

COURSE TITLE : **PRODUCTION AND POSTHARVEST
MANAGEMENT OF FRUIT CROPS**
YEAR : III BSc.(Ag) (2003-2004)
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EX. NO. 1

LAYOUT AND PLANNING OF AN ORCHARD

Orchard

Orchard is known as fruit garden. It is the place of cultivating fruit trees for various purposes.

1. Supply to the local market
2. Export

Principles of orchard planning

1. The orchard should be established in the right location of site having suitable climatic and soil conditions and other facilities required for successful growing of fruits and disposal of the produce.
2. Minimum space should be allotted for roads, paths and building and should not exceed more than 10% of the total area. The roads and path should ensure convenience and economy in orchard transport and supervision. The building should be near the road and in the center of the orchard.
3. The irrigation and drainage channels should be laid out in such a way as to serve the needs of every plot in a most efficient and economic manner. For every 100 feet length of irrigation channel, 2 inches of slope should be given, drains also should follow the gradient of the land and should be concealed from the visitors.
4. The evergreen fruit trees should be planted in the front and the deciduous trees or those shed their leaves partially at seasons at the back.
5. The dwarf fruit trees should be allotted at the front and tall trees at the back to facilitate better supervision.
6. Fruit requiring frequent irrigation should be planted nearer to the source of water, while the rainfed ones can be kept further away.
7. Fruit varieties ripening at a time should be located in adjoining plots to facilitate proper orchard operations.
8. Fruits that attract birds and other animals should be located close to the watchman's shed.

9. Fertile area of the orchard should be planted with more paying and gross feeding fruit trees
10. Self sterile or self incompatible fruit trees (deciduous) should be planed with pollinisers at the rate of every third tree in every third row to ensure optimum fruit set.
11. The spacing for each species should be the optimum. The vigorous varieties as well as the varieties growing in fertile soil generally require wider spacing.
12. There should be provision of wind breaks around the orchard to protect the trees from strong winds.
13. Fencing should be done sufficiently ahead of planting
14. Selection of fruit varieties suitable to the area and procurement of genuine planting materials from reliable sources are essential.
15. Nursery for maintaining the clones and raising of seedlings should be located near the water source.

The important points to be considered for planning an orchard are the following:-

1. Selection of site

1. It should be in a well established fruit growing area
2. It should be close to the market or connected with road or rail transport.
3. It should have favourable climatic and soil conditions and source of irrigation
4. It should have proper drainage and there should not be water stagnation during rainy season
5. The availability of labour in the particular area while selecting the site should be considered.
6. There must be assured demand in the market for the fruits to be grown.

2. Climate

The climatic factors of the site *viz.*, day and night temperature, rainfall, wind, light, atmospheric humidity, hail storm, frost occurrence etc. must be considered carefully. The fruits suitable for regions with different climatic conditions are,

1. Tropical climate

- Mango, banana, papaya, sapota, ber, guava etc.

2. Subtropical

- Hill banana, grapes, pineapple etc.

3. Temperature

- Apple, peach, plum, black berry, straw berry etc.

3. Soil

A loam or sandy loam soil considered to be the best for most fruits.

The grower must have knowledge on soil type, its depth, section, water table and fertility status before selecting a fruit crop.

- a) shallow soil with rock substrates
- b) soils with very high or low pH
- c) soils having poor drainage
- d) soils with high water table during rainy season should be avoided.

Sandy soils may be suitable for cashew, gravelly red laterals soil for cashew, mango, jack etc. and loamy soils for banana, papaya, sapota etc. The poor fertility of soil can be improved through soil management practices like green manuring and intercropping.

III. Land preparation

After selecting the suitable locality of site, preliminary operations have to be done

- a) Trees are felled, stumps and roots are uprooted
- b) Shrubs and weeds are removed
- c) Ploughed thoroughly and deeply
- d) Levelled and manure
- e) In the hills, terrace should be made of levelling is done within the terraces.
Terracing protects the land from soil erosion.

Irrigation source

- An orchard flourishes well under irrigation particularly during dry months
- a) Irrigation source should be made available well ahead of planting
 - b) There should be permanent assured supply of water at required quantity
 - c) Wells should be located at convenient places in different parts at the rate of one well for every 5-10 acres.

Fencing

- Fence live or alive is essential. Live fence is economic and cheap. The plants suitable for live fence should be
- a) Drought resistant b) Easy to propagate from seed c) quick growing d) have dense foliage e) should stand severe pruning f) should be thorny.

Eg. Agave, *Casuarina equisetifolia*, Acacia

Wind breaks

When a strong wind of high velocity passes through the orchard, damages like uprooting of trees, breaking of branches, drooping of blooms and immature fruits, erosion of surface soil etc. are accused. Hence, establishment of a tall growing wind break is necessary to protect the orchard.

To give effective protection wind breaks are to be planted atleast two year ahead of planting of fruit plants.

The efficiency depends upon the height of the trees and their compactness. A ideal wind break should be upright in growth, tall, mechanically strong, quick growing and sufficiently close to offer the resistance to the wind and planted in two rows at 12-25 feet spacing.

Tree species suitable as wind breaks are,

Polyathia longifolia

Casuarina equisetifolia

Erythrina indica

Eucalyptus globulus

Building

Construction of an office building should be planned before planting fruit trees. Other buildings such as implement shed and labour quarters may also be constructed.

Roads, paths, irrigation and drainage channels

Planning of these should also be done well in advance. The foot path should be made in between the rows of trees without utilizing any additional space. The permanent irrigation and drainage channels should be dug in straight lines and without interfering the main roads to economise the use of irrigation water by avoiding seepage and for efficient drainage and excess water.

Before the actual laying out of the orchard and undertaking the planting work, a detailed plan of the orchard should be drawn showing all structures and plots for the fruits to be grown, to help to establish the orchard correctly and conveniently.

Layout

It is very important operation. The plants are planted at optimum distance for proper development for accommodating the required number of plants per unit urea and to improve the aesthetic look of the orchard. Hence, the factors which are considered important for proper layout of the orchard are,

- i) Systems of planting
- ii) Planting distance

These allow

- 1. Equidistance for each tree for uniform growth
- 2. Easy orchard operation
- 3. Proper supervision and management

Systems of planting

- 1. Square 2) Rectangular 3) Triangular 4) Hexagonal 5) Quincunx 6) Contour

Square system

This is the most commonly followed system and very easy to layout. The trees are planted on each corner of a square in straight rows at right angle. Here, inter cultural operations can be done easily from both the directions. Number of plants are less.

Rectangular system

The plot is divided into rectangular and fruit plants are plant at the 4 corners of the rectangle. As the distance between two rows is more than the distance between any two trees in a row there is no equal distribution of space per tree. Intercultural operations can be done at one direction only.

Triangle system

The plants are planted as in square system but the plants in the 2nd, 4th, 6th and such other alternate rows are planted midway between the 1st, 3rd, 5th and such other alternate rows.

Quincunx

This is similar to square system except that a 5th tree is planted at the centre of each square which is known as “Filler”. The fillers are usually quick growing, early maturing and erect. Fruit crops like banana, papaya, pomegranate etc. can be grown as filler tree.

Contour system

This system is followed on the hills with high slopes and undulated topography. The objective is to minimize soil or land erosion and to conserve soil moisture so as to make the slope fit for growing fruit trees. The contour line is designed in such a way that the water fall in the irrigation channel is slow and penetrate into the soil with out erosion. The greater the width of terrace the less is the chance of erosion. The planting distance in contour system may not uniform.

Laying out a plot for planting

While laying out a plot, a base line should be drawn as per pythochorum theorem. A baseline 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 base line at regular required spacing. At both ends of the base lines at right angles lines are drawn to form the hypotenuse line based on 3,4,5 m system ($ab^2 + ac^2 = bc^2$). After the formation of 3 lines (triangle), it is easy to fix all the other pegs to mark the tree locating in between the lines at the required spacing by using ropes connecting the pegs of the lines in opposite directions.

EX. NO. 2

PROPAGATION AND NURSERY PRACTICES FOR MANGO

Mango may be propagated by sexual (seed) and asexual (vegetative) means. Asexually propagated mango plants are preferred because they bear fruits early, shorter, and true-to-type. Although mangoes can be vegetatively propagated through cuttings, air layering or mound layering, these methods are not commercially practiced.

Vegetative propagation

Advantages

- Progenies are genetically true-to-type. At the progenies will be similar in both genotypic and phenotypic characters.
- Pre bearing period is considerably reduced
Eg: Mango seedlings take 8-10 years for bearing, while grafts take only 4 years.
- Quickest method of multiplication specially through micro propagation
- Vegetatively propagated plants are generally dwarf in stature than seedlings which favour high density planting
- Resistance to biotic and abiotic stress can be incorporated through selection of resistant/ tolerant root stocks. Eg. Citrus.

Disadvantages

- No new varieties could be obtained through chance seedlings
- More expensive because more labour oriented
- As the plants do not posses well developed tap root system for anchorage, they do not tolerate cyclonic storm and hence comparatively short lived.

The commercial methods of mango propagation being followed are inarching (approach grafting), veneer grafting, epicotyl or stone grafting. In polyembryonic cultivars, seeds may give rise to apomictic seedlings which will also be true to type to that of the mother plants. Polyembryonic varieties can also be useful as rootstocks to induce dwarfing and early bearing.

Seed collection and preparation of seed beds

The seeds are collected from retail fruit juice vendors, processors, and institutional sources. If seeds are collected from processing units, germination may be sometimes poorer as these seeds may have broken cotyledons or injured embryos. Seeds should be collected from mature fruits only for raising the rootstocks. The stones (seeds) are sown immediately after they are removed from the ripe fruits. If sown after two months of their extraction, only 15-20% germination is noted. The stones are to be collected in their peak season. Before sowing, the stones are immersed in water and only those seeds which sink in water are to be sown.

Slow diffusion of water and gas into the husked seed reduces its germination. Dehusking can be done to remove the outermost seed cover that physically prevents the entry of water and oxygen needed for germination. Dehusking also reduces the size of the seed and consequently more seeds can be sown per unit area of the germination bed. Once dehusked, the seeds should be sown immediately.

Sowing

The stones are sown at a depth of 5cm and at 15-20 cm apart on raised beds prepared with sand, loam and farm yard manure. Seeds are sown with the concave side down at 1-2 cm deep or with plumule portion up at the subsurface of the medium. Otherwise, seedlings will develop crooked shoots and roots that snap off easily when uprooted by hand. Seedbeds are to be preferably established either under shade of trees or under partial shade. Incase of absence of seedbed, seeds maybe spread on the ground and pre-germinated by covering them with coir dust, saw dust, or rice hull. Germinated seeds are then sown individually in plastic bags. Seeds may also be sown directly in individual containers.

Transplanting and Potting

Seedlings are transplanted in nursery rows or in individual containers four to six weeks after germination. Nursery rows are established on a small piece of land within the nursery. Here, seedlings can be grown at closer spacing until they are asexually propagated. The site should be well drained and fertile. Seedlings are transplanted in nursery rows at 30 cm x 60 cm. In the absence of lack of a suitable area for nursery rows,

seedlings are transplanted in poly bags or in tube pots measuring 13 to 15 cm in diameter and 20 to 25 cm depth. Prior to transplanting, each bag is perforated at the sides to provide drainage and its two bottom and corners are pushed inward to make the bottom flat when filled up with growing medium.

As soon as the seedlings recover from transplanting shock, they should be transferred to an area with full sunlight to harden them and minimize the incidence anthracnose. The seedlings should be watered regularly. Young seedlings can be fertilized with 5 g of ammonium sulphate every 2-3 months. Seedlings can be grafted when their stem diameter has attached 1 cm thickness or when they are six to ten months old.

Selection and preparation of Scion

Scions should be collected from full-bearing trees of choice cultivars. The scion shoots should be mature, 8 to 15 cm long, 1 cm in diameter, about six to nine months old, plump and have well developed growing points. Only those shoots from the current season flush should be selected for grafting.

The scions can be precured before collection. This is done by defoliating the selected shoot atleast 7 days before grafting. This helps in swelling the dormant buds and results in greater graft success. If the scions are to be collected from a distant place, wrap them with moist newspaper, paper towels, or sphagnum moss before placing them in polyethylene plastic bags to keep them fresh until they reach the nursery.

Approach Grafting

This technique involves grafting the terminal portion of a branch of a selected tree onto a seedling rootstock. Nine months to one year old rootstock is grafted with the scion which remains attached to the mother plant. In the rootstock, 20 cm above ground level, 5 cm long slice of bark with wood is removed and a similar corresponding cut is also made on the scion so as to attach both the cut surface areas firmly with the help of jute thread. The tied portion is covered with cowdung mud paste. After 8 to 10 weeks of grafting, the graft union will be completed and can be separated from the selected tree and hardened off before planting in the field. Approach grafting is carried out when the cambial activity

is maximum and should be avoided during the seasons of desiccating winds of heavy rainfall. July to February is the best season for approach grafting in South India.

Some points to obtain successful graft union

- ◆ Wipe any soil or debris adhering on the stem of the stock.
- ◆ Cut back the stock to the point where there is active growth or where the bark easily separates from the wood. The stem is actively growing when it is greenish-brown. Retain two or more leaves intact below the grafting cut.
- ◆ Choose a scion whose diameter is as big as that of stock.
- ◆ Use a scion that is 10 to 15 cm long. Cut its base into a smooth wedge of about 2 cm long.
- ◆ Make a vertical cut at the middle of the stock, deep enough so that the wedge of the scion fits firmly
- ◆ Insert the scion onto the stock and secure it with polyethylene plastic strip. This should be tied firmly to avoid entry of water which can eventually cause the rotting of the graft union.
- ◆ Wrap the entire scion with a polyethylene plastic strip by winding it upward. Each turn should overlap one third of the width of the preceding one. This will minimize loss of water.
- ◆ Cover the scion with small polyethylene plastic bag during the rainy season to avoid rotting of the graft point.
- ◆ Place the newly grafted plants under the shade and then transfer them in the open (in full sunlight) when new shoots develop from the apical and axillary buds.

