Punicaceae		Iran	Balusta	Juicy Seed Coat
14.	Litchi	*Litchi chinensis*	Sapindaceaae	30	China	Pome	Fleshy thalamus

Exercise No. 3
Date:

Selection of site and planting systems for planting of tropical and subtropical fruit crops

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, particularly in summer.
iv) Whether the site is near to a market or city and whether three are proper transport facilities.
v) Whether climatic conditions are suitable for the fruits to be grown and whether the site is free from cyclone, frost, hail-storms and strong hot winds.
vi) Whether there are seasonal gluts or 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 his orchard is a new venture or whether 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. Frost is a great hazard of fruit-growing and a site with good air-drainage is the best protection against such frosts.

Layout of fruit crops:

For better development and for accommodating the requisite number of plants per unit area, the proper layout of the fruit orchard is important. The factors which are considered important for proper layout of the orchard are as below.

A) Systems of planting: The system of planting to be adopted is selected after considering topography, type of fruit crop, utilization of orchard space, etc. Generally, six planting systems are recommended for fruit crops.

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 the 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 can not 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 are 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 5th 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.

B) Spacing: Provision of optimum spacing to fruit trees is one of the most important aspects of successful fruit culture. If the spacing is inadequate the trees grow poorly and produce poor yields with inferior fruit quality. The cultural practices are also greatly hindered. On the other hand, if the spacing is too wide , there will be wastage of valuable land with low yields per unit area. Hence optimum spacing is desired so that fruit trees grow and bear properly. The optimum spacing is one in which on attaining its full size will not touch the branches of the neighboring ones and root systems of one tree must not encroach that of the adjoining tree. The spacing to be adopted depends upon the various factors like soil and climate, varieties, growth habit, root stock used, etc.

Planting of the fruit crops: For planting the fruit crops the pits are dug at required spacing. The pit size varies from 0.6cub.m to 1cub.m. While digging pits, the top soil upto 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, upto 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.

The points to be considered while planting are 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 the with the dug out soil and press gently.
- Apply water immediately after planting just to wet the pit soil 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 logging and damage to bud or graft joints by strong wind.

SPACINGS FOR DIFFERENT FRUIT CROPS

1.	Mango	10 x 10 m
2.	Banana	
	i. Tall	3 x 3 m
	ii. Semi Tall	2.5 x 2.5 m
	iii. Dwarf	2.0 to 1.8 x 2.0 to 1.8 m
3.	Sweet Orange	7 to 8 m
4.	Mandarin Orange	5 to 6 m
5.	Acid Lime	5 x 5 m
6.	Guava	5 x 5 m.
7.	Grapes	3 x 3 m. or 2 x 2 m.
8.	Papaya	1.8 x1.8 m.
9.	Sapota	10 x10 m.
10.	Fig	5 to 8 m.
11.	Pomegranate	5 x 5 m.
12.	Litchi	10 x 10 m.

Exercise No. 4
Date:

Training and pruning in Grapes, Mango, Guava and Pomegranate

GRAPES:

A) 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 as given below

1) Head system 2) Kniffin system 3) Over head 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. Under of south India vine makes vigorous growth and have pronounce apical dominance, bower system of training is best suited while in North India vines are vigorous hence head system is mainly adopted under north Indian conditions.

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 Ana-be-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 secondary

arms. 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 0.9m and 0.6m 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 Muskat, Perlette, Bhokari and Delight.

4) Over head 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, Ana-be-Shahi, etc.

Pruning: Clear understanding about the meaning of 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 is called fruiting cane.
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 a 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.

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 2 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.

POMEGRANATE:

Training: Pomegranate plants can be trained on a single-stem or in multi-stem system. The single-stem training has its own disadvantages. The plants have a tendency to produce ground suckers, making the plant bushy. As such it is rather difficult to train the plant to a single stem. The crop is highly susceptible to stem-borer and shoot-hole borer. Moreover, this system is hazardous. Thus single-stem training is uneconomical for commercial cultivation. Therefore multi-stem training is more prevalent in the country. Allowing too many stems also comes in the way of intercultural operation. The varying of stem number of 3–4 does not affect the yield significantly in early years of bearing and a multi-stem training with 4–5 stems/hill is beneficial.

Pruning: Pomegranate plants do not require pruning except removal of ground suckers, water shoots cross branches, dead and diseased twigs and giving a shape to the tree. Pomegranate fruits are borne terminally on short spurs, arising from matured shoots, which have the capacity to bear fruits for 3–4 years. With advance in age they decline. A little thinning and pruning of old spurs to encourage growth of new ones is required. Some useful tips on pomegranate pruning are:

- Fruitful and differentiated buds are located at the distal portion of the branches.
- Pruning of terminal portion of a branch lowers down the total flower production.
- Pruning does not affect sex ratio and fruit quality.
- Pruning affects significantly total fruits, marketable and unmarketable fruits. Fruit size and yield of higher grade fruits are more with high intensity pruning.
- Pruning minimizes the bending of branches and staking.

Exercise No. 5
Date:

Training and pruning in Citrus and Fig

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 Blitox.

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 prunings are not beneficial in the long run.

FIG:

Fig trees are trained initially to a single stem to encourage a wide, symmetrical crown with a mechanically-strong framework having evenly distributed laterals. The tree is allowed to grow for about a metre and then it is topped, which induces side branches all round the main stem. The interior of the bush should be maintained free of suckers, dry and sick branches.

Pruning in fig is practiced annually to stimulate production of new growth, and bearing fruits. The time and type of pruning vary with location, variety and number of crops harvested annually. The best time to secure a mature crop is hot, dry summer. Therefore, pruning may be done 4–5 months in advance. Generally, a single marketable crop is harvested yearly in our country. Either heavy or light pruning can be adopted in fig. When heavy pruning is practiced, trees are headed back severely every year, leaving about 2 buds on each one-year-old shoot. If light pruning is adopted, shoots which have yielded fruits are lightly headed back after harvesting. Copper fungicide should be used to protect the cut ends.

Notching is practiced sometimes in Poona fig for activating dormant buds before the start of vigorous growth. Usually 1–2 buds are selected for notching in the middle portion of about 8-month-old canes. Notching involves removing of small slice of bark immediately above the dormant bud, giving 2 slanting cuts as deep as the bark. Notch should be about 2.5 cm long and the breadth depends on thickness of the shoot. The cut checks the free flow of sap and stimulates the bud just below it to throw out a fruiting shoot. The technique is useful for induction of fruiting laterals on vigorous upright branches and to increase the total bearing area of the plant.

Exercise No. 6
Date:

Pretreatment of Banana suckers

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 Basrai 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. Bulbs with a small heart bud and a flat bud pointing up. In some countries, pieces of the parent-rhizome are also used for propagation, but this practice is not followed in India.

Exercise No. 7
Date:

Desuckering and propping in Banana

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 centre or injection of kerosene from the side of the sucker just above the meristem can also be adopted.

Propping: Strong wind is a threat for successful banana production. Though planting season is carefully chosen in areas where strong winds are a routine menace, propping becomes essential for tall cultivars. Lodging of plants is due to the selection of weak suckers, shallow planting leading to poor anchorage, damage by pests, diseases and nematodes, extra large bunches and removal of adjacent, deep-rooted suckers. Bamboo or *Casuarina* poles are commonly used. These poles have effective life of 3–4 years. Props using polythene wire can also be practiced. Propping should be done immediately after bunch emergence to avoid overloading on the prop.

Exercise No. 8
Date:

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 were also reported by Sen (1940) and Kumar (1952). Storey (1958) identified 8 working categories as staminate, terotological staminate, reduced elongata, elongata, carpelloid, elongata, pentandria, carpelloid pentandria 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.