Epicotyl (or) stone grafting

This method is very popular as large number of plants can be produced in a shorter time. Grafting is done on very young two weeks old rootstocks. The seedling rootstocks are cut about 5 cm above the cotyledon end and procured scions with wedge-shaped base are inserted into them by making a vertical split after topping the rootstock. Two hundred gauge thick polythene tape is used for tying the union of the grafts. The

grafted plants may be kept in the mist chamber with more than 80 % RH for higher rate of success.

Mangos are also propagated through veneer grafting, side grafting and budding in North India.

Veneer grafting is practiced to establish *in situ* orchards and to rejuvenate unproductive old trees. In this method, a slanting down ward and inward cut of 2.5 cm long is given on the smooth area of the root stock at 20 cm height. At the base of the cut I a slanting cut is given to intersect the first cut and a piece of wood along with a bark is removed. Similarly, at the base of the scion a long slanting cut is given one side and a short cut on the opposite side so that the base will fit on the rootstock firmly. The scion is placed on the stock to make the cambial layers match and the graft joint can be secured with a cut polystrip. After the graft union the top portion of the stock can be gradually cut.

Poly embryony

The phenomenon in which more embryo are present in single seed is called as poly embryony. It may results due to nucellar embryo. Development of more than one nucleus with in the embryo sac leading to multiple embryos.

Polyembryony varieties of mango

Bappakai, Chandrakaran, Kurukkan.

EX. NO. 3

PROPAGATION AND NURSERY PRACTICES FOR SAPOTA

Sapota is propagated both by seed and vegetative methods. Seed propagation is usually resorted for improving the existing varieties and occasionally for raising rootstocks. Vegetative propagation is the standard practice in Sapota.

Seed Propagation

Seeds remain viable for several years if kept dry. The best seeds are large ones from bigger fruits. They germinate readily but growth is slow and the trees take 5 to 8 years to bear. Since there is great variation in the form, quality and yield of fruits from seedling trees this method is considered as an undesirable method of propagation. For sexual propagation, seeds are collected from elite trees and sown in pans or beds with light sandy soil as germinating medium and watered at regular intervals. The seeds can be soaked overnight in water or treated with gibberellic acid to enhance germination.

Vegetative Propagation

Propagation by vegetative methods is essential to get true to type plants. Several methods such as grafting, layering, cutting or budding can be practiced. Sapota is commercially propagated in India by inarching on selected rootstocks. Inarching is preferred as compared to air layering. Shield-budding, cleft-grafting and side-grafting were moderately successful but they are often too slow for large-scale production

Air-layering

This method is practiced in Maharashtra, Gujarat, Karnataka and Andhra Pradesh. By this method, a sizeable plant can be obtained in a short time but mortality rate is heavy and root system is shallow. So, the air-layered plants can easily succumb to heavy winds especially in sandy soils. The best time for air-layering is the beginning of rainy season. High humidity prevailing during the monsoon facilitates rooting. Applying a mixture of IBA and NAA at 10,000 ppm to the exposed tissue can increase the rooting percentage in air layers of sapota. In rooting of air layers, the juvenile shoots or the newly

emerging shoots that are produced as a result of beheading a grafted tree, possess a better rooting ability than mature shoots.

GRAFTING

Approach grafting

- Select healthy one year old rootstock of pencil thickness
- Remove 5 cm long slice of bark with wood to 1/3rd of its thickness on the side of the root stock 20 cm above the ground level.
- Select scion shoot of the same size which is attached with the mother plant
- Make a corresponding cut in the scion
- Place two cuts face to face and tie firmly with jute thread and cover this with a piece of wax coated cloth
- Cover the union with a mixture of cowdung and mud in equal parts.
- After union (8-10 weeks after grafting) remove the top of the root stock and scion shoot below the graft joint in stages.

Side grafting

- Make a slanting cut of 2.5 cm long on one side of the root stock at an angle of 20-25° at 20 cm above the ground level.
- Collect 10 cm long pre cured scion from the mother tree
- Prepare the scion by giving two slipping cuts opposite to each other at the base
- Insert the scion in the root stock and tie firmly
- After union remove the top of the root stock in stages

Cleft grafting

- Select root stock and scion of similar or varying thickness
- Beheaded the stock and split it vertically at its centre to a length of 5 cm.
- Prepare the base of the scion in the form of a wedge
- Insert the scion wedge in the central split of the rootstock and tie firmly
- In bigger sized rootstocks, 2 scions can be inserted one on either end of the stock.

Usually adopted for top working.

Soft wood grafting

Soft wood grafting is also possible in sapota. Precured shoots can be used for grafting on pencil thick green one year old root stocks by cleft method as done in mango during July-August months. Procuring is done by defoliating the leaves on scion shoots 2-3 weeks before grafting. If soft wood grafting method is practiced, grafted plants are maintained under high humidity conditions, more than 80 per cent success can be achieved.

Root stocks

Grafts have been successful on several root stocks. These include.

- | | |
|---------------------------|--------------------------------------------------------------|
| 1. Sapota | - <i>Achras sapota</i> |
| 2. Khirnee / Pala / Rayan | - <i>Manilkara hexandra</i> (or)
<i>Mimusops hexandra</i> |
| 3. Star apple | - <i>Chrysophyllum cainito</i> |
| 4. Mahua | - <i>Madhuca latifolia</i> |
| 5. Mee tree | - <i>Bassia longifolia</i> |
| 6. Miracular fruit | - <i>Sideroxylon dulcificum</i> |

Graft compatibility and percentage of graft success are more with pala root stock and so it is commercially used. Pala tree is a natural habitat of marshy plants. Its fruit are small, oval and sweet. Fruits are washed to get rid of pulp in water and dried under shade and sown. The seeds are soaked in water overnight for easy and quick germination. Seeds are sown in raised beds or pots. Seeds germinate in about 4 weeks and when they are about 15 cm height, they are transferred to small pots. When they attain a thickness of 1 cm, the are used for grafting or budding.

Graft incompatibility

It is a situation when stock and scion do not unite to form a single system. This is due to the reason that both stock and scion respond differently. The inability of two different plants when grafted together to produce a successful union and develop into one plant is termed as graft incompatibility.

Symptoms of incompatibility

- Failure to form a successful graft/bud union
- Yellowing of foliage
- Over growth at the graft joint
- Unusual swelling at the graft union
- Premature death of tree
- Marked differences in growth
- Deficiency or nutritional disorder symptoms.

EX. NO. 4

PROPAGATION AND NURSERY PRACTICES FOR PAPAYA

Papaya is generally propagated by seeds though it can be also propagated by vegetative means. Of late, tissue culture methods are also being adopted for mass multiplication especially-for gynodioecious varieties when there is a distinct demand for oblong shaped fruits. Several attempts have been made to propagate papaya by vegetative means. Rooting of cuttings is possible but they are successful only 'to a limited extent and so they are not being commercially practiced.

Seed multiplication

Papaya is polygamous in nature and is a cross pollinated crop. Since it is cross pollinated, pure seeds have to be obtained from controlled pollination. In dioecious types 'sib mating' is done by effecting crossing of the female flowers by the pollen collected from the male plants of the same variety. Incase of gynodioecious varieties, controlled pollination is carried out to obtain true types by 'selfing' the bisexual flowers of the Andromonoecious trees. Flowers are selected for crossing before they are fully open. Flower buds after crossing are labelled and bagged using butter paper bags.

Fruits takes about 12 to 14 weeks from fruit set to maturity and fully matured fruits are to be harvested when the colour of the fruit at the base turn yellow and kept for ripening. Seeds are extracted from these fruits by washing off the mucilage in running water, then dried in shade and stored in sealed polythene covers or in plastic containers. Removal of 'sarcotesta' the mucilaginous coating accelerates germination. The viability period of papaya seeds are very low and drastic fall in germination is noted with extended storage. Seeds can be stored in refrigerated conditions at around 8°C.

Micropagation

If there is a distinct demand for oblong shaped fruits then propagating bisexual plants will be of great help and this can be done by tissue culture methods easily. Protocols are available for regeneration of plants from shoot tips and axillary buds and from callus by organogenesis and somatic embryogenesis.

Nursery management

Papaya seeds loose viability quickly if stored under room temperature or dried in open sun. Treating the seeds- with 100ppm GA for 8 hrs enhances germination. Seeds are sown in perforated polythene bags. Polythene bags of 150-gauge thickness and 25 x 12 cm size are ideal. These are filled with 2 parts of sand, 1 part of red earth and 1 part of FYM. In dioecious varieties, in each bag 5-6 seeds are sown at a depth of 1 cm, while in gynodioecious varieties 2-3 seeds per bag should be sown. The best time for raising the seedlings is between June to October depending on the monsoon arrival. Seeds germinate in about 10-20 days time depending on the environmental conditions. The seed rate is 500 g/ha. Seedlings that are 45 to 60 days old with the height of 30-45 cm height are preferred for planting. The older seedlings are generally not preferred as their roots get damaged during transplanting. As a prophylactic measure against root rot or wilt / drench the bags with 0.1 % copper oxy chloride @ 25ml per bag.

EX. NO. 5

PROPAGATION OF GUAVA, AMLA AND TAMARIND

Propagation of Guava

Guava is an important tropical fruit crop rich in pectins. It can be propagated both by seeds and various asexual methods. Though it can be propagated through seeds, only vegetative propagation should be followed for commercial plantings.

Seed Propagation

Seeding trees derived by germinating the seeds usually show lot of variability in growth and fruit characters. Seeds are, however, used to generate seedlings for evaluation under breeding programmes. Seeds are extracted from fresh, fully matured and ripened fruits. Seedlings can be raised in nursery or in polyethylene bags. Seed viability declines very quickly after extraction. The seed viability can be increased by treating the seeds with 1 % KNO_3 or GA_3 1000 ppm for 24 hours. To enhance germination, the seeds can be soaked in water overnight or acid scarified with concentrated H_2SO_4 for 2-3 minutes.

Vegetative Propagation

Guava can be propagated through vegetative methods like cuttings, layering, budding or grafting

Cuttings

Guava can be successfully propagated by cuttings under mist. Both softwood and semi-hardwood cuttings can be used. Semi-hardwood cuttings with 2 to 4 leaves register around 90 per cent rooting when treated with IBA at 5000 ppm and planted in sand under mist. NAA 500 ppm can also be employed to promote rooting. If softwood cuttings are used, they should be kept in mist with atleast 4 leaves on the cutting and after treating with 1000 ppm NAA

Air-layering

Air-layering is the most popular commercial method of propagation of guava in India and Tamil Nadu. Shoots selected for air-layering should be of pencil thickness and

from previous year's growth. A ring of bark about 2.5 to 3 cm long should be removed and covered with wet media (soil : leaf mould, 1:1) or with sphagnum moss and wrapped with polyethylene film. Both the ends of polyethylene film should be carefully tied and left for rooting. It takes 30-40 days for rooting by air layers during humid months.

Stooling

The mother plants of 3-5 years age are cut back and allowed to regenerate. The invigorated shoots that arise from the stump should be ringed at the bottom and IBA can be applied with linolin paste on the ringed surface. The shoots can be separated and planted in nursery beds. Etiolating the shoots for 30 days and treatment with IBA at 5000 rpm can be helpful to get higher success (90-100%) of rooting as well as survival of the shoot layers. Stooling is better practiced during spring (or) rainy seasons.

Grafting and budding

Root stocks

Chinese guava (*Psidium friedrichsthalianum*) is a resistant root stock for wilt disease of guava and nematodes (*Meloidogyne incognita*). Another species *P. pumilum* has dwarfing effect and *P. cattleianum* can be helpful as rootstocks to get higher yield. Potentially dwarf aneuploidy no. 82 root stock of guava had been identified at IARI, New Delhi.

Grafting

It is an another important method of propagation. The method, however, is more laborious than cutting and air layering. The other method of grafting which showed success is veneer grafting. Using one year old root stocks, these graftings are carried out. Young and vigorous scion shoots can be defoliated 7-10 days before grafting and then used as scion sticks.

Budding

Forkert, patch, shield and ring budding were reported to be successful in guava. Patch budding on one year old seedling root stock during May-June normally gives 80-

85% success. Buds of 2 x 1 cm size collected from leaf axils of one year old scion shoots are used for budding.

Types of cuttings

1. Herbaceous

Pick up the 6 inches of top apical portions put into the soil retaining all the leaves

2. Soft wood cuttings

Remove the apex away and take 9 inches from top pencil thickness should be maintained. Retaining all the leaves in the shoot and lower 1/3 are removed.

3. Semi hard wood

Remove 2/3 of the leaves and top two leaves should be retained.

4. Hard wood cutting

Remove all the leaves. Cuttings with pencil thickness should posses the following characters.

There should be 3-4 vegetative buds. Upper cut is away from the bud and lower cut is nearer to the bud. All the metabolites come down very slowly, so that rooting is faster in the cutting. So, make the cut near the bud at lower. Semi hard wood cutting is well practiced in Guava.

Amla (or) Aonla

Grown in rainfed, arid and semi arid conditions. Fruits are rich in vitamin C. Good medicinal value used for curing jaundice, dysentery and diarrhoea. It is also used against cough, bronchitis, asthma.

Cultivated species

1. *P. emblica*
2. *P. acidus* (Star goose berry)
3. *P. longiflorus*

Seeds are little, seeds have to be treated before sowing with 2000 ppm of GA₃ (24 hrs) and 0.5% KNO₃ (8 hrs). Soak it and seed germination is good. Take H₂SO₄ for 2-3 minutes. Soaking improves germination, seeds cannot store for a long time, it should be sown immediately after collecting the seed from plant.

Softwood grafting and 'T' budding is practiced.

Propagation of Tamarind

Tamarind is a perennial tree and its fruits are used as a spice in India and elsewhere. There are sweet types of tamarind available and the fruits of these sweet tamarinds are packed and marketed. Tamarinds are usually propagated by seeds in the social forestry schemes. Vegetative propagation is a must to obtain true to type, high yielding, early bearing tamarinds.

Seed propagation: This is done mainly to generate rootstocks for vegetative propagation. One Kilo of seeds will contain around 2500 seeds. Clean seeds can be stored for about an year. The seeds can be soaked overnight or given slight mechanical scarification treatment to enhance their germination. Seeds are sown in well prepared seed beds or in nursery bags. Seedlings can be transferred to bigger bags, if necessary, during their early stages of growth.

Vegetative propagation: Tamarind can be propagated through cuttings, layers, budding or grafting. The success with rooting of cuttings is poor. Because of the shallow root system usually noted with layers and cuttings, tamarind should be better propagated through budding or grafting. It can be propagated by approach grafting, side-veneer grafting or patch budding. In Tamil Nadu, approach grafting is the popular method of propagation. The mother plants can be raised closely and 2-3 year old plant can be cut back to encourage development of more branches. These branches can be then trained down ward to facilitate approach grafting. It takes nearly 3-4 weeks, before union commences and the grafts are separated 8-10 weeks after grafting.

EX. NO. 6

DESCRIPTION AND STUDY OF MANGO AND GRAPE VARIETIES

There are hundreds of varieties of mango in our country and out of which only a limited number of them are cultivated. The choice of the cultivars varies with regions and market opportunities. The local consumer reference has a great influence in the expansion of area under a particular variety. Though there are numerous varieties, the important mango varieties are described here.

Alphonso: (Gundu, Khader, Badami, Hafus)- a choice variety; suitable for export market; attractive pink coloured; very tasty; medium sized fruits; excellently flavoured; highly suitable for processing. .

Bangalora: (Kallamai, Kilimookku, Totapuri)- a mid-season variety; regular and heavy yielder; large oblong fruits with a prominent sinus and beak; very good keeping quality; pulp is good for processing.

Banganapalli: (Baneshan, Sappattai, Safeda)- another popular South Indian early season variety; regular bearer; moderate yielder; large attractive pale golden yellow fruits; smooth, skinned; obliquely oval fruits; fibreless flesh; good flavoured. .

Dashehari: a mid-season variety; popular in North-India; attractive fruits; good taste; well flavoured elliptical-oblong medium sized fruits; high yielder but a biennial bearer.

Himayuddin : (Imam pasand)- a choice large fruited variety, oblique shouldered; firm fleshed and fibreless;" lemon yellow coloured; excellently flavoured and tasty; a shy and alternate bearer; good in keeping quality.

Kalepad: (Karu Neelum): -fruits resemble Neelum ; dark green skin when unripe turning to light green after complete ripening; yellow fleshed, sweet and juicy.

Mulgoa: a late season variety; large oblique round fruits with sunken basal cavity; excellent in taste; good in flavour; a shy and biennial bearer.

Neelum: (Kasa Laddu, Kajaladdu) -a late season variety; heavy yielder; highly regular bearer; very popular in South India; medium sized orange-yellow fruits; ovate to round shape; prominent sinus; distinctly beaked

Peter: (Syn: Nadusalai, peter-pasand, Raspuri, Paire,Grape, Yerra Goa)

- popular in Western India.; medium ovate fruits; prominently red blushed; shoulder equal and levelled; broadly mammiform beak; slightly to obliquely flattened base; round apex, leathery skin with a pleasant aroma; fibreless golden yellow to orange yellow flesh; heavy yielder but an alternate bearer.

Rumani: medium round fruits; yellow skinned with a red blush on shoulder thin skinned with a characteristic camphor odour; good in keeping quality; a heavy yielder; moderate in fruit quality .

Swarnarekha: (Chinna Swarnarekha, Sindhuri, Sendhuram, Sundari)

-an ideal table purpose early season variety; biennial bearer; sweet taste; possess attractive pinkish red blush; medium sized ovate-oblong fruits; moderate yielder. .

Selections and Hybrids

Ratna: a cross of Neelum x Ratnagiri Alphonso; tasty fruits with good flavour.

Sindhu: a back-cross progeny of Ratna having paper thin seeds

TNAU Varieties

PKM-1: a mid-season variety; a hybrid between Chinna Swarnarekha x Neelum; regular and cluster bearer; medium fruits are long, narrow with prominent beak; suitable for long distance transport

PKM-2: a mid season hybrid between Neelum and Mulgoa ; large fruits with vertical stalk insertion; long ovate, slightly oblique flattened base, very sweet taste, good quality, firm fleshed, light orange with scanty fibre pleasantly flavoured, abundantly juicy; good keeping quality.

Paiyur 1: a selection from Neelum; dwarf; suitable for high density planting; medium sized fruits

IARI Varieties

Mallika: a cross of Neelum x Dashehari; medium sized fruits, good keeping quality; a mid-season variety and a regular bearer.

Amrapali: a cross between Dashehari x Neelum; dwarf, regular bearer; a late bearing variety.

Manjira: a cross between Rumani and Neelum; semi-vigorous; regular bearer; medium sized fruits with light yellow skin; firm, sweet and fibreless flesh.

IIHR Varieties

Arka Aruna (IIHR-10) : a progeny of the cross Banganapalli x Alphonso; regular bearer; dwarf statured; suitable for high density planting (1400 plants/ha); large sized fruits; attractive reddish tinged skin; creamy fibreless pulp; sweet with 20-22°brix TSS; 'fruits are free from spongy tissue.

Arka Puneet (IIHR-13): a regular and prolific bearing hybrid of Alphonso x Banganapalli; medium sized fruits; attractive reddish tinged skin; fibreless pulp; TSS20-22°brix; good in keeping quality and free from spongy tissue.

Arka Anmol : a semi-vigorous variety developed by crossing Alphonso and Janardhan Pasand; a regular bearer free from spongy tissue; uniform yellow fruits with good keeping quality; suitable for export.

Arka Neelkiran: obtained by crossing Alphonso x Neelum; suitable for high density planting; regular bearer; medium fruits with red blush; deep yellow pulp free of fibre and spongy tissue; good in keeping quality.

STUDY OF GRAPE VARIETIES

Grapes are cultivated under varying climatic conditions in India. In Punjab, Uttar Pradesh and Himachal Pradesh, it grows and fruits once a year in summer, and rests during winter. In southern India, where it is cultivation mainly in Maharashtra, Hyderabad-Deccan, parts of Karnataka and Tamil Nadu, the vine grows throughout the year and bears two crops, the first in April and the second in August-September.

VARIETIES Varieties suitable for different regions of the country are:

1. Northern plains: 'Black Prince', 'Bedana', 'Foster's seedling', 'Kandhari Dakh' and 'Muscat of Alexandria', 'Perlette'.
2. Dry and temperate regions: 'Thomson Seedless', 'Sultana' and 'Kishmish White'.
3. Southern plains: 'Bangalore Blue', 'Pachadraksha' and 'Anab-e-Shahi', 'Gulabi', 'Black Champa', 'Thompson Seedless'.

4. Western plains: 'Cheema Sahebi', 'Anab-e-Shahi', 'Thompson Seedless'.

Classification: The edible commercial grape varieties have been classified on the basis of fruit quality and usage into five groups viz., Canning, juice, raisin, dessert and wine varieties.

Canning varieties should preferably be without seeds, smooth skinned and tasty. Some examples are Perlette, Thompson seedless, Black Champa etc.

Juice varieties should have thin skin, high juice content and high pulp to peel ratio. The fruits should not have seeds and should have good flavour. Varieties like Champion, Anab-e Shahi, Bangalore Blue, Concord, produce juicy fruits.

Table Grapes (Dessert Grapes) should have attractive appearance, good eating quality with pleasant aroma, taste and preferably seedlessness. The principal table varieties grown are Perlette, Thompson Seedless, Pusa Seedless, Anab- e- Shahi, Delight, Beauty seedless, Bangalore Blue and Cheema Shahibi.

Raisin Grapes are those that can be dried to produce dehydrated grapes. Generally the varieties should have high TSS (around 22%). Three varieties viz., Thompson seedless, Muscat of Alexandria and Black Corinth are processed in large scale internationally to produce raisins.

Wine Grapes will generally have high sugar and moderate to low acidity. These varieties should produce satisfactory flavour in the wine. Early Muscat, Arka Soma, Rubi Red and Beauty seedless are suitable for wine making.

Varietal Descriptions: Descriptions of some of the important grape varieties are given below.

Seeded varieties

Anab-e-shahi : one of the most important among Indian grape varieties; yields around 75-90 tonnes/ha per year; produces attractive large bunches with pale green oval berries; keeping quality is excellent; TSS - 12-16°brix; acidity -0.4 to 0.5 %; a late maturing variety.

Bangalore Blue: (Bangalore Purple): an important variety around Bangalore; used in brewery industry and for making juice; medium vigorous vines; medium yielder; compact bunches; small to medium berries; spherical shaped; thick skinned, dark

blackish purple in colour with uniform ripening. TSS -16-18°brix; acidity 0.8 to 0.9%; has good keeping quality; highly resistant to anthracnose and powdery mildew; suited for kniffin and bower systems of training.

Cheema Sahebi : A seedling selection from open pollinated progenies of Pandhari Sahebi from Agricultural College, Pune by Dr. G.S. Cheema.; vigorous with heavy yielder; medium sized, oval berries with pale colour; has weak pedicel attachment

Paccha Draksha : (Bhokri): Grown in Maharashtra and Tamil Nadu; vigorous vines, heavy yielder, medium to large bunches, compact, berries green, medium size, round to slight oval in shape, seeded, soft pulped, TSS 17-18° brix, high acidity, poor keeping quality.

Black Champa: vigorous vines, moderate yielder, high quality purple coloured berries; highly suitable for table, juice and wine making; bunches are small, compact with small to medium sized berries.

Champion: highly flavoured juicy variety with a TSS 21° brix and suitable for juice industry. It has small bunches with medium sized berries.

Early Muscat: medium vigorous variety; perform well on kniffin system of training; good muscat flavoured, loose bunches with yellowish green berries which turn golden yellow when over ripe.

Gulabi : (Panneer Drakshai, Karachi or Black Prince Muscat) most important cultivar for Coimbatore conditions; very weak vines, have high tolerance to powdery mildew and anthracnose; medium bunches (175 g), bold berries and good eating quality with characteristic muscat flavour; uneven ripening is a problem.

Arka Kanchan: A cross between 'Anab-e-shahi' and 'Queen of Vineyards', evolved at IIHR, Bangalore; very vigorous vines; well filled medium to large bunches of around 700 g; large sized, golden yellow and ellipsoidal to ovoid berries; pleasant muscat flavoured with a TSS of 19-22°brix.

Dilkush : a bud sport of Anab-e-shahi producing golden yellow elongated berries in attractive bunches.

Arka Shyam: a cross of Bangalore Blue x Black Champa, evolved at IIHR. Moderately vigorous, well filled to compact medium bunches (350 g), medium large berries, black

coloured spherical with mild foxy flavour, TSS 22-25°brix and yield potential is very good.

Arka Hans: a cross between Anab-e-shahi and Bangalore Blue; evolved at IIHR. Vigorous vines produce well filled medium bunches weighing 330 g; Medium large size berries; yellowish green in colour with pleasant foxy flavour; TSS ranges from 18 to 21° brix.

SEEDLESS VARIETIES

Thompson Seedless: ('Sultanina' or 'Oval Kishmish'); an introduction from the University of California, USA; commercially cultivated in Tamil Nadu and Maharashtra; large bunches; ellipsoidal, golden coloured berries; TSS is 22-23° brix; suitable for bower and trellis systems of training. The berries are also used for raisin making.

Pusa Seedless: a selection from Thompson seedless developed at IARI, New Delhi; vigorous vines with moderate yields; similar to Thompson seedless in many characters; for table purpose and raisin making.

Perlette: a hybrid between Scolokertekhiralynoje 26 x Sultanina Marble; medium bunches; has scattered shot berries; medium sized spherical and whitish green. Berries with good keeping quality.

Delight: a sister seedling of 'Perlette'; early ripening variety with good muscat flavour; yields conical compact and medium size bunches with attractive small round green berries; a good table variety with good shipping quality.

Beauty Seedless: medium vigorous in growth; long compact bunches; large sized with spherical bluish black coloured berries; susceptible to pre-harvest berry drop; suitable for head system of training.

Arka Vathi: a hybrid between 'Black champa' and 'Thompson seedless' , evolved at IIHR, Bangalore; vigorous vines; medium sized, well filled and long conical shaped bunches; medium sized berries; spherical yellowish green with thin skin; 22-25°brix TSS and having good yield potential.

Sarath Seedless: a selection from Beauty Seedless

Kish Mish :

Kishmish Beli : small sized, elongated and golden yellow berries.