Exercise:

1) Write the examples of papaya varieties
   Dioecious varieties:
   Andromonoecious varieties:
   Hermaphrodite varieties:
2) Write the definitions of the flower types mentioned in this exercise with suitable examples.

Exercise No. 9
Date:

Seed production in Papaya, latex extraction and preparation of crude papain

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 was 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.

Drying of latex:

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 100^0F are preferred. The coagulated latex may be placed upon sheets of glass or porcelain or enameled 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.

The crude papain thus prepared is exported in air-tight containers to Europe and America, where it is further refined and sold as a powder or in tablet form under various trade names.

The coagulated latex produces about 25 per cent of its weight as dried powder which still contains six to ten per cent of moisture. About one-sixth of the dried powder is papain.

In the humid zones of the east and west coasts of south India, where the weather remains rainy or cloudy for about eight months in the year, sun-drying of the latex may not be practicable. In these parts, it would be necessary to dry the latex artificially in a home-made drier such as is used in Ceylon and the West Indies. It is a kind of drying stove constructed by building in brick a chamber about a metre high, a metre wide and two metres long. The sides and ends are of brick, with an opening at the end to admit fuel. The top is open. About 30 cm. below the top, a sheet of iron is placed, and upon this 2.5 to 5 cm. of sand to modify and distribute the heat arising from the fire beneath.

The coagulated juice is spread upon brown linen stretched upon the frames which are made to fit the top of the drier. Smoking spoils the latex. Therefore, coconut shells or

charcoal are recommended as fuel. The fuel is so regulated that the drying is effected slowly with temperatures, preferably below 38^0C.

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 or per acre varies greatly according to the variety, its fruiting vigour and the culture adopted in different climatic conditions. In Ceylon, the yield of dried latex varies from 56 gm to 112 gm per tree per year. it is estimated that a good yield is 196 kg per hectare per 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 one of the most recent reports from Ceylon, it is stated that the best variety gave, on an average, 322 g of papain per tree, with the best tree giving over 450 gm. In Tanganyika, the average yield is 84 to 244 gm. per tree, or 90 kg. to 196 kg. per hectare. In India, at the Harcourt Butler Technological Institute, Kanpur, the yield per plant was found to vary from 112 gm. to 450 gm. in the same variety. At Poona, the yield of papain from the Gujarat variety was 112 gm. per tree while the Singapore variety yielded twice as much. At Coimbatore, the yield of papain is 200 to 300 gm. per tree with a maximum of 450 gm. The yield per hectare works out to 250 to 375 kg.

It has been observed that the lanced papaya fruits from which the latex has been tapped ripen normally and become sweet. These fruits will, however, have to be sold at lower prices in the market, as their appearance is spoiled by the scratches produced on them during the process of tapping.

The market price of papain usually fluctuates between Rs. 40 and Rs. 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.

In Ceylon, where the production of papain has long been an important industry, the best results are obtained from the rainfed papaya trees planted in the well-drained loamy soil, rich in humus, in the moist hilly regions, particularly where the forest trees are freshly cut and the land is newly opened. Similar areas in the rain forests of the east and west coasts of south India may profitably be utilized for planting papaya.

ECONOMICS OF CULTIVATION:

Cost of cultivation is worked out for three years because in the first year only the inputs are involved and return will start from second year on wards. The cost of cultivation is worked out purely on the basis of inputs and outputs involved during the three years. Interest on the investment is not considered while working out the cost of cultivation. Returns from papain are calculated separately.

Cost of cultivation for fruit/hectare:

	Cost of inputs	First year Rs.	Second year Rs.	Third year Rs.
1	Raising of nursery Bed making farm Yard manure (100 kg) and seeds (500 g).	150 300	-	-
	Transplanting to polythene bags.			
2	Preparatory cultivation Ploughing, Disking and harrowing Digging of ½ x ½ x ½ meter 3100 pits/ha (at Rs. 45.00 per 100 pits) Filling of pits and cost of FYM (50 tonnes each year)	500 3000	- 1200	- 1200
3	Manuring: Urea (1600 kg/yr/ha) Muriate potash (2600 kg/yr/ha) Super phosphate (4650 kg/yr/ha) Labour	 3400 3300 4400 600	 3400 3300 4400 600	 3400 3300 4400 600
4	Interculture: Weeding, channel making	 500	 500	 500
5	Plant Protection: Fungicides, labour etc.	 500	 500	 500
6	Irrigation 40 irrigation @ Rs. 50/- irrigation	 2000	 2000	 2000
7	Harvesting charges	250	1000	1000
	Total cost of inputs	20500	16900	16900

Total cost of inputs for 3 years/ha: Rs. 54,300/-

Income from fruits:	Rs.
Total yield for 3 years 200 tons per ha (after giving allowances for loss in transit etc.) at Rs. 600/- tonnes.	1,20,000
Cost of inputs 3 years/ha	54,300
Net profit for 3 years/ha	65,700
Net profit for 1 year/ha	21,900

Cost of cultivation for papain production/ha

	Input costs	Rs.	Rs.	Rs.

1	Raising nursery	450	-	
2	Preparatory cultivation	5100	1200	
3	Manuring			
	a) Urea (1600 kg/ha)	3400	3400	3400
	b) Muriate of potash (2600 kg/ha)	3300	3300	3300
	c) Superphosphate (5650 kg/ha)	4400	4400	4400
	d) Labour	600	600	600
4	Interculture	500	500	500
5	Papain extraction			
	a) Labour	4500	4500	4500
	b) Other equipments	1500	-	-
6	Plant protection	500	500	500
7	Irrigation	2000	2000	2000
8	Harvesting charges	250	1000	1000
	Total cost of inputs	26500	21400	21400

Total cost of inputs for 3 years/ha Rs. 69,300/-

Income from papain and fruits:

Total papain yield 750 kg/ha for 3 years @ Rs. 100/- kg	Rs. 75,000
Sale of papain extracted fruits 200 tonnes @ 500/- per tonnes.	Rs. 100,000
Total return from papain and fruits	Rs. 175,000
Total cost of inputs for 3 years	Rs. 69,300
Net profit for 3 years/ha	Rs. 105,700
Net profit for 1 year/ha	Rs. 35,233

Exercise No. 10
Date:

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. This web page includes links to information on the use of plasticulture in the form of plastic mulch, degradable mulch, tunnels (low and high), hoop houses, greenhouses and agricultural plastic recycling as well as crops most often grown with plasticulture, and agriculture plastic recycling in the Northwest. For an overview of why and how season extension can be accomplished through plasticulture, see:

Mulch: 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 colors 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.

Structures: Various types of structures are available to lengthen the growing season for the crop and improve overall crop health and quality. The following are just a few of the structures available, such as high tunnels, low tunnels, hoop 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.

- **Low Tunnels and High Tunnels:**
- **Hoop houses:**
- **Greenhouses:**
- **Crops:** Information regarding specific types of crops commonly grown on mulch, in tunnels or in hoop houses for season extension (spring, fall, winter), or during the main summer season, crops for high tunnels, resources of warm season vegetables and melons, cut flowers and small fruits grown with high tunnels, hoop houses on the farm, small fruit and vegetable crops production is important. There is significant increase in crops with greatest success due to plastic mulch.
- **Irrigation systems:** Drip, Micro sprinklers, Fogging system
- **Recycling:** Recycling is a common issue faced by agricultural plastic users. The cost of removing and disposing of agricultural plastics can be high.

Exercise No. 11
Date:

Preparation and use of plant growth regulators in fruit crops

The plant growth regulators are the organic compounds other than the nutrients which accelerate, inhibit or modify the various physiological processes in plant system when applied in small concentration. These growth regulators are readily absorbed and move rapidly in the tissues when applied to the plant system and regulate its life processes in some beneficial way so as to enhance the yield and improve the quality of the fruits.