Kishmish Charni: .brick red, spherical to slightly elongated, medium sized berries.

Sonaka Seedless: a bud sport of Thompson seedless.

Tas-a-Ganesh : another bud sport of Thompson seedless.

Some of the new introductions from IIHR, Bangalore are as follows

Arka Neelamani - for table purpose; a cross between Black Champa and Thompson Seedless; black seedless high quality berries; vines are vigorous; highly productive with an yield potential of 28 t/ha; average bunch weight is 360 g; berries are black, seedless, weigh about 3.2 g and crisp with a T.S.S. of 20 to 22° Brix; very good for table purpose; tolerant to anthracnose.

Arka Shweta - for export market; a cross between Anab-e-Shahi and Thompson Seedless; moderately vigorous; very high yield potential (35 tons/ha); medium sized bunches (260 g); greenish yellow coloured, ovoid seedless berries.

Arka Chitra - for table purpose; a cross between Angur Kalan and Anab-e-Shahi; moderately vigorous vines; 38 tons/ha; well filled bunches very attractive, gold yellow berries with pink blush; TSS varies from 20 to 21° brix ; good for table purpose.

Arka Krishna - for juice making; a cross between Black Champa and Thompson Seedless; vigorous vines; yield potential of 33 tons/ha; well filled to compact bunches round to ovoid, dark coloured berries with a TSS of 20-22° brix. Possible to take two crops in a year and very good hybrid for juice making.

Arka Soma - for wine making; a cross between Anab-e-Shahi and Queen of the Vineyards; vigorous vines and have high yield potential (40 tons/ha); bunches weigh around 400 g ; greenish yellow coloured, round to ovoid berries that makes very high quality white dessert wine.

EX.NO. 7

DESCRIPTION AND STUDY OF BANANA VARIETIES

Bananas belong to the family 'Musaceae'. Edible bananas of present day were derived from the natural hybridisation of two ancestral species *Musa acuminata* and *Musa balbisiana* and further human selection over centuries. These two species are diploids and they are genetically represented as AA and BB respectively. Depending on the ploidy levels, the genomic constitution may be AA, AB, AAA, AAB, ABB ,AAAA or ABBB.

To an ordinary consumer, banana represents a simple name for the yellow fruits so abundantly marketed for raw consumption, and 'plantain', the more angular fruits intended for cooking but also edible raw when fully ripe. However, the distinction is not that clear and the terms may be reversed. Ordinarily, the present day cultivars set fruits by 'parthenocarpy' though occasionally, some cultivars can produce seeds by natural or hand pollination. While as many as 600 or more cultivars are known (many carry synonyms), only about 15 cultivars are widely cultivated in India.

Description of important banana cultivars

Matti : (AA) A popular variety grown in southern districts of Tamil Nadu mainly around Nagercoil district. Fruits are very small but are very good in taste.

Dwarf Cavendish: (AAA): It is also called as 'Basrai Dwarf', 'Kullan', 'Vamanakeli', 'Pachavazhai' 'Mauritius', 'Moris', etc

This variety is popular in Maharashtra. The pseudostem is dwarf and the fingers are long, curved, thick peeled with soft and sweet flesh. The bunch weighs about 16 kg with seven hands each having about 13 fruits. The duration of this variety is 10-12 months.

Robusta (AAA): It is also called as 'Bombay green', 'Harichal' and 'Pedda Pacha Arati'. It is a semi-tall sport of 'Dwarf cavendish'. The fruits retain the full green colour of the rind even when ripe. Fruits are sweeter and more delicious in taste and keeping quality than 'Dwarf cavendish'. The bunch weighs around 25 kg. Most of the export market in USA and UK is catered by this variety.

There are other Cavendish clones such as Grand Naine , Williams and Giant Cavendish and are popular in other banana producing regions of the world.

Red Banana (AAA):

It is also known as 'Lalkela', 'Chenkadali', 'Sevvazhai', and'Rathambala'. The colour of the pseudostem, petiole, midrib and fruit rind is purplish red. Fruits are .of good size, slightly curved with a blunt apex. The bunch weighs around 20 - 25 kg with 80 fruits. The variety takes about 16- 18 months from planting to harvest.

Poovan (AAB): It is also known as Champa, Karpura Chakkarakeli, Palayankodan, Mysore etc.

This is an important commercial variety of Tamil Nadu, Andhra Pradesh and West Bengal. It grows tall and vigorously and suitable for ratooning system. The fruits are small to medium sized, yellow skinned, firm flesh with a sub-acid taste. Individual finger has a prominent nipple. The duration ranges from 11 to 14 months. Bunches weigh around 13-16 kg approximately with 8 - 12 hands and 11 - 18 fingers per hand

Mottapoovan (AAB): A natural mutant (sport) of Poovan and differs from it by the absence of apex or prominent nipple. The taste and flavour are similar to Poovan.

Rasthali (AAB): It is known also as 'Mutheli', 'Malbhog', 'Martaman', 'Amruthapani', 'Rasa Bale Poovan' and 'Silk.

The cultivar is moderately vigorous and can be easily identified by the yellowish green stem with brownish blotches, reddish margin of the petiole and leaf sheath and a few persistent male flowers after the female flower phase. The bunches weigh around 12 kg with 60 to 80 fruits in five to seven hands. The pulp is mealy, cream coloured, sweet and excellently flavoured. The peel is thin and 'ripe fruits have poor pedicel attachment but often with hard lumps. Duration of the cultivar is 15 to 16 months. It is highly susceptible to 'Panama wilt' disease and leaf spot.

Ayirankachi Rasthali (AAB): It is a natural mutant of Rasthali and lacks the male phase and so, the entire bunch is filled with fruits

Hill Banana (AAB): A pome type of banana is popular in Tamil Nadu and known as 'Virupakshi', 'Malavazhai', 'Vellavazhai' and 'Sirumalai'. The fruits have good flavour and keeping quality. The variety is cultivated as a perennial crop in mid-elevations of the

Palani hills under rainfed conditions. The average bunch weight is about 12 kg with about 60-80 fruits per bunch. Duration of this variety is about 14 months. If cultivated in plains, hill bananas will lose their fruit quality and becomes acidic.

Co-1 banana

It is a hybrid cultivar developed at the HC & RI, Tamil Nadu Agricultural University, Coimbatore. The fruits have similar flavour and taste as that of hill banana but can be grown in plains.

Ladan x *Musa balbisiana*
(AAB) ↓ (BB) Clone Sawai
F1(AB) x Kadali(AA)
↓
CO 1. (AAB)

The plants are medium tall (2.7 M). The bunch weighs on an average 10.5 kg having 7 hands with a total number of 80-85 fruits. Each fruit weighs about 150-160 g.

Nendran (AAB): It is also known as Ethankai, French plantain or Plantain.

A popular cultivar of Kerala and Tamil Nadu. It is highly suitable for processing especially for chips. The plants are semi tall and has a distinct shade of pink colouration on pseudostem. The fruits are relatively longer and the fruit skin is thicker than most other bananas. The bunch is loose with 4 - 6 hands and having 8 - 10 fingers/hand. Each bunch weighs about 12 to 15 kg. Fruits are with 3 prominent ridges. Ripe fruits have yellow peel with mealy yellow pulp. The duration of this variety is about 11 - 12 months.

Monthan (ABB): It is also known as 'Bontha', 'Kanch Kela', 'Khasdi', 'Bankel', 'Madhuranga Bale', 'Pisang Nanka', 'Batisa' and 'Bluggoe'.

It is a commercial banana variety and fruits are used for cooking on maturity but before it is ripe. The plant is hardy and to certain extent drought tolerant. The duration is around 12 to 14 months. The bunch weighs around 20 - 25 kg with about 60 fruits per bunch.

Sambarani Monthan (ABB): A mutant of monthan with fruits having an ashy coated rind.

Naattu Vazhi (ABB): It is also known as 'Vayal Vazhai', 'Ney Mannan', 'Ney Vannan'.

The unripe fruits are used for culinary purpose and ripe fruits for dessert purpose in certain areas of Tamil Nadu; mostly southern districts.

Ney Poovan (AB): The other popular names of the variety in other regions are 'Safed velchi', 'Kadal' and 'Deva Bale', 'Elakki Bale',

The fruits are small sized and bunches weigh about 12 kg The duration of this variety is about 12- 13 months. The pulp is juicy and sweet while the rind is thin and papery.

Karpooravalli (AAB). It is known as Karpura vazhai, Raja vazhai, Kostha Bontha

The pseudostem is light green, tall and large leaved. Bunches are heavy with 8 - 9 compact hands, each hand having 13 - 14 fingers. Fruit peel is yellow with ashy coating. Pulp is cream coloured, crisp and sweet with a pleasant taste and flavour. This variety can tolerate some extent of alkalinity.

Gold finger (FHIA-01)

It is a hybrid developed at Honduran Federation of Agricultural Research. Honduras. It is resistant to burrowing nematode, race 4 of Fusarium wilt, and Black sigatoka disease. The fruits have a good flavour. The bunches are compact with good shipping Quality.

BRS-1 : (Banana Research Station, Kannara, KAU, Kerala)

A hybrid between Agniswar and Pisang Lilin; 12.5 kg bunch, tolerant to rhizome weevil, nematodes and pseudostem borer; short statured (240 cm height); semi horizontal bunches; pome group; resistant to sigatoka leaf spot.

BRS-2 : (Banana Research Station, Kannara, KAU, Kerala)

A hybrid between Vannan and Pisang Lilin; medium statured plants with 14 Kg bunches; tolerant to leaf spot, panama wilt, rhizome weevil and nematodes, bold fruits; yellow skinned on ripening

EX. NO. 8

DESCRIPTION AND STUDY OF SAPOTA VARIETIES

Sapota (*Manilkara achras* Mill; Syn: *Achras zapota* L.) belongs to the family Sapotaceae. It is also known as Sapodilla or Chiku and is a popular tropical fruit of India. The immature fruits are astringent and the sweet ripe fruits are used for dessert purpose. There are several varieties in sapota. The sapota varieties can be classified based on the tree growth habit (as erect growing, semi-spreading, spreading or drooping habit) or fruit size (big, small, medium), shape (round, oval and oblong) and quality attributes (crispy, gritty or juicy) etc. A good table sapota should be medium sized with sweet melting pulp. Semi erect types and erect types with compact canopy are ideal for high density planting. Brief descriptions of some of the important sapota varieties are given below:

IMPORTANT VARIETIES

Baramasi

A popular variety in West Bengal, Bihar and Uttar Pradesh; fruits are medium in size and round.

Bangalore

It bears large, oval shaped fruits with ridges running upwards from base; golden coloured pulp with a tinge of muskmelon; medium sweet in taste.

Cricket Ball

Known also as Calcutta Large; large and round fruits; gritty, granular and moderately sweet pulp; performs well in both arid and humid climates; popular in Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka, and West Bengal.

Dwarapudi

Fruits resemble those of Cricket Ball; but smaller in size; popular in Andhra Pradesh; sweet pulped.

Jonnavalasa Round

Small to medium in size and round fruits; firm, cream coloured and very sweet pulp.

Kalipatti

It is a leading variety of Maharashtra, Gujarat and North Karnataka. Fruits are oval shaped, less seeded with a sweet mellow flesh of excellent quality and mild flavour. Fruits appear singly.

Kirthibharthi

Small to medium sized and oval shaped fruits; rough, medium thick and buff coloured fruit skin; sweet pulp; rounded fruit apex; 4-6 ridged, suitable for long distance transport.

Long

Popular in Maharashtra; narrow and small leaved, thin, long and very sweet fruits.

Pala

A popular variety in Andhra Pradesh and Tamil Nadu; small to medium sized fruits; oval or egg shaped, with broadly pointed apex; very sweet; heavy bearer; cluster bearing; thin skinned with good flavour.

Pot Sapota

Small-sized, oval fruits with pointed apex and no ridge on the surface, excellent taste with sweet and good flavour; Fruits are borne when the plants are still in pots and hence the name.

Thagarampudi

A familiar variety in Tamil Nadu, medium-sized fruits, round or oval shaped with flat base; fruit skin is thin and rough without any ridge; very sweet taste.

Vanjet

It is a sterile or male type, slow growing in nature. It is a shy bearing cultivar but fruits have a good quality.

Vavivalasa

Grown in the coastal districts of Andhra Pradesh; oval fruits with good sweet taste and good keeping quality.

Bangalore

It bears large, oval-shaped fruits with nine ridges upwards. Pulp is gold coloured with a tinge of muskmelon sweet in taste running from base, fruits are medium in size.

IMPROVED VARIETIES

CO 1

A hybrid developed by crossing Cricket Ball x Oval at Tamil Nadu Agri. University, Coimbatore. This variety is superior to either of the parents. The fruits are long oval (egg shaped), medium in size with a mean fruit weight of 125 g. The flesh is granular in texture and reddish brown in colour, the taste being very sweet with a TSS of 18°brix.

CO 2

A clonal selection from Baramasi developed at Tamil Nadu Agricultural University, Coimbatore. The tree is vigorous, conical, fruits are obovate to round with mean fruit weight ranging from 112-168 g. The flesh is soft, juicy having a TSS of 23° brix.

CO 3

A hybrid between Cricket Ball and Vavivalasa; trees are more upright. in growth habit with compact canopy; fruits are oblong-ovate, pleasantly flavoured, high TSS (22-24° brix), medium sized fruits weighing around 165g;trees amenable for high density planting.

PKM 1

A clonal selection from the variety Guthi developed at Horticultural College and Research Institute, Periyakulam of Tamil Nadu Agricultural University. The tree is dwarf in stature. Fruits are of two shapes viz., round and oval. The skin is very thin and the pulp has a buttery consistency, very sweet with a TSS' of 24° brix. High yielder with medium size fruits, individual fruit weight ranging from 88 to 120g.

PKM 2

It is a hybrid between Guthi and Kirthi Barthi developed at Horticultural College and Research Institute, Periyakulam of Tamil Nadu Agricultural University. A high yielder with an yield potential of 1500 to 2000 fruits per tree per year weighing 80 to 100 kg. Fruits are bigger in size and oblong to oval shaped. The average fruit weight is 95 g. TSS ranges from 25 to 27° brix.

PKM 3

It is a hybrid between Guthi and Cricket Ball. It has vertical growth habit and hence lends itself for high density planting. Trees bear big sized fruits with oval shape and have cluster bearing habit. The fruit yield is 14 tonnes per hectare.

DHS 1

A hybrid between Kalipatti and Cricket Ball. Tree is vigorous, bearing round to slightly oblong fruits with high yield. The fruits are very sweet having a soft, granular and mellowing flesh with a TSS of 26°brix. The colour of the pulp is light orange. The mean fruit weight is 150 g.

DHS.2

It is also a hybrid 'between Kalipatti and Cricket Ball. Tree is vigorous, bearing round fruits. It is a high yielder. The fruits are sweet with a TSS of 23° brix having a light orange brown pulp which is soft, granular and mellowing. The mean fruit weight is 180g.

EX. NO. 9

DESCRIPTION AND STUDY OF GUAVA VARIETIES

Guava belongs to the family Myrtaceae. It is considered as 'the apple of the tropics' and is a popular fruit of India. Though there are about 150 species belonging to the genus *Psidium*, the *P. guajava* alone is cultivated commercially in a large scale. Other species such as *P. cattleianum* (strawberry guava), *P. guineense* (Brazilian guava), *P. friedrichsthalianum* (Chinese guava) and *P. montanum* (mountain guava) are of minor importance. More than 100 cultivars are known in guava. Many of the guava varieties are commonly named after the place in which they are popular. Scientifically, they can be classified based on the tree growth habit or fruit size, shape, colour of the flesh, pest or disease resistance etc. Brief descriptions of some of the important guava varieties are given below.

Allahabad Safeda

Most important cultivar of Uttar Pradesh; vigorous trees; medium round fruits with yellowish white smooth skin; 6-7 cm diameter; white fleshed; few seeds and good keeping quality

Apple colour

Grown for coloured fruits; medium trees with spreading habit; small- medium sized fruits with dawn-pink colour; few seeds; good keeping quality.

Anakapalli

Slightly oval fruits with a length of 5.9 - 6 cm and average fruit weight of 95 g; seeds are soft and fleshy; 393 mg of vitamin C per 100 g of flesh.

Bangalore

Bigger fruit size 6.7 x 6.8 cm; spherical in shape with an average fruit weight of 215 g; Flesh is white with good taste and flavour; 210 mg of vitamin C/100g.

Banarasi Surkha

A sweet guava with out acidity; round shaped; yellow skin; medium keeping quality

Nasik

Fruits are pyriform but neck very long and beak very short; rough surfaced; good storage life

Nagpur Seedless

Round fruits; thin yellow coloured skin having warty surface; average weight 100 g; medium sized (4.0 x 4.6 cm); white pulp with pleasant aroma; good taste; almost seedless 340 mg of it C/100 g of flesh.

Red flesh

Fruits are round with 4.5 to 5.0 cm diameter. Each fruit weighs on an average of 50 g. The pulp is red with moderate flavour and taste. Fruits are heavily seeded. The flesh contains 385 mg of vitamin C/100g.

Saharanpur Seedless

The average fruit weight is 65 g with the size of 4.5 x 4.9 cm. The skin is yellow with white pulp, seeds are very much limited. The vitamin C content is 250 mg/100g of flesh.

Arka Mridula (Selection-8)

It is a selection from open pollinated seedlings of the variety Allahabad Safeda developed at IIHR. Hessarghatta, Bangalore. Fruits are round, smooth with few soft seeds. Flesh is white. The TSS is 12°brix. Flesh is firm and keeping quality is good. It is a heavy yielder.

Safed Jam

This is a hybrid variety released from Fruit Research Station, Sanga Reddy (AP). It is a hybrid between Kohir and Allahabad Safeda; fruits are bigger than parents and less seeded.

Smooth Green

Medium round fruits; 5.0 -5.2 cm diameter glossy skin, greenish yellow and slightly rough. The average fruit weight is 79 g. The flesh is white in colour with good taste and flavour.

Behat Coconut

Profuse bearer; heavy branching tree; round-ovate fruits with white flesh and medium keeping quality

Chittidar

A white fleshed variety; spherical fruits; average weight - 95 g; medium sized fruits (4.4 x 4.7 cm) good taste and flavour. At calyx end, longitudinal furrows are seen. Skin is thin; 108 mg of vitamin C/100 g.

Hafsi

Fruits are round, thin skinned; 6.5 cm in diameter; average weight is 142 g, pulp red coloured with good taste and flavour. Among the red fleshed varieties, less seeded. It has 108 mg of vitamin - C/100g.

Hisar Safeda

A cross between Allahabad Safeda x Seedless; has upright growth habit with a compact crown; round fruits, 13.4 % TSS; 185 mg ascorbic acid / 100g; yield 114 Kg / tree.

Hisar Surkha

A cross between Apple Colour and Banarsi Surkha, pink fleshed, medium trees with broad to compact crown, round fruits, 86 grams, 13.6 % TSS, 169 mg ascorbic acid / 100g; yield-94 kg/tree/year.

Kohir Safeda

It is a hybrid between Kohir and Allahabad Safeda; yield and quality is better than the parents.

Lucknow-46

Fruits have got a short neck at the pedicel end and broad tip resembling the pear fruits (Pyriform). Each fruit weighs 80 g, size 7.4 cm long and 4.9 cm diameter. Flesh is white, meaty with good taste. Vitamin C is 130 mg/100 g of flesh.

Lucknow-49 (Sardar guava)

Fruits are round, fairly bigger each weighing 150-170 g with a rough surface. The flesh is white with good taste. It has a good adaptability to various localities and is a popular cultivar.

EX. NO. 10

SEX FORMS AND VARIETIES OF PAPAYA

There are around 30 varieties of cultivated papaya in the different parts of the world. These varieties can be grouped as dioecious or gynodioecious based on their flowering nature.

Sex forms in papaya

There are three basic sex forms in papaya viz., i) female flowers(pistillate) ii) male flowers (staminate) iii) bisexual (hermaphrodite). Accordingly, the varieties are classified based on their sex expression as dioecious and gynodioecious

1. Dioecious

These varieties when grown segregate into male and female trees in the ratio of 1:1. There are no practical methods to identify the sex of the trees either in seeds or seedlings. Only at flowering (approximately 3rd month after planting) male and female trees can be identified. The female trees produce single large flowers in the axils of the leaf while the male trees produce clusters of small flowers in a branched and pendulous inflorescence. Dioecious varieties are less influenced by environmental conditions. Occasionally during summer months certain male trees produce bisexual flowers which set fruits having viable seeds. This is called sexual ambivalence and such seeds produce female and male trees in the ratio of 1:2.

2. Gynodioecious

These varieties produce two types of trees viz., female and andromonoecious trees in the ratio of 1:2. Andromonoecious trees bear bisexual as well as male flowers in one and the same inflorescence. The bisexual flowers are smaller in size than female flowers. The shape of the fruits borne on female and andromonoecious trees differ in their shape. Usually female trees of gynodioecious type produce round fruits while those on andromonoecious trees are either pyriform or oblong in shape. Like male trees, the andromonoecious trees are also influenced by changes in temperature. The fruits of

andromonoecious trees sometimes are misshapen due to stamens of the flower adhering to the ovary of the fruit and such misshapen fruits are called “cat-faced” fruits or stamen carpellody. When temperature goes above 38°C with low humidity, the flowers and fruits drop off. This phenomenon is called “summer-skip”. Gynodioecious varieties, there fore, are not recommended for commercial cultivation for regions having extremes of temperature.

The varieties can be also grouped as dessert types, varieties for papain extraction and dual purpose varieties based on the usage. The crop improvement programme vigorously pursued at TNAU has resulted in the development of seven improved papaya varieties. This includes two gynodioecious types viz., CO 3 and Co 7 which are ideal table purpose varieties. Similarly, for papain extraction, Co.2 and Co.5 varieties are found to be highly suitable. Apart from the 'CO' series of varieties released from TNAU, other varieties are also cultivated in India. A brief description of the important varieties of papaya are given here.

TNAU Varieties

Co.1: It is developed by ‘sibmating’ Ranchi type over a period of eight years. The plants are dwarf in stature and dioecious. Fruits are round with flattened base. They are medium sized and smooth skinned. Slight nipple and ridges are present at the apex. Fruits have orange yellow flesh. There is no papain odour in the fruit. It is a good table variety with good keeping quality.

Co.2: It is a pureline selection from a local type. A dioecious, dual purpose type with a good papain yield (4-6 g from each fruit). Each fruit weighs about 1.5 to 2.0 kg. The fruit contains 75 per cent pulp with a pulp thickness of 3.8cm. Fruits are oblate and large in size, flesh yellow coloured, soft with TSS ranging from 11.4 to 13.45° brix. The yield ranges from 80-90 fruits per tree. The fruits contain 8.93% reducing sugars. The vitamin C content is 50.8 mg per 100g. The dry papain yield is 250 to 300 kg per hectare.

Co.3: It is a hybrid derivative of the cross between CO.2 (female parent) and Sun Rise Solo (male parent). It is a gynodioecious type suitable as a table variety. The fruits are medium sized with hermaphrodite flowers. The flesh is red with a TSS of 14.6° brix. The

mean fruit weight is 0.5 to 0.8 kg. Fruits are pyriform in shape. The tree yields 90-120 fruits / year.

Co.4: It is a hybrid derivative of the cross between CO.1 (female parent) and Washington (male parent). Fruits are medium sized weighing 1.2 to 1.5 kg. It is a dioecious type. The fruits contain a TSS of 143.2 ° brix. The flesh is yellow with purple tinge. The tree has purple petiole and stem. Suitable for home gardens. The tree yields 80-90 fruits per year.

Co.5 : It is a selection from Washington type. It is a dioecious type suitable exclusively for papain production giving 14.45 g of dry papain per fruit. Suitable for growing in all seasons and all soils with good drainage in Tamil Nadu. Petiole colour is pink. Duration is two years and yields 75-80 fruits per tree with an yield of 1500-1600 kg of dry papain per hectare. Each fruit weights 1.5 to 2.0 kg. The TSS content of fruit is 13° brix and papain contains 72.2% protein.

Co.6 : It is a selection from a giant papaya. The plants are dwarf, and first harvest can be had in eight months of planting. It is suitable for papain (7.5 to 8.0 g of dry papain/fruit) and also for table purpose. It yields 80-100 fruits per tree. The plants are dioecious. The fruits are medium sized each weighing 2 kg with yellow flesh. The TSS content is 13.6° brix.

Co.7 (1997): This variety (culture CP-81) is gynodioecious and developed through multiple crosses involving are Pusa Delicious, CO.3, CP.75 and Coorg Honey Dew.

Pusa Delicious x Co.3

↓

CP.75 x Coorg Honey Dew

↓

CO.7

It is superior to CO.3 papaya. The first bearing height is 52.2 cm with low incidence of stamen carpellody. It produces 112.7 fruits/tree with an yield of 340.9 t/ha which is 45.96 % more than CO.3. The fruits are oblong, attractive, firm, red fleshed with TSS of 16.7 % a total sugar content of 15.80 % and carotenoids content of 7.95 mg per 100g. The crop has an economic duration of 21 months.

Other Varieties

Coorg Honey Dew: It is a chance seedling of Honey Dew developed at Central Horticultural Experiment Station, Chethalli of IIHR. It is a gynodioecious variety . The fruits are oblong and the flesh is thick with good flavour.

Pusa Delicious: This is a gynodioecious type developed at IARI, New Delhi. Trees are dwarf, fruits are medium in size with deep orange flesh colour having good flavour.

Pusa Majesty: A gynodioecious type developed at IARI, New Delhi. The fruits are medium in size, round in shape and with good keeping quality.

Pusa Giant: This is a dioecious cultivar developed at IARI, New Delhi. Fruits are big sized each weighing 2.5 to 3.5 kg.

Pusa Dwarf: It is another dioecious cultivar developed at IARI, New Delhi; dwarf plants; Fruits are oval in shape medium in size, the weight ranging from 1 to 2 kg.

Pusa Nanha: A dwarf mutant producing fruits of medium size at a very low bearing height. Suitable for .high Density Planting and pot culture.

Punjab Sweet: It is a dioecious type developed at Punjab Agricultural University. Fruits are round to oval with yellow flesh. The weight of the fruit ranges from 1 to 1.5 kg.

Sun Rise Solo: Improved variety from Solo, red fleshed; very good keeping quality; 25-30 kg /tree

Surya: Released from IIHR, Bangalore. It is a progeny from Sun Rise Solo x Pink Flesh Sweet; Gynodioecious, medium sized fruits weighing 600-800 g, red fleshed, firm fruits with 14° Brix.

Washington: It is a dioecious cultivar with pink petiole. Fruits are medium to large, each fruit weighing about 1 kg. The fruits are sweet with good keeping quality .