The growth regulators are classified into the following groups.

1) Auxins: IAA, IBA, NAA, 2-4D, and 2-4-5 T.
2) Gibberellines: GA
3) Cytokinins: Kinetin, Zeatin, BA (Benzene adenine)
4) Ethylene: Ethrel, Ethephon
5) Inhibitors : ABA, and MH
6) Retardants: CCC, Alar and Paclobutrazol

Major applications in fruit production

1) Propagation: The most common use of the plant growth regulator is in the case of rooting of the cuttings. The application of 100 to 500 ppm IBA for soft wood cutting, 500 to 1500 ppm for semi hard cutting, 2000 to 5000 ppm for hard wood cutting is common for the vegetative propagation of the fruit crops. The auxins are also used in the air layering of Guava, Citrus, Pomegranate, etc. Poor seed germination in some of the fruit crops is major problem in sexual propagation. Gibberellines are used for seed germination and as a substitute for chilling requirement e.g. Grapes

2) Use in plant tissue culture: The plant growth regulators are the key factors for multiplication of any plant part through the plant tissue culture. In banana low concentration of IAA and high concentration of BA are essential for the rapid growth of the ex-plants. In Grapes BA and NAA are essential for establishment of the ex-plants and IBA helps in rooting of ex-plants.

3) Control of vigour: In fruit crop the tree size control is important for producing the dwarf trees for high density orcharding. The excessive growth can be prevented by applying growth retardant like CCC or Alar. The use of PBZ is effective in reducing the tree size in apples, pears, peaches, litchi, apricot, plum and mango.

4) Control of flowering: The ethylene is active principle responsible for flowering in pineapple. The acetylene, calcium carbide (Cac2), ethrel, auxins like NAA has used to induce the flowering in pineapple. The effective concentration of these

growth regulators used is 10 to 15 ppm NAA or 1.0% calcium carbide or 25 ppm ethrel. The biennial bearing in mango can be regulated by using some growth retardants. The paclobutrazol has shown the great promise in regulating flowering and fruiting in mango. The application of paclobutrazol checks the gibberelline synthesis and retards the vegetative growth; ultimately inducing the flowering in mango. The soil application of PBZ @5gm/tree or Cultar 20ml/adult tree is very effective in regulating the flowering in mango.

5) Fruit setting and fruit development: Many growth regulators like NAA, TIBA, 2-4D, GA, PCPA (Parachlorophenoxy acetic acid) are found to be useful in increasing the fruit set. The effective range of concentration of growth regulators is in between 25 and 50 ppm. In Eureka lemon and Washington Navel oranges, application of 1000 ppm GA increases the frit set to maximum. The application of GA, 4-CPA (4-Chloro phenoxy acetic acid) increases the fruit set in strawberry, peach, plum and cherry. The 4-CPA treatment serves as an alternative to caprification in Fig for improving fruit set. The auxins are used for increasing the fruit size in grapes, strawberry and oranges. The application of 40 ppm GA at flowering and again at fruit set increases the berry size in grapes.

6) Induction of parthenocarpy: Many auxins like IAA, NAA, IBA and GA are used for inducing parthenocarpy in fruits. GA is useful in inducing parthenocarpy in apple, pears, peaches and grapes. The application of 200 PPM GA reduces the number of seeds in papaya; considerably in mango parthenocarpy can be induced by applying 250 ppm BA at flowering and fortnightly application of 200 ppm GA.

7) Fruit thinning: The thinning of fruits helps in optimizing the fruit size and quality. The traditional practice of manual fruit thinning is cumbersome and labour intensive. The growth regulators can be used as effective alternative for fruit thinning by hand. The application of DNOC (4,6-Dinitro-o-cresol) at full bloom or NAA at post bloom period helps in satisfactory fruit thinning in apple. Similarly, DNOC sprays are effective in fruits like apricot, plum, pears and sweet cherry

8) Prevention of fruit drop: The premature abscission of fruit is a major problem on mango, citrus, apple and pears. The auxins like 2,4-D, 2,4,5-T control the fruit drop in citrus. In mango, 2 sprays of 10 ppm NAA or 2,4-D, One at the time of fruit setting and second spray when the fruits attain the size of ber fruit reduces the fruit drop. The post harvest berry drop of grapes in certain varieties like Cheema Sahebi, Ana-be-Shahi and Dilkhush can be overcome by spraying 50 to 100 ppm NAA a week prior to the harvest.

9) Fruit ripening: The ethylene is a ripening Harmon. The sprays of ethylene during fruit ripening in apple, grapes and strawberry are useful in early maturity and uniform ripening. The Ethephon applied to the citrus fruits prior to the storage ensures the better colour development. In Lemon dipping in 1000 ppm Ethephon results in attainment of marketable yellow colour. Similarly, fruits like banana, mango can be ripened at the faster rate with the ethylene treatment. The uneven ripening in coloured varieties of grapes viz. Beauty seedless, Gulabi is the major problem in the viticulture, which can be overcome with the application of ethephon @ 250 ppm at colour break stage of the berries. The Cycocil @ 500 ppm when applied twice at 15 days interval induces early maturity in Kagzi lime in about 20 days.

10) Harvesting: The harvesting can be achieved by spraying chemicals like ethrel in apple, walnut, cherry, pears, and plum. The ethrel sprays bring about early maturation of fruits with accelerated ripening and result in the formation of abscissic layer at the base of fruit peduncle that facilitates the harvesting. In citrus, application of Cycloheximide at pre harvest stage facilitates the harvesting of the fruits.

11) Weed control: Hand weeding is very cumbersome, laborious and expensive method of controlling weed in the fruit orchards. Some growth regulators like 2,4-D can be used as a herbicide effectively for controlling the weeds in fruit garden.

PREPARATION OF DIFFERENT PLANT GROWTH REGULATORS (PGR) SOLUTIONS

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 (0.1 N) 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 0.1 N HCl (dilute acid) and little quantity of distilled water is added, excess acid is neutralized with little quantity of 0.1 N 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 1/2-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 chemical balance or 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, N_1 = Normality of stock solution (ppm)

V_1 = Volume of stock solution (ml)

N_2 = Normality of required solution (ppm)

V_2 = 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

Exercise No. 12
Date:

Manure and fertilizer application including biofertilisers

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 (artificial manure)

1) Bulky manure: These 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.

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.

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.

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.

Care to be taken while manuring and fertilizer application

1. The manure and fertilizers should not be allowed to come into direct contact with stem of the plant. They should be applied sufficiently away from the main trunk.
2. They should be properly incorporated in the soil.
3. The field should be irrigated after manuring if soil is not moist.
4. The application of nitrogen is done when the leafy growth is desired. For flowering and fruiting, the quantity of nitrogen is reduced and that of phosphorous and potassium is to be increased.
5. The raw or undecomposed manure should not be applied to the crops as they may cause damage to the tender roots.
6. Heavy dose of inorganic fertilizers should not be given to young plants frequently.
7. It is better to apply fertilizers in smaller dose at long intervals.