Waimanalo : It is a gynodioecious variety. The fruits are round with orange yellow flesh. The flavour is good and the flesh is thick and firm.

EX.NO. 11

PAPAIN EXTRACTION AND ITS USES

The latex collected from unripe fruits containing a proteolytic enzyme is called papain. Many of the medicinal properties found in different parts of papaya plants are due to papain. The dried latex is called crude papain which is creamy yellow in colour with a characteristic odour and taste. The quality of crude papain varies according to potency of the enzyme. The crude papain on industrial purification results in two forms of crystalline enzymes called papain and chymopapain.

Papain is a typical protein digestive enzyme with a pH of 9.0 and a molecular weight of 27,000. It contains 15.5% nitrogen and 1.2% sulphur. The enzyme potency is quickly destroyed at pH below 2.5 and above 12.0. The protein digestive activity of chymopapain is nearly half of that papain. But it is stable in acid solution. The amount of chymopapain in crude latex is greater than papain.

Uses of papain

Food and beverages (90% of the production)

- ◆ Chill proofing of beer
- ◆ Meat tenderization
- ◆ Fish and other food industries
- ◆ Cheese making
- ◆ Dietary and baby foods
- ◆ Baking and confectionary
- ◆ Animal feed

Pharmaceuticals (2% of the production)

- ◆ Vaccine preparation
- ◆ Ointments, toothpaste and cosmetics
- ◆ Medicines for diphtheria, anaemia and gastric ailments
- ◆ Medicine for cancer detection

Miscellaneous uses

- ◆ Leather bathing
- ◆ Textiles (wool softening and silk degumming)
- ◆ Paper industry
- ◆ Photography
- ◆ Adhesives
- ◆ Water based paints
- ◆ Plastics
- ◆ Rubber moulding
- ◆ Dry cleaning and laundering

Latex extraction

Latex should be tapped from 70 to 80 days old fruits (65 to 75 per cent maturity) in the morning hours before 10 a.m. Four longitudinal incisions were spread over the fruit should be made at a depth not exceeding 2 to 3 mm. The latex coming our has to be collected either in aluminium, plastic and rexin trays. No other metallic containers should be used as the enzyme reacts with other metals. The same fruit can be lanced four times each at 4 days interval. The latex that solidifies on the cut surface should also be scrapped and added to the collecting trays. The latex so collected in the trays should be transferred to a wide mouthed plastic containers. Add 0.05% w/w sorbitol to prevent excessive coagulation. The latex collected every day may be dried in the sun or in the artificial driers at temperature of 50-55°c. Addition of 0.05% w/w of potassium metabisulphite to the liquid latex before drying helps to extend storage life of papain. Drying is continued until the product comes off in flakes having porous structure. Avoid rapid drying at higher temperature as the final product could become dark coloured with poor enzyme activity. Drying in vacuum driers improves the quality of the product. The dried flakes are powdered using wooden mallets and sieved through 70 mesh. The creamy white crude papain is friable and has to be stored in cool dark place to enhance shelf life of papain.

Grades

Currently papain is classified in to three groups i) crude papain ranging from first grade white brown to second grade brown. ii) crude papain in flake or powder form,

sometime referred to as semi-refined and iii) spray dried crude papain of higher activity in powder form referred to as refined papain. Papain in flake form supply from Zaire and in powder form Tanzania, South Africa, Taiwan and Equador. The flake variety is prepared is prepared by oven drying thin layers on plastic sheets while the granular are powder form is prepared by spray-drying techniques.

Varieties suitable for latex extraction

Co.2

It is a dioecious variety obtained form Coimbatore local type and most popular among the growers. Fruits are medium to large in size, oblong in shape. Fruits are subtended in long pendulous pedicel. It is suitable both for latex and table purpose. It yields 80-100 fruits/tree each weighing 1.5 to 2.0 kg. Each fruit gives 25-30 g of wet latex which when dried gives 5-6g of crude papain.

Co.5

It is a selection from Washington, suitable for its high latex production. It produces 50-60g of wet latex/fruit (10-12g of crude papain). But the enzyme activity lower than that of Co. This variety gives 75-80 fruits per tree. It is dioecious.

Co.6

It is selection from Giant and dioecious in nature. The fruits are larger in size weighing 1.5 to 2.0 kg. Fruits are round to oval shape .The latex yield ranges from 15 to 20g per fruit (3-4g of crude papain). Tree yields 80-100 fruits. It is suitable for both for table and latex extraction.

EX. NO. 12

TRAINING AND PRUNING OF GRAPE VINES

Training of grape vines is important as it helps to maintain the stature and spread of the vine in a way that is convenient to carry on the operations like pruning, interculture, plant protection and harvesting. The system of training depends mainly on the nature of the vine with reference to its apical dominance and vigour. Although a number of training systems are known, in India, only four systems viz., Bower, Kniffin, Telephone trellis and Head system alone are followed to a great extent.

Bower system

Owing to the vigorous growth of the vine and pronounced apical dominance in the tropics, this system is found most suitable for many of the commercial grape cultivars. It envisages the distribution of growing apex at many points and spread of the branches horizontally. Among all the training systems, this is the most expensive one. Bower of 2.1 m (7) height is erected using granite stone pillars, galvanized iron wires of 5, 8 and 10 gauge thickness and turning buckles.

Only the best growing shoot from the plant is allowed to grow upright along the stake provided upto the bower height. The axillary shoots are discouraged. Growing tip is pinched off at 15 cm below the pandal level. Two shoots arising from below the cut end are allowed to grow in opposite directions on the wires over-head. These two shoots develop into 'Arms'. Side shoots from these arms are allowed to grow at regular intervals of 45 to 50 cm in dry regions, whereas, in comparatively cooler and more humid regions like Bangalore, they are allowed at intervals of 60 to 75 cm. These side shoots are called 'secondaries' as they grow. Tertiaries or the canes which are the fruiting spurs develop from the secondaries. The arms and secondaries form the permanent frame work of the vine: The area allocated for a vine is covered in installments by intermittent pinching of the primary arms and secondaries, not allowing them to grow more than 60 cm at a time. They are allowed to trail straight along the wires by tying intermittently with banana fibre, All the tendrils are removed.

In this system though the initial investment is very high, the cost-benefit ratio in a long run is favorable to the grower. Moreover this system is highly suitable for varieties like Anab-e-Shahi, particularly in the peninsular India.

Kniffin system:

This system is suitable for the moderately vigorous varieties with less apical dominance. Closer planting (1.8 or 6') is adopted for this training system within the row and 3 m (10') between the rows. Galvanised iron wire of 8 gauge thickness is stretched parallel to the ground at an height of 75 cm above which two more wires are stretched at successive heights of 60 cm (2'). When the plant crosses the first wire, it is topped leaving a bud above the wire. Two laterals are developed on either side of the plant along the wire and the terminal shoot is allowed to grow vertically. Similarly, a pair of laterals is developed along the second and third wire. In some cases only two pairs of laterals are developed at heights of 1.35 m (4 %') and 1.95 m (6 %) from ground level and in such cases it is called 'Four arm Kniffin'.

Telephone trellis system

This system is suitable for moderately vigorous varieties with more apical dominance. If such varieties are trained to Kniffin system, the yields of the canes on the lower wires will be less by 30 to 40 per cent as compared to those on the upper wire. This is an improvement over bower system with respect to ventilation and light penetration. It is relatively less expensive than bower, but more expensive than Kniffin system.

Trellis is erected by using the granite stone pillars of 8' length and 6" x 6" thick at the ends and 8'x4'x4' in the middle of the lines. The middle pillars may be spaced at 20 feet distance. Cross arms of 4 % feet length are fixed on each pillar at a height of 5 feet. These can be iron blades of 4' width and 1/4" thick or the angle iron pieces of 2" x 2" width and 1/4" thick. Three wires of 8 gauge galvanised iron are pulled horizontally over the cross arms at a regular spacing of 2 feet using turning buckles at the end pillars. The end pillars.

Head system:

This is the least expensive system of training. Plants are spaced very closely to accommodate 2,000 to 2,500 plants per acre. Less vigorous varieties are suitable for this system. Plant is topped at 1 m (3') above ground level, by which two lateral branches are encouraged and the plant is topped again at 1.3 m (4') height by which two more laterals are developed. The laterals are allowed to grow to a length of 45 cm (1.5') only. Fruiting canes are developed on these laterals. Live stakes of *Erythrina indica* or *Commiphora beryri* are provided to the vines.

PRUNING OF GRAPES

Pruning is the very crucial operation in viticulture. So, much care and precision are to be exercised in pruning a vine. A wise pruning envisages less depressing effect on the vine but more concentration of the activity in the parts' left after pruning. Light pruning i.e. retention of more cane on a vine results in heavy crop, while, severe pruning i.e. retention of less canes results in a light crop. A vine in a given season can properly nourish only a certain quantity of fruit. Hence, while pruning vigorous vines, more canes are retained, but in less vigorous vines less number of canes are retained. If a vine has given a heavy crop during the previous season, it has to be pruned severely during the present fruiting season.

Pruning is done to direct the activity of the vine in the parts left after pruning and to induce sprouting of the fruitful buds located in the middle portion of the canes, which otherwise do not sprout. Pruning is done once only in North India during the month of January to make the fruitful buds sprout. In South India, it is done twice in the year, once in summer and again in winter. Grape vines in this region grow continuously without any dormancy. Hence by pruning in April (summer) the vines are forced to have a rest period, which helps in the fruit bud differentiation. Pruning time mainly depends on rainfall and temperature.

It is adjusted so that there is no coincidence of rainfall with fresh growth and flowering and also the winter does not set in within 8-10 days after pruning.

Summer pruning : It is done during March - April in the states of Andhra Pradesh and Karnataka, but in June in Tamil Nadu. In this pruning, the canes are cut back to one or

two-bud level for building up the fresh vegetative growth. Hence, it is called "back pruning" or "growth pruning". The dried canes also are removed.

Winter pruning: Vines which have attained the age of one year can be subjected to this "pruning" during December in Tamil Nadu. The mature (about 6 months old) current season canes are pruned. The entire foliage and immature shoots are removed. Levels of pruning differ with varieties and can be ascertained by bud forecasting. In general, Anab-e-Shahi and Bhokri are pruned to 5 bud level, Thompson Seedless to 10 buds, Bangalore Blue to 4 buds and Gulabi to 9 in case of the ideal canes of pencil thickness. More number of buds are retained on thicker canes and less on thinner ones. This pruning is also called "Forward pruning".

Note these points

All canes in a vine cannot be equally fruitful. Canes that are away from the trunk are more fruitful than the ones nearer the trunk. Hence, the former are pruned lightly than the latter. Partly mature and immature canes are sterile. Canes that taper suddenly or reversely also are sterile. Hence, such canes are to be removed completely. Within a variety, the thicker canes are pruned lightly as compared to the thinner canes. Flat canes and the canes with longer internodes also are not fruitful. Hence, such canes also are to be pruned to the base.

EX. NO. 13

MANURING PRACTICES FOR FRUIT CROPS

Fruit crops require more nutrition than field crops, but in practice many growers apply lesser quantities of fertilizers than required. The time of application of fertilizer, method of fertilizer application, dosages and the form of Fertilizer to be applied depends on many factors such as soil, climate, age of the fruit crop, stage of the crop, quality of the produce etc. While several types of manure are available, the one matching the crop needs should be alone used. Soil" fertility analysis, the quality of irrigation water and the nutrient uptake by plants at different" stages of crop growth are some of the factors to be considered to arrive at the nutrient requirements of a fruit crop in consideration. Of late, tissue analysis (leaf samples) is employed to find out the nutrient status of a plant.

Plants require N, P,K, Ca, Mg and S and traces of Mn, B, Cu, Fe, Zn and Mo from the soil in optimum concentrations to carry out their functions effectively leading to better yield and quality. Orchards can be manured both with organic and inorganic fertilisers.

Organic manures

Farm yard manure, poultry manure, compost, oil cakes, leaf mould, bone meal, fish meal, vermicompost, green manures, and green leaf manure etc., are all different forms of organic manure. The quantity of N, P or K available in organic manure is very less compared to the inorganic forms and hence organic manures should be applied in bulk quantities. Besides serving as a source for primary, secondary and minor elements, organic manures also improve the physical and biological properties of the soil. Addition of organic manures can improve the availability of nutrients supplied through inorganic forms. Application of organic manures, to certain extent, also helps to control pest and diseases and to improve the quality of the fruits.

Bio-Fertilizers or microbial Fertilizers are also organic fertilizers in a sense. *Azospirillum* and *Azotobacter* help the crop growth by fixing up of atmospheric nitrogen. Phospobacteria helps to make phosphorus in an available form. Similarly, Vascular arbuscular mycorrhizal fungi (VAM) colonize on roots and help to mobilize phosphorus.

Under congenial conditions, these biofertilizers can build-up in the soil over the years and make valuable nutrients available to the plants, saving substantial quantity of fertilizers in the process.

Inorganic fertilizers

The inorganic fertilizers can be called as nitrogenous, phosphatic or potassic fertilizers, depending on the element in which they are abundant. Complex forms of fertilizers containing all the three major elements (NPK) in different proportions are also available in the market

Nitrogenous fertilizers

Urea, ammonium sulphate, ammonium nitrate, calcium nitrate, calcium ammonium nitrate, cyanamide, diammonium phosphate etc., are rich in nitrogen.

Phosphatic fertilizers

Single/ double/triple super phosphate, rock phosphate, mussorie-phos, diammonium phosphate are sources for phosphorus

Potassic fertilizers

Muriate of potash, potassium sulphate or potassium nitrate can supply the potassium requirements.

Percentage of nitrogen available in nitrogenous fertilizers

Nitrogen

Sodium nitrate	- 16%
Potassium nitrate	- 12.5% - 13.5%
Ammonium sulphate	- 20.6%
Amorphos A	- 11.0%
Amorphos B	- 16%
Ammonium nitrate	- 13%
Ammonium sulphate nitrate	- 25.6%
Urea	- 46%
Calcium cyanamide	- 20.6%

Ammonium sulphate and urea are most commonly used.

Percentage of phosphorus available in phosphatic fertilizers

Super phosphate – 10-18%

Basic slug – 8-18%

Rock phosphate – 30-40%.

Percentage of potassium available in potassic fertilizer

Muriate of potash – 48-62%

K_2SO_4 – 48%.

Complex fertilizers

Fertilizer mixtures containing 0: 9: 9 or 17: 17: 17 NPK are examples for complex fertilizers. Different complex fertilizers, with different levels or proportions of NPK are available commercially.

Time of application

The time of application of fertilizer should be determined based on the nutrient requirement of the fruit plant at a particular stage. To be effective, the nutrients must be readily available at a time when these are needed at the most. Since nitrogen is required through out the growth phase, it can be supplied in 2 or 3 splits in a year. Phosphorus requirement is higher in the early stages of crop growth and is needed for flowering. Hence, phosphorus is applied well before flowering. Usually it is combined with nitrogen. Potassium also is required through out the crop growth period. In certain fruit crops, potassium has been known to distinctly affect the fruit quality. So, the application of potassium during the fruit maturity phase, apart from the earlier applications, can enhance fruit quality.

Water availability at the time of fertilizer application is essential, otherwise the fertilizers may cause injury to the plant.

Fertilizer schedule for mango

	I year	II year	III year
FYM	10 kg	30 kg	40 kg
N	200 kg	400 kg	800 kg
P	200 kg	400 kg	800 kg
K	200 kg	400 kg	1000 kg

FYM is applied at all the initial vegetative phase and part of the nitrogen is applied immediately after harvest. Remaining part is applied during 15th September to 15th November.

Method: It is through basal application applied in a circular trench at 15-20 cm deep.

Method of application

The method of application should be appropriate taking into account the age of the trees, root spread, system of planting, kind and amount of fertilizers to be applied etc. The different methods of application are as follows.

1.Band/Strip placement: frequently practiced

2.Broadcasting : not so commonly practised

3.Foliar spray: especially for quick - relief from nutrient deficiency symptoms and for providing micro nutrients

4.Fertigation: Recently developed technology and practical in orchards where the labour costs are high. This method is advantageous as water and fertilizer usage can be efficiently managed. The dosage can be regulated depending upon the growth stage of the crop and its requirement.

EX. NO. 14

USES OF GROWTH REGULATORS IN FRUIT CROPS

Plant growth hormones (Phytohormones) are chemical substances which mediate cell to cell communication within the plant system to bring about specific growth and physiological responses even when they are present in lower concentrations (even in nanogram level). These are synthesised at specific organs and are often translocated from the site of synthesis to the site of action. The quantity of plant growth hormone synthesised varies from plant to plant and from organ to organ. It is also determined by the internal and external stimuli or factors within a plant cell they bind to a specific protein called '*receptor proteins*' and mediate the response.

Plant growth regulators can be broadly classified as growth promotores and growth inhibitors depending on the nature of action. However, a particular hormone may be a growth promotor at a lower concentration but can inhibit growth at a higher concentration. Based on chemical nature and general action, plant hormones can be broadly classified to five major groups.

- i. Auxins
- ii. Gibberellins
- iii. Cytokinins
- iv. Abscisic acid
- v. Ethylene

Besides the above, there are some other compounds such as brassino-steroids, triacontanols, morphactins and several other phenolics which regulate plant growth.

Auxins are synthesised generally at higher concentrations in the growing tips (meristems) and are translocated downwards. During reproductive phases, auxins are synthesised in flowers and developing fruits. Gibberellins are synthesised in almost all organs but they are concentrated more in seeds and produced in comparatively larger quantities during seed development. Root apical meristem is the primary centre of cytokinin synthesis and cytokinins are transported to the shoot system. Ethylene is generated during ripening and abscisic acid during later stages of seed development.

When the endogenous production of a particular plant growth hormone is low, exogenous application of that growth hormone can elicit a favourable response. To substitute natural growth hormones that occur within the plant system, synthetic growth regulators are now used. These synthetic growth regulators are best suited for commercial and industrial uses.

Uses

Some of the commercial uses of plant growth regulators in fruit crops are as follows

- ◆ to break seed dormancy and enhance germination
 - GA₃ and Thiourea
- ◆ to promote rooting of cuttings and layers
 - IBA and NAA
- ◆ to propagate horticultural plants through tissue culture
 - BAP, Cytokinin, GA₃
- ◆ to break bud dormancy
 - GA₃, 2, 4-D
- ◆ to induce flowering
 - NAA, Ethrel, GA₃ in several crop species
- ◆ to prevent flower and fruit drop
 - NAA, 2, 4 D in low concentrations
- ◆ To overcome alternate bearing
 - Paclobutrazol
- ◆ to induce parthenocarpy
 - 2, 4-D
- ◆ to improve fruit size and fruit quality parameters
 - GA₃
- ◆ to regulate ripening (i.e. delaying or promoting) process
 - Ethrel
- ◆ to control weeds
 - 2, 4-D

It is essential to know prior, the kind and concentration of growth regulator, the stage of the crop growth and method of application to bring about the desired change.

The application of growth regulators in various crops are described as follows.

Banana

2, 4-D @ 25 ppm is applied 20 days after the emergence of last hand to overcome seediness in Poovan banana. Since it is insoluble in water, it is dissolved by adding 1 (or) 2 drops of ethanol. The solution is made up to 1 litre and further 9 litres of water are added.

Grapes

Cuttings are soaked in 500 ppm of IBA for 12 hours (or) 12,000 ppm for 3 seconds. It gives good percentage of rooting.

- At the 5 leaf stage after pruning, application of cycocel @ 500 ppm further increases the fruit set and decreases the vegetative growth.
- GA at 10 ppm at 20-25 days after pruning elongates the cluster and make flowers to borne fruits.
- Application of GA₃ at 40 ppm at 50% flowering cause thinning of flowers and increases fruit set.
- The berry size is decreased when bunches are dipped in GA₃ at 50 ppm and BA at 10 ppm.
- At the colour break stage, application of ethaphon at 250 ppm gives uniform ripening.
- Application of NAA at 50 ppm alone a week before harvest decreases the post harvest berry drop.
- Application of ascorbic acid at 20-25% of sodium diethyl 1 dithiocarbamate at 15 days interval from onset of berries reduces the incidence of soft berries.

Guava

- To promote air layering (in roots) IBA 3000 ppm is applied
- Spray of urea at 10% in Allahabad safeda and 20% urea spray in Lucknow 49 thins out the flowers.

- GA₃ at 1000-8000 ppm induces parthenocarpic fruits.

Mango

- Paclobutrazol is applied at 2ml per tree induces flowering during off season
- NAA spray @200 ppm lowers the incidence of malformation
- NAA, 2, 4-D and GA₃ reduces the fruit drop in mango.

Sapota

IBA and NAA at 1000 ppm in Linolin paste gives higher percentage of rooting of grafting. For extending shelf life, fruits are dipped in 300 ppm of GA₃ along with Bavistin.

Papaya

- GA₃ @ 100 ppm is applied for seed soaking which increases the percentage of seed germination.
- Paclobutrazol application at 25 mg per tree as soil drench reduced the fruit bearing height, increased fruit yield and latex yield.

Aonla

- The semi hard wood cuttings are treated with IBA at 1500 ppm for increasing the rooting percentage.
- NAA and IBA at 1000 ppm each increases rooting in stools.

EX. NO. 15

STUDY OF PHYSIOLOGICAL DISORDERS AND DIAGNOSIS OF MALADIES IN FRUIT CROPS

MANGO

Malformation

Malformation is widely prevalent in northern Indian states of Punjab, Delhi and western U.P. The malformed panicles remain unproductive and are characterised by a compact mass of male flowers, greenish in colour and stunted in growth. The main and secondary rachis becomes thick and short and bear flowers with relatively larger sized bracts, sepals and petals as compared to normal flowers. Some of the factors that are attributed to be the cause for this disorder include poor cultural practices, nutritional deficiencies, hormonal imbalances, accumulation of biochemicals called 'malformins', mites(*Aceria mangiferae*), fungal pathogen (*Fusarium moniliformae fsp subglutinans*) viral infections etc. The exact cause and control of the malady is yet to be established.

Some remedial measures that are recommended include

- i. Pruning of shoots bearing malformed panicles by cutting 15 cm below / paste cut ends with 0.2% capton +0.1 % malathion
- ii. Deblossoming of early emerged infested panicles
- iii. Spraying 200 ppm NAA on affected panicle during I week of October
- iv. Adopting regular practices and timely control measures
- v. Spray antimalformins like glutathione 2200 ppm or ascorbic acid 2100 ppm from the time of panicle emergence, three times at an interval of 10 days.

Biennial bearing: (Alternate bearing)

This refers to the tendency of mango trees to bear a heavy crop in one year (On year) and very little or no crop in the succeeding year (Off year). Most of the commercial varieties of north India, namely Dashehari, Langra and Chausa are biennial bearers, while south Indian varieties like Totapuri Red Small, Neelum and Bangalora and recently bred varieties from IIHR are known to be regular bearers. The problem may be due to genetical, physiological, environmental and nutritional factors. For overcoming biennial

bearing, deblossoming is recommended to reduce the crop load in the 'On' year so as to balance it in the 'Off' year. Proper, regular and timely cultural operations, judicious pest and disease management is essential. Soil application of Paclobutrazol (Cultar or PP333) @ 4 - 5 g per tree in the month of September can be taken up.

Fruit drop

Despite high fruit set initially, the ultimate retention is quite low (< 0.5% of perfect flowers) in mango. The intensity of fruit drop varies from variety to variety. The variety Langra is more susceptible to drop while Dashehari is the least. The fruit drop occurs during all stages of development but more during

(i) Pinhead stage (ii) Post-setting phase and (iii) near maturing stage. Variety, climate and management factors influence fruit drop to a great extent. The reasons may be lack of pollination, low stigmatic receptivity, defective flowers, poor pollen transfer, 'lack of available soil moisture, high pest and disease incidences, unfavourable climate, deficiency of auxins, gibberellins and cytokinins but high amount of inhibitors.

To overcome fruit drop

- ◆ provide regular irrigation during fruit set and developmental stages
- ◆ spray NAA @ 25-40ppm or 2-4 D @10-15 ppm at pea stage
- ◆ spray 1-2 % urea at marble stage & 1 month after
- ◆ grow self compatible varieties

Black tip

Black tip is a serious disorder, particularly in the cultivar Dashehari. The affected fruits become unmarketable and reduce the yield to a considerable extent. The damage to the fruit gets initiated right at marble stage with a characteristic yellowing of tissues at distal end. Gradually, the colour intensifies into brown and finally black. At this stage, further growth and development of the fruit is retarded and black ring at the tip extends towards the upper part of the fruit. Black tip disorder has generally been detected in orchards located in the vicinity of brick kilns. It has been reported that the gases like carbon monoxide, sulphur dioxide and ethylene constituting the fumes of brick kiln are known to damage growing tip of fruits and give rise to the symptoms of black tip. Apart

from these factors, irrigation, condition of the tree and management practices also play important role in deciding the severity of the disorder. Planting of mango orchards in North-South direction and 5 to 6 km away from the brick kilns may reduce incidence of black tip to a greater extent. The incidence of black tip can also be minimised by the spray of borax (1%) or other alkaline solutions like caustic soda (0.8%) or washing soda (0.5%). The first spray of borax should be done at pea stage followed by two more sprays at 15 days interval.

Clustering disorder (Jhumka)

A fruiting disorder, known as 'Jhumka' in North India, is characterised by the development of fruitlets in clusters at the tip of the panicles. Such fruits do not grow beyond pea or marble stage and drop down after 30-45 days of fruit set. These fruits do not contain seeds. The disorder seems to be due to lack of pollination / fertilization which may be attributed to absence of sufficient population of pollinators in the orchards, old and overcrowding of trees, indiscriminate spraying against pests and diseases, use of synthetic pyrethroids for spraying, monoculture of Dashehari and bad weather during flowering. Some of the remedial measures are

1. Insecticides should not be sprayed at full bloom to avoid killing of pollinators. .
2. Pest and disease should be controlled in time by spraying the recommended pesticides only.
3. Introduction of beehives in the orchards during flowering season for increasing the number of pollinators.
4. The practice of monoculture of a particular variety may' be avoided. In case of Dashehari, 5-6 per cent of other varieties should be planted in new plantations. In old orchards, where monoculture of a particular variety like Dashehari is followed, a 'few branches may be top worked with pollinizing varieties.
5. Pruning of old trees may be done to open the canopy.
6. Spraying of 300 ppm NAA may be done during October-November.

Spongy tissue

This disorder is a major problem in Alphonso variety; a pulp patch fails to develop due to inactivation of ripening enzyme.

This may occur due to

- i. high temperature during fruit development/maturity stages
- ii. convective heat radiating to fruit surface
- iii. postharvest exposure of fruits to sunlight or
- iv. genetical factors - to overcome, sod culture/mulch/post harvest exposure of fruits at 10-15 ° C for 10-18 hours is recommended.