Recommended fertilizer dose for different tropical and subtropical fruit crops

Sr. No	Crop	N (g/tree)	P (g/tree)	K (g/tree)
1	Mango	1500	500	500
2	Banana	200	100	100
3	Sweet Orange	500	100	400
4	Mandarin	700	500	600
5	Kagzi lime	500	300	300
6	Guava	260	320	260
7	Grape	625	375	250
8	Papaya	240	500	500
9	Sapota	1500	450	550
10	Fig	600	250	250
11	Pomegranate	600	250	250

COMPOSITION OF MANURE AND FERTILIZERS

Manure	Composition		
	N (%)	P (%)	K (%)
I) Bulky manure			
1) Compost	1.0	1.0	1.5
2) FYM	0.5	0.25	0.5
II) Concentrated manure			
1) Neem cake	5.2	1.0	1.5
2) Caster cake	4.5	1.8	1.6
3) Groundnut cake	7.5	1.9	1.5
4) Bone meal	---	20 to24	---
Manure	Composition		
	N (%)	P (%)	K (%)

III) Inorganic fertilizers			
A) Nitrogenous			
1) Urea	46		
2) Ammonium sulphate	20.5		
3) Ammonium nitrate	33to 35		
4) Sodium nitrate	16		
5) Calcium ammonium nitrate	20.5		
B) Phophatic			
1) Single super phosphate	----	16	
2) Double super phosphate	----	35 to38	
3) Triple super phosphates	----	45	
4) Ammonium phosphate	----	48	
5) Diammonium phosphate	----	54	
6) Dicalcium phosphate	----	26	
7) Calcium meta phosphate	----	63	
C) Potassic			
1) Muriate of potash			60
2) Sulphate of potash			
3) Potassium sulphate			48
4) Potassium carbonate			65
5) Potassium magnecium sulphate			21 to 30
6) Sodium potassium nitrate			15
7) Wood ash			5

BIOFERTILIZERS:

Genetic manipulation through biotechnology to develop more efficient strains of nitrogen-fixing and phosphorous-solubilizing microorganisms is likely to increase biofertilizer efficacy. Horticultural crops require large quantity of N and P, which can be considerably replaced through use of nitrogen-fixing organisms *Rhizobium*, *Azotobacter* and *Azospirilla*, and phosphate-solubilizing bacteria *Pseudomonas* and *Aspergillus*. The VA mycorrhizal association in horticultural crops is also now known. In papaya, citrus, mango, banana and pomegranate, VAM fungi can be effectively inoculated with beneficial effects. Association of endomycorrhiza starting material is ready for potato seed production with litchi is known since long. Standardization of quick detection techniques of more efficient strains of beneficial microorganisms for biofertilizer use seems to be possible. The PCR amplification technique to identify different genera of VAM fungi has already been standardized.

Exercise No. 13
Date:

Study of ripening of fruits, grading and packing

1) 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

2) 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.

3) 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 hand picked 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 **4) 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 the 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. Harvesting is done during the cool hours of the day i.e. early morning or evening. The clusters are removed from the vine by cutting with a sharp scissor near its attachment to the cane. Before packing, the broken, decayed or defective berries from the clusters are removed.

The bunches are then packed in CFB boxes along with the 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.

5) 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.

6) Sapota: Sapota 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.

7) Pineapple: The pineapple generally flowers in about 18 to 24 months after planting. The fruits require about 115 to 130 days to mature 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 a10 % 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.

8) 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.

9) Pomegranate: The fruits are ready for 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.

10) Mango: In case of mango, fruits take about 95 to 115 days to mature after flowering. AT maturity the colour of the 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 tree 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 KKV 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

CONTROL OF RIPENING PROCESS:

Ripening in fruits can be retarded by using proper packing, low temperature, ethylene absorbants, skin coating of waxol, growth retardants and using fungicides for controlling their spoilage. Frutox (fungicidal waxol 3%) and Tal Prolong (1.0–1.5%) retarded ripening in mango Alphonso and Pairi. However, the fruits turn soft at ripening. Waxol is more efficient than Tal Prolong to retard ripening. Combination of waxol treatment and hot-water treatment results in fruits with uniform ripening, and extending storage life of mangoes. Use of Cycocel (500mg/litre), Alar (500mg/litre), GA (250 mg/litre) and menadione bisulphite (500 mg/litre) significantly retards ripening. Ripening in banana is achieved by GA treatment. In mandarin, GA (500 ppm) and 2,4,D (500 ppm) retard ripening and also prevent the browning of the stem-end. Waxol (3%) is more efficient in retaining the freshness of fruits than Tal Prolong (1.0–1.5%), vapourgaurd (di-p-menthene at 5%) extends the storage life of Dashehari mango by 25–30%, while 6% Frutox retains green colour and also retards the normal ripening phenomenon. Use of purafil (alkaline potassium permaganate on a silicate carrier) is effective in the complete absorption of ethylene in banana held in sealed polythene bags. The effect of Maleic hydrazide on the ripening process varies with different fruits.

RIPENING OF FRUITS:

Ripening transforms a physically mature but inedible plant organ into a visually attractive taste and smell sensation. It marks the completion of development and commencement of senescence with life of a fruit and is normally an irreversible event. Ripening can be achieved by the application of ethylene.

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. By use of ethephon commercially known as ethrel or cepa (7 fluid ounces release 1 cft of ethylene), making it alkaline using caustic soda (3 g of caustic soda for 20ml of ethephon). Calcium carbide can also be used for ripening (100 g for 100 kg fruits).

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. Before applying Ethephon its time of spraying with concentration are the prerequisites. About half to a litre Ethephon is enough for pre-harvest spraying of one hectare crop and fruits may be treated with 5 – 10 ml of Ethephon, costing only 7.5 – 15.0 paise to one kg fruits.

Application:

Stage of maturity at which the fruits are harvested has the greatest effect on flavour, storage life and marketability. The stage of fruit development when fruits attain full growth is known as maturation. Ripening is a terminal period of maturation when fruits attain maximum aesthetic and edible quality.

A technique to induce early and uniform ripening in the season provides an opportunity to obtain premium price of produce in the market. Early ripening also avoids early rains, which is a limiting factor in commercial cultivation of grape, litchi and dates in north India. Ethephon, an ethylene releasing chemical has significant effect on fruit ripening. The time of application and concentration has been standardized for some fruits as discussed below.

Mango:

The conventional technique used for ripening of mango causes considerable losses due to rotting. Pre-harvest application of Ethephon (500 ppm) at maturity (green stage) enhances uniform ripening by 10 days in ‘Dashehari’. Number of pickings is also reduced from 2 to 1. The treated fruits become most attractive (bright yellow). Total

carotenoids increase from 3582 μg/100 g and total soluble solids (T.S.S.) form 15 to 18 per cent.

Guava:

Guava, 'Sardar' (L-49), is very productive. The winter season crops do not ripe properly (hard fruit with poor colouration due to low temperature in North). A pre-harvest spray of Ethephon at 500 ppm during the end of November advances fruit ripening by 12 days. It reduces number of picking from 4 to 2. Surface colour of fruits becomes very attractive. Pulp quality in terms of TSS/acid ratio and ascorbic acid content increase from 17 to 24 and 190 to 261 mg/100 g pulp, respectively.

Post-harvest treatment of mature, hard fruits with 600 ppm of Ethephon for 4 minutes induces uniform creamy-yellow colour just after 3 days of treatment. The TSS/acid ratio of the fruit increases from 17.3 to 22.5 and ascorbic acid content from 204 to 253 mg/100 g pulp, respectively.

Banana:

A variety of culinary banana group is very hardy and productive in eastern UP. The fruits of this variety do not ripen like table varieties. Treating bunches with 500 ppm of Ethephon at maturity induces uniform ripening with bright yellow surface colour. T.S.S. content of fruits increases from 12.5 to 19.5 per cent.

Lemon:

Degreening of citrus fruits is very important for marketability or to obtain better returns. 'Kagzi Kalan' is one of the important cultivars of lemon. Post-harvest treatment of its fruits with 50 per cent Ethephon degreens the fruits completely with bright yellow colour after 4 days. Juice content of the fruits increases from 27 to 32 per cent and vitamin C from 40.2 to 51.5 mg/100 ml juice.

Litchi:

Litchi fruits ripen in June under north India conditions. Early rains cause fruit cracking. 'Calcutta' is well known cultivar for higher productivity. Pre-harvest spraying of Ethephon at 500 ppm at turning stage advances ripening by 7 days and produces most attractive bright pink coloured fruits. The TSS/acid ratio of the pulp increases from 36 to 48 and ascorbic acid content from 35 to 44 mg/100 g pulp. Anthocyanin, responsible for bright pink colour of this fruit also increases from 0.33 to 0.50 mm.

Papaya:

Papaya 'Pusa Dwarf' is very prolific. The colour development in fruits of papaya is very poor due to low temperature. Post-harvest treatment with 1000 ppm Ethephon to mature, hard, green fruits advances ripening by 3 days. T.S.S. content of the fruit

increases from 6.5 to 11.9 per cent. Vitamin A content increases from 1300 to 2253 I.U. and vitamin C form 26.80 to 58.32 mg/100 g pulp.

Grape:

The early rains causes cracking in the grape berries. The early cultivar recommended for commercial cultivation in Northern India are ‘Perlette’, ‘Beauty seedless’ and ‘Delight’. Post-harvest spraying of clusters of Delight with 500 ppm Ethephon during the second week of May or 10% of T.S.S. of the berries advances ripening by 11 days. The TSS/acid ratio increases from 18 – 24. Pre-harvest spraying of clusters with foliage of ‘Beauty seedless’ with 500 ppm Ethephon at colour break stage advances ripening by 8 days with most attractive uniform deep coloured clusters. Fruits are picked in a single harvest. The TSS/acid ratio of berries increases from 17 to 23 and anthocyanins from 0.5 to 0.8 nm.

Exercise No. 14
Date:

Production economics of fruit crops

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 under stand baric 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

The goals of agricultural production economics are two fold

i) To provide guidelines in using the farm resources most efficiently.
ii) To facilitate the most efficient use of resources from the stand point of the economy.

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 period 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 6^{th} year, for mango the average life is considered as 60 years and for cashew as 50 years beyond the productive life become uneconomical to mango.

Per hectare cost of cultivation of Mango

	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	F.Y.M./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%			250.00		
11	Rental value of land (1/6)					
12	Amortization value			12000.00		
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					

Exercise No. 15
Date:

Report on visit to commercial orchard and diagnosis of maladies

Exercise No. 16
Date:

Important diseases of tropical and subtropical fruit crops and their control

Sr. No.	Fruit crop	Disease	Symptoms	Control measure
1	Banana	1) Bunchy top	It is caused by the virus transmitted by the aphid (*Pentalonia nigronervosa*),the leaves appear in bunches and overlap, give rosette appearance at the top, length of petiole is reduced ,dark green streaks are observed along the secondary veins, plants remain stunted, do not produce the bunches and dwarf varieties are susceptible.	Control banana aphid by spraying Rogor or Malathion. Remove and destroy the affected plants. Dip the planting material in Endosulphon solution. The Soil application of Phorat granules @10 gm/plant.
		2) Panama wilt	It is caused by *Fusarium oxysporum*. Sudden yellowing of the leaves and petiole. Leaves get bent down at the base of the petiole. Yellowish to reddish streaks are seen on the pseudostem.	Remove and destroy the affected plants. Grow the resistant varieties like Basrai, Poovan /Champa.
		3) Sigatoka leaf spot	It is caused by *Cercospora musae*. Light yellow spots develop on the leaves, later on increase in size & turn dark brown. In severe cases, the leaf dries out.	Spray Dithane-Z-78 or Dithane M 45 @ 2.5 gm/lit.
2	Citrus	1) Tristeza (Quick decline)	It is caused by virus which is transmitted by Citrus aphid (*Toxoptera citricida*). Heavy leaf fall, root decay, heavy off season bearing, die back of branches and finally death of the plant.	Control aphid attack, use tolerant rootstocks like rough lemon, sweet orange, Cleopatra mandarin, Rangpur lime, Trifoliate orange and citranges. Avoid rootstocks like sour orange, Kagzi lime, etc.

		2) Citrus canker	It is caused by *Xanthomonas citri* . Presence of corky, watersoaked spots surrounded by the bright yellow margins on leaves and shoots; lateron spots increase in size.	Remove and destroy the affected plant parts. Spray 0.1% B.M. Apply 500 ppm Streptomycin sulphate
		3) Greening	It is caused by mycoplasma and transmitted by Citrus psylla (*Diaphorana Citri).* Chlorosis of leaves, thickening of leaflet, shortening of twigs and internodes and off season bearing.	Inject Tetracyclin and control the pest citrus psylla.
3	Grapes	1) Powdery mildew	White powdery mass of fungal growth i. e. *Uncinula necator* is observed on upper leaf surface, affecting growing tips, flowers and fruits.	Spray 0.2% Wettable sulphur or 0.1% Karathane
		2) Downy mildew	Appearance of yellow spots on the upper leaf surface due to fungus *Plasmopora viticola*. Whitish fungal growth on lower side of the leaf appears and leaf fall occurs	Spray 1.0 % B.M>
		Anthracnose	It is caused by the fungus *Elsionae ampelina*. Small circular spots with grayish black center and yellow margin are developed on the leaves. The spots developed on the berries resemble the bird's eye, hence the disease is also called Birds eye spots disease of grape.	Spray 0.2 % Copper oxychloride or 1.0% B. M.
4	Guava	1) Wilt	It is caused by the fungi like *Fusarium soloni, Macrophomina phaseoli and Cephalosporium spp.* Yellowing of leaves and twigs from tip and complete wilting of the trees within 10 to 15 days. The disease occurs severely in alkaline soils.	Drench the soil with Brassicol or spray 0.1% Bavistin. Use resistant rootstock like *Psidium friedrichstalianum.*

		2) Anthracnose	It is caused by *Gloeosporium psidii*. The fungus attacks shoots, leaves and fruits. The growing tip turns dark brown and black necrotic areas develop which cause die back.	Spray copper oxychloride or Dithane Z-78.
		3) Leaf spot	It is caused by *Cercospora spp* .Watersoaked patches develop on the leaves which causes leaf fall.	Spray 0.3% copper oxychloride.
		4) Stem canker	It is caused by *Phasalospora psidii* .Infected plants show cracks and lesions on the stem causing wilt of the branches.	Cut the affected shoots and apply the Bordeaux paste to the cut ends. Spray 1.0% B.M.
5	Papaya	1) Collar rot	It is caused by *Pythium aphanidermatum* The rotting of trunk occurs at collar region.	Spray 1.0% B.M.
		2) Damping off	It is caused by *Rhizoctonia solonii* and *Fusarium spp*.	Treat the seeds with Captan or ceresan.
		3) Papaya mosaic	It is caused by virus. The affected plants show stunted growth, bending of petiole , yellowing of leaves and finally death of the plant. The virus is transmitted by aphids like *Aphis gossypii*, *Aphis malvae*, etc.	Control aphids by spraying Rogor or Phosphamidon. Remove and destroy the affected plants.
		4) Papaya leaf curl	It is caused by the virus transmitted by the white fly (*Bemisea tabaci*).Severe curling of the leaves, reduction in leaf size and yellowing of the leaves.	Control white fly by spraying pesticides.