BANANA

Choke throat

Due to low temperature, the bunch is unable to emerge from the pseudostem properly. The distal part of the inflorescence comes out and the basal part gets stuck up at the throat. The fruits in the hands which are situated immediately next to the enclosed ones develop and become mature but being held in a vertical position and it is called straight fruits or sun lookers. Twisting of stalk before emergence also occur. Prevention is by providing shelter belts

Seediness (Kottaivazhai) in Poovan

Distinctly conical and ill filled fruits with a prominent central streaks, striation and blotches on pseudostem and leaves, peduncle become irregular curvature, bunches at above horizontal angle. Application of 2,4-D 25 ppm within 20 days 'of last hand emergence is suggested as a control measure.

Hard lump

This problem occur in cv. Rasthali. The lumps are more firmer than the usual pulp and may appear as light to pinkish brown and occur more so on the the bunches developing during dry winter.

Neer vazhai in Nendran : Fingers fail to fill out; seen in Nendran

GRAPES

Pink berry formation

This is a serious problem of Thompson Seedless in Maharashtra. As the bunch approaches harvesting stage, some berries develop pink colour in the bunch at random. Such berries were reported to turn black within a day after harvesting and the entire bunch becomes unmarketable. Incidence of pink berries was low in the early season crop and increased with the raising temperatures late in the season. Indiscriminated use of ethrel for berry colouration could also cause this disorder.

Hen & Chicken Disorder

Presence of small and big fruits on the same bunch. Occurs due to Boron deficiency. This can be controlled by spraying 0.2 % boric acid a week before bloom and another at full bloom stage.

SWEET ORANGE

Granulation

A physiological disorder of the juice sacs of citrus fruits which causes them to become comparatively, hard, dry. The juice sacs become grey, coloured and enlarged. It is common in varieties like Sathugudi, Mosambi, Jaffa, Malta Blood Red and Valencia hate. To decrease this disorder, the trees should not be over irrigated. Lime spray @ 20 kg in 450 lit. of water and Zinc (0.5%) spray and copper (0.25%) spray can control this disorder.

Colour development in sweet orange is a problem under tropical conditions. Pre harvest spray of 1000 ppm of ethephon or as fruit dip in combination with 1000 ppm Benlate is recommended to get better colours.

Little leaf malady

To control, spraying zinc sulphate at 1.0 per cent plus Teepol 1 ml/lit of solution at various stages viz., new flush, one month after, at flowering and fruit set is recommended

GUAVA

Bronzing of leaves and fruits

Spraying of a combination spray containing ZnS04, MgSo4 and MnSo4 @ 0.5% and CuSo4 and FeSo4 @ 0.25 % plus Teepol @ 1ml per 5 lit of solution on various stages viz., new flush, one month after, at flowering and fruit set is recommended

Zinc and Boron deficiencies also occur and can be corrected by foliar application of 0.5 % Zn SO4 and 0.4 % boric acid at 10-14 days before flowering.

POMEGRANATE

Fruit cracking

This problem occurs mainly due to high temperature coupled with moisture stress at the time of fruit growth and maturity. Boron and potassium deficiency also causes fruit cracking. The intensity increases if the matured fruits are subjected to drought or heavy rains. It can be controlled by avoiding moisture stress during fruit development and application of recommended dose of 500 g of potash coupled with bimonthly spraying of 0.25% borax + 0.1% urea during the later stages of fruit development.

EX.NO. 16

POSTHARVEST HANDLING PRACTICES FOR IMPORTANT FRUIT CROPS

MANGO

At maturity, the color changes from green to yellow and the development of "shoulders" on the stem end of the fruit are the best indicators of maturity. Fruits are not ripe at this stage, but picked firm to withstand transport. Mangos are hand-harvested, simply by snapping-off fruits from peduncles using a mango harvester (a long pole attached with a knife and a small net bag). Fruits can be washed prior to packing to remove surface resins and then dipped in hot water (55°C). Fruits are stored for 15 days at 15°C and RH of 85-90%. Ethylene is used to accelerate color development (by 3-8 days) and allow more uniform ripening. Mangoes are susceptible to chilling injury and must not be stored at < 10-12°C. Storage life is only 2-3 weeks under optimal conditions. Dip the fruits in 52 ± 1°C hot water immediately after harvest for 5 minutes followed by 8% plant wax (Fruitox or Waxol) to reduce anthracnose disease in mango during storage. Two pre-harvest sprays of 0.20% Mancozeb (2.0 g/lit) will also reduce the incidence.

BANANA

Fruits are harvested when about 75 % mature as angles become less prominent and fingers on upper hands turn light-green in color. The bunch is cut from pseudostem leaving a portion of peduncle for handling during transport. Bunches should be kept out of light after harvest since this hastens ripening and softening. For local consumption hands are often left on stalks and sold. For export, hands are cut into units of 4-16 fingers, graded for both length and width and carefully placed in poly-lined 12 to 18 kg boxes. Prior to packaging, fruits are cleaned in water or diluted sodium hypochlorite solution to remove the latex and treated with thiobendazole and other fungicides. It is successfully demonstrated that 100 gauge thick polythene bags with 0.2% holes enhance shelf life under room temperature as well as in cold storage. Fruits are ripened by exposure to ethylene gas (1000 ppm for 24 hrs) at their destination, in sealed "banana ripening

rooms". Hands can be stored for a short time at temperatures not lower than 12°C since fruits are susceptible to chilling injury

CITRUS

The best indices of maturity for citrus are brix, acid content, and the brix/acid ratio. External color is a function of climate more than ripeness and is a poor indicator of maturity. For limes, juice content must be at least 42% to market. Brix (sugar) content increases during maturation. It will be around 7-14 % for oranges, 16 % in tangerines and less than 10 % in lemons/limes. Brix is not a maturity index for limes and lemons. Citrus is a non-climacteric fruit and may be stored for fairly long periods at low temperatures. Chilling injury is common in grapefruit and other acid citrus when stored at 10-15 °C and rare in oranges and mandarins at this temperature. For fresh fruits, packing line operations include (in order) dumping→culling→ washing→ brushing→ waxing→drying→ grading → boxing. Degreening using Ethrel is done to improve appearance. Acid limes can be treated with 4 % wax emulsion and pre-packing in 200 gauge polythene bags with 1 % ventilation is done to improve the shelf life

GRAPES

For table grapes, the time of harvest is determined mostly by appearance, including color and size of berries. The stems of the cluster also turn a wood or straw color when berries are mature. For raisin grapes, it is best to allow grapes to ripen fully on the vine before picking since drying ratio should be minimized for maximum yield and quality. For wine grapes, sugar and pH are the important parameters and wines with pH above 3.6 are potentially unstable. Brix/acid ratio and total acidity are also important, and Brix/acid ratio together with Brix has been used to accurately predict wine quality. For juice grapes, the important parameter is sugar content (not less than 15 %). Individual clusters of table grapes are judged for maturity by pickers and clipped from vines with minimal handling and the vines are harvested 2-3 times over a period of several weeks, since grapes ripen rather slowly and hold their condition on the vine for weeks following ripeness.

Shipping of table grapes is done immediately after harvest when possible. The grapes meant for storage should be packed and pre-cooled soon after harvest.

Therefore, the grapes to be cold stored should be pre-cooled to 0-2° C using forced air-cooling and shifted to the cold store immediately after harvest. Raisins can be stored for long periods of time at room temperature due to low moisture content. Fresh grapes can be stored for 90 to 180 days of time at 0-1°C and 95% RH depending on cultivar. The bunches are placed in the pack in such a way that the stem end lies on the outer side of the package which facilitates easy removal of bunches during retail marketing. The CFB boxes of 2 to 4 kg are very popular for packing grapes. "Grape Guard" is a brown-coloured paper (which is impregnated with potassium sulphite) which releases sulphur dioxide gas when it gains moisture. Sulphur dioxide helps checking the grey mould disease of grapes which occurs at ambient as well as under cold storage conditions. It also helps keep the stem of the bunch from drying up. Two types of "Grape Guard" strips are available - slow release (active up to 40 days) and quick release (active for six to seven days). The slow release Grape Guard strips are usually used during storage of grapes while the quick release strips are used during transport. For getting the best advantages from "Grape Guard", the grapes should be wrapped in thin tissue paper or perforated polythene bags and a strip of Grape Guard placed in it before packing the grapes in box.

Wine making. The science of wine-making is called enology. The basic processes are as follows

1. Harvested grapes are dumped into bulk bins and taken to the de stemmer/crusher, where the juice ("must" = juice + skins + seeds: stems for red; juice only for white) is extracted. Initial quality evaluations are made and the vinification process is decided upon. Adjustments of sugar level and acid are done at this point.
2. Sulfur dioxide is added to prevent enzymatic oxidation and color deterioration, and selectively activate certain yeasts for fermentation and kill bacteria and other undesirable microbes.
3. 'Must' is transferred to large fermentation vessels (25 to 500 hl) for sugar alcohol conversion. Red wine is produced by partial fermentation with skins where anthocyanin pigments reside; Rose is produced by limited contact of must with

skins; White wine is produced with no contact with skins. Fermentation temperature is higher for red wine (24-28°C) than white wine (14-18°C). Racking or dispensing wine into containers stops fermentation. Sometimes SO₂ is used to stop the process and act as a preservative. .

4. Wines are filtered once, then can be aged in oak barrels for some time prior to bottling; Generally, red wine is stored in large (100-200 hl) barrels, and white in small (2 hl) barrels. White wine is aged for only short periods of time (< 1 yr), whereas some reds may be aged for up to 10 years. Bottling takes place at appropriate age, after ultra-filtration for clarity and antisepsis.

GUAVA

Dessert fruits are hand harvested when fully mature but green stage. For processing fruits are to be picked at firm yellow to half ripe stage. Mature green fruit develop yellow colour within a week if held at 20°C, full ripe fruits can be stored at 7°C for a week without any chilling injury. Ethrel can be used to accelerate ripening.

PAPAYA

Fruits have better quality when the skin turns 80% yellow in color. For distant market papayas are harvested when the first streak of yellow appears. Fruits are hand harvested carefully to avoid scratching the skin. Fruits are sorted in the field and packed into single-layer boxes with tissue or foam padding to avoid bruising. Fruits can be stored at 30°C and 100% humidity for better color expression prior to packing. To reduce post-harvest fruit rotting papayas are commonly dipped in hot water (48 to 52°C) for 20 minutes, then rinsed in cool water. Fungicides and radiation treatments have also been used for this purpose and to kill fruit fly eggs that may present under the skin. The shelf life at room temperature ranges from 3 to 8 days, depending on storage atmosphere. CA storing is done at 12°C which allows ripe fruit to be stored for up to 12 days. At storage temperatures below 10°C papayas experience chilling injury.

SAPOTA

It is a climacteric fruit and it improves in quality after harvesting. The fruits at full maturity develop a dull orange or potato colour and brown scaly material disappears from

the fruit surface. As the fruit matures, the milky latex content gets reduced shows a yellow streak upon scratching. The dried spine like stigma at the tip of the fruit falls or drops off easily when touched. The fully mature fruits are harvested with the stalk intact, individually by giving a twist and collected without bruising.

POMEGRANATE

The fruits are ripe when they have developed a distinctive color and make a metallic sound when tapped. The fruits must be picked before over maturity when they tend to crack open, particularly when there are rains. The pomegranate is best maintained at a temperature of 0-5°C and can be kept for a period of 1 month within this temperature range and at 80 to 85% relative humidity without shrinking or spoiling. The fruits improve in storage, becoming juicier and more flavored.

PINEAPPLES

Color change is the' most common method -of determining' maturity. Fruits are harvested when the eyes show a pale-green color and become shallow and less spiny Ethepron applied when fruits are ripening, synchronizes maturity and eliminates the need for multiple pickings. Fruits are cut or broken off stalks and placed in piles or onto trucks in alleyways. Fruit for fresh market are often marketed with crowns although crowns are sometimes used for planting. A short section of flower stalk is left to protect the base of the fruit during shipment. For canning, fruit is de-crowned cored and peeled, then either sliced or diced. Pineapples can be stored for 4-6 weeks at temperatures of 10°C or above. Chilling injury is common at temperatures less than 10°C.

JACK

At maturity the fruits lets out a dull hollow sound when tapped and the pale green skin colour changes to yellowish brown. The surface spines will also get flattened. From fruit set it takes nearly 12-14 weeks to attain full maturity. Jack can be stored at 12 °C for 3 weeks and it takes 3-7 days for ripening.

APPLES

Apples should be harvested when mature but not yet fully ripe *or* overripe. If harvested before maturity, they will have poor eating quality and become easily susceptible to storage disorders such as scald, cork spot, bitter pit and may not ripen properly. Some cultivars mature in as little as '100 days, where others may take 180-210 days. Firmness, TSS are good indicators of maturity to use in determining picking time. Apples must be picked by hand to avoid bruising and reduction of fresh market quality grade. Standard packing line operations are used for apples after harvest' include hydrocooling, washing, culling, waxing, sorting and packing. Firmer, less ripe fruit are placed in long term CA (150-200 days), while more mature fruit are sold directly or placed in short-term CA. Controlled atmosphere storage at 0°C to 3.5 °C with 2-3% oxygen, with 2-3% carbon dioxide is the normal practice. Spraying 0.5 % CaCl₂ starting from 2nd week of July three times or post harvest dipping in 4 % CaCl₂ for 1-2 min or Hydrocooling in chilled (3-4°C) 2 % CaCl₂ solution for 20 min can improve post harvest shelf life.