6	Pineapple	1) Heart rot	It is caused by *Phytophthora paracitica* .The leaves turn yellowish green and tips turn brown. The leaves start rotting at basal end, emitting foul smell.	Provide good drainage and the planting material with copper fungicide. Spray Captan or Difoltan.
		2) Leaf spot	It is caused by *Phytophthora spp.* Small water soaked areas develop on the leaves, gradually enlarge and affected portions dry.	Spray 1.0% B.M.
7	Sapota	1)Leaf spot	It is caused by *Phaeophlespora indica.* The numerous ,small to reddish brown spots with white center develop on the leaves and affected leaves drop down.	Spray 0.2% Dithane Z-78.
		2) Flattening of branches	It is caused by *Botryodiplodia theobromae*. The branches are flattened , affecting fruit set and yield.	No suitable control measure.
8	Fig	1) Fig rust	It is caused by *Cerotelium fici* Small, round, brownish lesions develop on the leaf surface; causing heavy defoliation and reducing the yield.	Spray 0.2% Zineb or 0.1% Bavistin or 0.2% Dithane Z-78.
		2) Fig mosaic	It is caused by the virus, transmitted by the Fig mite (*Aceria ficus*) The yellowish green spots develop on the leaves. Plant do not attain the normal size and bear very few fruits.	Control fig mite by spraying pesticides. Remove and destroy the affected plants.
9	Pomegranate	1) Fruit spot	It is caused by Cercospora spp. The irregular black spots develop on the fruit's surface, causing fruit drop.	Spray Dithane M-45 Or Dithane Z-78.

		2) Fruit rot	It is caused by *Phomopsis* spp. The irregular black spots develop on the fruits. The fruits remain immature, undersized and become soft and start rotting.	Spray Dithane M-45or Dithane Z-78.
10	Mango	1) Powdery mildew	It is caused by *Oidium mangifereae*. The appearance of grayish white powdery mass on the flowers and fruitlets. The panicles get dried and turn black with total failure of the crop.	Spray 0.2% Wettable sulphur or 0.1% Karathane.
		2) Anthracnose	It is caused by *Colletotrichum gloeosporides* The appearance of black necrotic areas on the shoots, leaves and fruits. The affected shoots show dieback symptoms and fruits drop down.	Prune the affected shoots and apply the Bordeaux paste. Spray 1.0%B.M. or 0.1%Bavistin.
		3) Pink disease	It is caused by *Pellicularia salmonicolor*. The fungus grows on the branches. The pink coloured encrustation with irregular cracks are formed on the shoots and ultimately killing the branches.	Prune the affected branches and apply the Bordeaux paste to the cut ends.
		4) Bacterial spot	It is caused by *Pseudomonas mangifereae.* The appearance of small dark green water soaked spots on the leaves and the fruits. The affected fruits drop down and yield is adversely affected.	Spray B. M. or 200 ppm Streptocyclin twice can reduce the incidence.

Exercise No. 17
Date:

Study of important insect-pests of important fruits

Sr. No.	Fruit crop	Insect-pests	Nature of damage	Control measure
1	Mango	1) Mango hopper	Both nymphs and adults suck the cell sap from the tender shoots and panicles. The panicles wither and fruit set is affected. These hoppers give out the honeydew like substance on which black sooty mould develops, so the leaves turn black and photosynthesis is adversely affected.	1) Spray Cypermethrin (3ml/10lit) in the month of Septemberon the vegetative flush.2) Spray Endosulphon @1.5ml/lit or Carbaryl @2g/lit on flowering. 3) Spray Quinalphos @2ml/lit 2 weeks after 2nd spray.4) Spray Diamethoate @ 1ml/lit 2weeks after 3rd spray.
		2) Mealy bugs	The female lays the eggs during May under the soil. The nymphs emerge out in the month of December-January and they climb over the tree and suck the juice from the leaves, shoots, panicles and flowers; hence, the yield reduces.	Apply Folidol 2%@500g/tree in the soil and spray 0.04% Nuvacron.
		3) Shoot borer	The caterpillar enters the young shoots from the terminal end and bores down, causing the drying up of the shoots.	Spray 0.1% Carbaryl or 0.05% Endosulphon (1ml/lit)
		4) Stem borer	It attacks the stem and branches and makes the tunnels. The affected branches start drying.	Apply EDCT mixture or Zinc borer solution in the holes. Plugging the holes with cotton wool dipped in the Carbon sulphide is effective.
2	Banana	Banana weevil	The adults feed on the pseudostem, borers in the stem, causing drying and yellowing of the pseudostem. Some times complete plant dies.	Apply phorate granules @ 10g/plant at the time of planting.
3	Citrus	Citrus psylla	The nymphs and adults damage the plant by sucking the cell sap from the tender shoots, leaves and flowers, causing curling of the leaves, defoliation and drying of the twigs.	Spray Monocrotophos 0.025% or Phosphamidon 0.025%

		2) Lemon butterfly	Caterpillar feeds on tender leaves right up to the midrib and completely defoliate the plants in case of severe infestation.	Spray 0.1% Sevin.
		3) Fruit sucking moth	The fruits are punctured and juice is sucked by the moth. The eggs are laid on the pulp and finally the fruits drop down.	1) Eradication of the alternate host 2) Trapping the moths by setting the light traps 3) Disposal of the fallen fruits. 4) Bagging of the fruits.
		4) Leaf miner	The larva mines the leaves and shoots and feed on the inner tissue producing zigzag mines. The damaged leaves become pale and curly in appearance and ultimately they dry and drop down.	Spray Methyl dimeton 25 EC @2ml/lit or Phosphamidon @2ml/lit.
		5) White fly	Both nymphs and adults suck the cell sap from the leaves which as a result wither and turn brownish. Fruit setting is adversely affected. The nymphs secrete honeydew on which sooty mould develops and entire plant turns black.	Spray Dimethoate 30
4)	Grape	1) Thrips	It sucks the cell sap from the lower leaf surface, the leaves wither and drop.	Spray Malathion or Dimethoate
		2) Chaffer beetle	It feeds on the leaves during the night hours voraciously.	Spray Endosulphon
		3) Termites	The pest damages the roots of the plant and makes the trunk hollow.	Apply Chloropyriphos 5ml/lit.
		4) Nematode	It damages the roots and the growth is adversely affected.	Apply nematicides.
5	Guava	1) Fruit fly	The adult lays the eggs on the fruit's surface inside the skin and maggots after hatching feed on the pulp. In severe damage, fruit drop occurs. The infestation is serious during the rainy season.	Spray Rogor or Malathion. Collect and destroy the affected fruits.
		2) Mealy bugs	The pest sucks the cell sap he young leaves, twigs and flowers. The yield reduces considerably.	Apply Thimet or Malathion. Cover the base of the plant with polythene film which prevents the nymphs to climb the tree.

		3) Scale insect	The pest attacks the leaves, shoots and fruits and sucks the cell sap.	Spray Fish oil or resin soap @ 500g/35lit or Crude oil emulsion @ 7.8Kg/450lit.
6	Pineapple	1)Mealy bugs	The pest attacks the roots and root growth gets ceased. Wilting of the leaves commencing from the tips.	Apply Thimet 10 G @ 17.5Kg/Ha at an interval of 100 to 125 days. Grow the resistant varieties like Queen, Red Spanish.
7	Pomegranate	1) Anar butterfly	The female lays the eggs inside the developing calyx of the flowers. The caterpillars on hatching feeds on the flesh inside the fruit. This makes the fruit hollow and the fruit gets infested by the fungus and the bacteria .The affected fruits rot and drop down. In severe cases 50 to 95% fruits get damaged.	Application of 0.2%Carbaryl or 0.03% Phosphamidon at 15 days interval in flowering season is effective.
		2) Bark eating caterpillar	The caterpillar bores the bark and feed inside. The infestation is severe in old and neglected gardens.	Spray 0.25%Carbarylor 0.03%Phosphamidion. Collect and destroy the infested fruits
8	Sapota	1) Stem borer	The grub bores into the bark of the trunk and feeds on the living tissues of the inner bark.	Plug the hole with cotton wool dipped in the Kerosene.
		2) Mealy bugs	The pest sucks the cell sap from leaves, flowers and fruit stalk.	Spray Dimethoate.
		3) Flower bud eating caterpillar	The caterpillar attacks the flowers and flower buds, causing the shedding of flowers and buds.	Spray Dimethoate or. Malathion
9	Fig	Stem borer	The grub feeds on the bark of the stem and bore inside. The attack is noticed by the chewed fibre fall on the ground and excreta is seen near the tunnel made by the pest.	Plug the hole with the cotton wool dipped in petrol or chloroform or kerosene and close the hole with the mud.
10	Papaya	Red spider mite, Aphid and White fly	All these pests suck the cell sap from the leaves so that yellow spots develop on the leaves.	Spray Dimethoate or Malathion

Exercise No.
Date:

Air layering in Guava

Air layering is one of the most important commercial methods in practice for propagation of Guava. When rooting is encouraged on the aerial part of the plant after wounding, it is known as Air layering. Air Layering is also known as Pot layerage or Morcottage or Gootee.

Season: July to September and February to March

Procedure: Shoots selected for air layering should be 1 cm in diameter and preferably from previous year's growth. A ring of bark about 2 to 3 cm in width, just below the node and about 25 to 30 cm away from the growing tips is removed. Growth Regulators containing powder like Keradix or Seradix is applied on the upper cut portion. Then handful of sphagnum moss is placed over the wounded portion and wrapped with polythene film of 20 to 25 cm in size, tightly and both the ends are tied firmly and left for rooting. The polythene film keeps the medium moist and prevents the loss of water by evaporation.

It takes about 6 to 8 weeks for rooting. When the roots are visible through the polythene sheets, the layered shoot is detached from the parent plant. Detachment of layers is done in 3 stages. In first stage, the incision just below the operated portion and about 1/3 of the thickness of the shoot is made. In the 2^{nd} stage, the cut further deepened half way through and finally 15 days after 2^{nd} cut, the shoot is separated from the parent plant. The detached air layers are then planted in polythene bag filled with good potting mixture and are kept in shade for a few days and then are brought to open field. Such layers can be used for planting in main field.

Root formation on the shoot: The root formation on the shoot is stimulated by removing a ring of bark or by making a notch which causes an interruption in downward movement of carbohydrates and auxins from the leaves and growing shoot tips. The food material accumulates near the point of treatment which helps in rooting. Root formation depends upon the continuous moisture supply, good aeration and moderate temperature around the rooting zone.

Exercise No.
Date:

Study of varieties and method of propagation of different fruit and plantation crops

Sr. No.	Common Name	Varieties	Method of propagation
1.	Mango	Alphonso, Sindhu, Ratna, Neelum, Dashehari, Amrapali, Mallika, Arka Aruna, Arka Puneet.	Stone grafting, Inarching and soft wood grafting
2.	Banana	Basrai, Poovan, Gros Michel, Harisal, Ney Poovan, Nendran, Monthan.	Sword Suckers
3.	Sweet Orange	Blood Orange, Washington Navel, Mosambi, Satgudi, Blood Red Malta, Pineapple, Valencia.	T-grafting, Seed
4.	Mandarin	Kinnow, Nagpur Santra, Willking, Satsuma, Khasi, Coorg Mandarin, Darjeeling.	T-grafting, Seed
5.	Kagzi Lime	Sai Sarbati, Vikram, Pramalini, PKM-1, Baramasi, Kagzi, Tahiti.	Seed
6.	Lemon	Lisbon, Meyer, Gandharaj, Eureka, Assam, Italian.	Air layering
7.	Grape	Pusa seedless, Bangalore Blue, Thompson seedless ,Black Champa, Anabe-Shahi, Bhokari, Muskat, Perlette, Delight, Arkawati ,Arka Hans, Arka Neelamani.	Hardwood cutting, layering, chip budding, micro-propagation
8.	Papaya	CO-1 to CO-6, Pusa Nanha, Pusa Majesty, Pusa Giant, Pusa Delicious, Solo, Washington, Ranchi, Madhubindu, Coorg Honey Dew.	Seeds
9.	Pineapple	Kew, Queen, Mauritious, Red Spanish, Singapore, Alexandria, Abacaxy.	Suckers, slips and crown
10.	Sapota	Kalipatti, Pilipatti, Cricket ball, CO-1, CO-2, Oval, Baramasi, Chhatri.	Soft wood grafting, Inarching
11.	Guava	Lucknow 49, Allahabad Safeda, Kohir Safeda, Safed jam, Chittidar, Red fleshed, Harijha, Supreme	Air layering, Stooling, Simple layering
12.	Fig	Poona Fig, Brown Turkey, Smyrna, San Pedro, Gentile, Kabul, Daulatabad, Lucknow.	Hard wood cutting
13.	Pomegra-nate	Ganesh (GBG-1), Alandi, Muskat, Mridula, Bedana, Kabul, Paper shell, Dholka, Kandhari, Ruby, G-137	Hard wood cutting, Air layering
14.	Litchi	Deharadun, Elaichi, Late Bedana, Early bedana, China, Shahi Muzzafarpur, Shahi Rose, Rose scented.	Air layering, Inarching, Chip budding

Exercise No.
Date:

Study of stone grafting and soft wood grafting in Mango

A) Stone Grafting: It is an easy and one of the best methods of multiplication of mango. Near about 70% success has been reported by adopting this technique. As the stone remains attached to the rootstock while grafting the technique is called as Stone grafting.

Advantages of stone grafting:

1. It is a simple technique. Hence, it has been widely adopted in Konkan region for multiplication of commercial mango varieties.
2. It is a rapid method. Large number of grafts can be prepared within short period of time.
3. The cost of production is less as compared to other grafting techniques such as inarching, veneer grafting, etc.
4. The graft joint smooth and perfect. Hence there is no dislocation of graft during transport and planting.
5. The establishment of the graft in the field is excellent.
6. There is no risk of sprouting of rootstock after in the main field.
7. The grafting operation is done in the shed. Hence the man power could be utilized effectively even when it is raining heavily outside.
8. About 70% success can be obtained by employing this technique.

Season of grafting: Stone grafting can be done from May to September. But the best season is June to1st week to August and the season prolongs the percent success decreases.

Selection of scion:

1. The scion stick should be selected from desirable variety and should be 15 to 20 cm in length.
2. It must be dark green in colour, smooth and round in shape.
3. The apical bud must be mature, plumpy, and about to sprout.
4. The scion stick should be free from insect-pest and disease infestation.

Raising of rootstock: The seedlings to be used as rootstock are raised on the raised beds.The beds of size 3m x 1m x 15 cm are prepared for sowing the stones. The healthy, heavier stones which sink in the water are selected. The stones are then treated with fungicides like Emisan, Monosan or Ceresan at the rate of 3 to 5 g/Kg. The stones are then sown horizontally on the raised bed and covered with thin layer of FYM and garden soil. Germination takes place within 3to 4 weeks of sowing and seedlings of stick. Insert the scion

stick in the prepared rootstock and union is wrapped tightly with polythene sheet (2 cm wide, 15 to 20 cm long and 250 gauge thickness). While uniting the rootstock and scion care should be taken that at least one side of the rootstock and scion stick will coincide with each other. Such prepared grafts are then planted in polythene bags of size 7 x 9in. filled with potting mixture of soil and FYM (3:1) and are kept in shade for protecting them from heavy rains about 3 to 4 weeks after grafting. The new vegetative growth put forth by the graft indicates the successful union of stock and scion. When newly produced leaves turn dark green, grafts are transferred to open space. To keep the grafts in erect position support them with bamboo sticks. The grafts are irrigated at regular interval and protected from insect, pests and disease infestation by following plant protection schedule. One year after 10 to 15 days old is ready for grafting.

Selection of rootstock:

1. It should be healthy, vigorous growing and free from insect-pest and disease infestation.
2. It should coppery red in colour.
3. The epicotyl should be thick.
4. The age of rootstock should be 10 to 15 days.

Grafting procedure: Uproot the selected rootstock carefully without injuring the roots and the epicotyl. The upper portion of the epicotyl is removed by giving a horizontal cut at the height of 6 to 8 cm above stone. The vertical cut exactly in middle of the epicotyl is given keeping a distance of 1.5 to 2 cm from the stone. Remove the leaves from selected scion retaining the leave petiole. The scion stick is prepared by giving wedge shape slanting cut of 5 cm in length on both sides of the scion graft, stone grafts are ready for planting in the main field.

B) Soft wood grafting: The technique of operation in soft wood grafting remains the same as that followed in stone grafting. In mango, soft wood grafting is done when the root stock produces secondary soft vegetative growth. Hence, soft wood grafting can be done throughout the year.

Care of grafts:

1. Newly prepared grafts are kept in the shade and protected from the rains
2. They are staked with the bamboo sticks to them erect.
3. The polythene strip should be removed when are transferred to open condition.
4. The inflorescence if produced by the graft in the month of January should be removed to maintain the vigour of the graft.
5. The grafts are to be irrigated at regular interval.

Exercise No.
Date:

Bahar treatment in fruit crops

On the basis of nutritional status (C:N), fruit plants have been divided into four general groups as given below.

1. C/NNNN: The plants in these groups make poor growth and bear little or no fruit. There is a small quantity of carbohydrates and abnormally large quantity of nitrogen in the tree. The young trees near the bearing age which have been defoliated by insects or diseases; or trees which grown in shade or are over crowded may fall in this class.
2. CC/NNN: In this class excess nitrogen is present with sufficient amount of CHO for strong succulent growth. Practically all the carbohydrates are used for vegetative growth and there no storage of carbohydrates. This represents the normal growth period for young tree, or for mature trees forced into growth by severe pruning or manuring.
3. CCC/NN: In this class, the balance of the carbohydrates and nitrogen is right for both vegetative as well as reproductive growth. Due to slight excess of carbohydrates, fair growth and fruits are produced.
4. CCCC/N: In this condition, excessive amount of carbohydrates and small quantities of nitrogen are present. Hence, poor growth and small amount of fruits are produced. It represents a starved condition. Most of the old or neglected trees are found to be of this class.

BAHAR TREATMENT

The bahar treatment is given to bring proper balanced nutritional condition i.e. CCC/NN in plants for inducing fruiting. It is a practice of withholding the irrigation for about 30 to 40 days prior to the expected flowering season so as to encourage flowering and to regulate the time of harvest. This treatment is followed in the region where the trees are usually in continuous vegetative growth which results into indistinct flowering season. Bahar treatment is followed in fruit trees like Santra, Mosambi, Guava, Pomegranate etc.

Types of bahar: There are mainly three types of bahar viz.,

1) Mrig bahar (flowering season-June-July)
2) Hasta bahar (flowering season-September-October)
3) Ambia bahar (flowering season-January-February)

Procedure:

1. Withhold the irrigation 30 to 40 days prior to the expected flowering season.
2. Plough the orchard crisscross wise
3. Remove the upper soil within the radius of 60 to 90 cm around the trunk of the tree and remove the dead and decayed roots. Thus, the roots are exposed but this type of root exposure is not necessary in case of sandy or light soils.
4. Due to withholding of irrigation and root exposure, yellowing, shrivelling and fall of leaves occur which indicates full rest and accumulation of food reserve by the plant.
5. Later on, the exposed area is again covered with soil.
6. Apply the required manure and fertilizers according to the recommended dose of the particular crop.
7. Prepare irrigation basins and water channels. Irrigate the orchard lightly and avoid the heavy irrigation as it may induce vegetative growth only. The successive irrigation is given as usual at regular intervals.

Choice of bahar: The selection of bahar depends upon the following factors.

1. Availability of water
2. The time of the year when the fruits are required in the market.
3. Attack of insect-pests and diseases.

Bahar treatment in important fruit crops

Fruit crop	Type of bahar	Flowering season	Harvesting season
1) Guava	Mrig bahar	March-April	November to January
2) Pomegranate	Ambia bahar	November 2nd week	June to August
3) Mandarin Orange	Ambia bahar	December	October-November
4) Sweet Orange	1) Ambia bahar 2) Mrig bahar	1) December 2) April	1)October-November 2)March-April

Exercise No.
Date:

Special horticultural practices in fruit crops

For successful cultivation of fruit crops and to obtain maximum returns, it is necessary to adopt certain operations by which trees are forced to flower for maximum fruit production. The special cultural operations exercise indirect control of CHO production, its utilization, its cultivation and accumulation which regulate the growth and flowering of the tree. The special horticultural practices followed in fruit crops are as follows.

1. Bending: It is widely adopted practice for increasing fruit production in Guava, especially in erect growing varieties. In local varieties of guava the branches grow erect and the buds which are situated at the top of the shoot generally sprout and produce flowers and fruits .This behavior of apical bud to dominate the buds situated at the lower side is termed as apical dominance of polarity. It is mainly because of poor accumulation of auxins at the lower side of the branch. When the branches are made horizontal by bending, apical dominance is removed and more auxins are accumulated at the lower side of the shoot. Hence, due to bending, the lateral buds sprout and produce more fruits and that increases the yield.

2. Girdling: In girdling operation the circular piece of bark about 0.5 cm width, is removed from any part of the vine like trunk, shoot or cane. Due to girdling operation, phloem tissues are disturbed and downward flow of CHO is interrupted and food material gets accumulated at the upper part of the plant that increases flowering and fruiting. In grape it is done one week prior to blooming or 60 to 70 days after October pruning. This helps in better development of berries and early maturity.

3. Thinning: It is nothing but the removal of the flowers or fruits by mechanical or chemical means with a view to improve the fruit quality. In grapes, when limited number of bunches are allowed to develop, the size and weight of the bunches increase and that improves the fruit quality. Hence, a limited number of flower clusters or bunches are retained and all others are removed. It is advisable to keep about 60 to 70 clusters per vine spaced at 3x3 m on bower system, where as 16 to 20 flower bunches is retained when Kniffin system is adopted. Thinning also involves removal of 25% portion of the bunch at flowering. Thinning reduces uneven ripening and improves the colour of the berries.

4. Smudging: The practice of smudging is followed in mango to induce alternate bearing varieties. It is done by burning the dry twigs, leaves and other waste material on

the ground and allowing the smoke to pass through the center of flowering trees. Smoking is done early in the morning and in night for about 15 days. The smoke is discontinued as the terminal buds begin to swell. The smoke contains acetylene and ethylene gas which help including flowering in mango.

5. Notching: It involves partial removal of strip of bark alone with inner wood portion which is followed in Fig. The effect of notching is similar as that of girdling i.e. interruption of downward flow of CHO. It is done just above or below the bud. When it is done below the bud there will be more accumulation of CHO in the bud which helps for better fruit development, while when it is done above the bud CHO will be accumulated above the bud and there will be more nitrogen in the bud which will give vigorous vegetative growth on which flowers are produced. The buds selected for notching should be large, plumpy, healthy and must be on the perfect mature wood. Generally 3 to 4 buds in middle portion of the shoots are the best for operation. In Maharashtra, notching is done above the bud and generally carried out in the month of June-July and in Jan-Feb; it is done below the bud.

6. Caprification: The Smyrna and san Pedro Fig require artificial pollination for fruiting. Therefore, Capri figs with wasps inside (*Blastophaga psens*) are collected in small bags or wire baskets are hung on fruiting Smyrna type fruit trees. The wasps covered with the pollen grains enter the Smyrna fruits and pollinate the flower inside the fleshy receptacle. Thus, for fruit setting of Smyrna Fig, Capri figs as well as Blastophaga wasps are necessary. This process of pollinating the Smyrna trees artificially is known as caprification.

7. Bahar treatment: Refer previous exercise.