E- PRACTICAL MANUAL

TROPICAL AND SUBTROPICAL FRUITS
HFS 121
3 (2+1)

B.Sc. (Hons.) Horticulture

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Practical Manual on
Tropical and Subtropical Fruits

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Practical:

Botanical description and identification of ber, fig, jamun, pomegranate, carissa, phalsa, wood apple, Indian cherry, tamarind, aonla, bael and annona, description and identification of varieties based on flower and fruit morphology in above crops, training and pruning of grapes**,** mango, guava and citrus. Selection of site and planting system. Pre-treatment of banana suckers, desuckering in banana and sex forms in papaya. Use of plastics in fruit production. Manure and fertilizer application including bio-fertilizer in fruit crops. Preparation and application of growth regulators in mango, banana and grapes. Seed production in papaya, latex extraction and preparation of crude papain. Ripening of fruits, grading and packaging, Production economics for tropical and sub-tropical fruits. Mapping of arid and semi-arid zones of India. Visit to commercial orchards and diagnosis of maladies.

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EXERCISE-1

Objective-Botanical description and identification of tropical and subtropical fruit

Family	**Common Name**	**Scientific Name**	**2n**	**Origin**	**Fruit type**
Bromeliaceae	Pineapple	*Ananas comosus*	50,75,100	Brazil	Aggregate berries
Musacae	Banana	*Musa balbisian*	22, 33, 44	Indo-Malayan	Berry
	Plantain	*Musa acuminata*	22, 33, 44	Indo-Burma	Berry
Areaceae/Palmae	Datepalm	*Phoenix dactylifera*	36	West Asia	Drupe
Anacardiaceae	Mango	*Mangifera indica*	40	S-E Asia	Drupe
Annonaceae	Atemoya	*Annona atemoya*	14	Man made hybrid	Aggregate berries
	Bullock's heart	*Annona reticulata*	14	-	Aggregate berries
	Cherimoya	*Annona cherimoya*	14	Bolivia	Aggregate berries
	Custard apple	*Annona squmosa*	14	West Indies	Aggregate berries
	Sour sop	*Annona muricata*	14	South America	Aggregate berries
Apocynaceae	Karonda	*Carissa carandas*	22	-	Berry
	Natal plum	*Carissa grandiflora*	22	-	Berry
Bombacaceae	Durian	*Durio zibethinus*	56	Malayan region (Borneo)	Berry
Caricaceae	Papaya	*Carica papaya*	18	Tropical America	Berry
Ehretiaceae	Lasoda	*Cordiya mixa*	-	-	Berry
Euphorbiaceae	Aonla	*Emblica officinalis*	28	S-E Asia	Capsule (Drupe)

	Star gooseberry	*Phyllanthus acidus*	-	Madagascar	Berry
Guttiferae/ Clusiaceae	Cowphal	*Garcinia cowa*	-	-	Berry
	Malabar tamarind	*Garcinia cambogia*	-	-	Berry
	Mangosteen	*Garcinia mangostana*	28	Malayan Archipelago	Berry
Lauraceae	Avocado	*Persea Americana*	24	Central America	Berry
Malphighiacae cherry	Barbadaos	*Malphigia punicifolia*	40	Trinidad and Tobago	Drupe
Moraceae	Aini	*Artocarpus hirsute*	56		Sorosis
	Bread fruit	*Artocarpus altilis*	56	Indo-Malayan	Sorosis
	Jack fruit	*Artocarpus heterophylla*	56	India	Sorosis
	Mondey jack	*Artocarpus lakoocha*	56	Western Ghats	Sorosis
	Fig	*Ficus carica*	26	-	Syconus
	Mulberry	*Morus alba*	308	-	Sorosis
Myrtaceae	Guava	*Psidium guajava*	22	Tropical America	Berry
	Jamun	*Syzygium cuminii*	40	India	Drupe
	Malayan apple	*Syzygium malaccense*	-	-	Berry
	Pineapple guava	*Feijoa sellowiana*	-	-	Berry
	Rose apple	*Syzygium jambose*	-	-	Drupe
	Watery rose apple	*Syzygium aqueum*	-	-	Berry
Oleaceae	Indian olive	*Olea ferruginea*	-	-	Drupe
	Olive	*Olea europaea*	46	Mediterranean region	Drupe
Oxalidaceae	Bilimbi	*Averrhoa bilimbi*	24	-	Berry

	Carambola	*Averrhoa carambola*	24	Sri Lanka	Berry
Passifloraceae	Passion fruit	*Passiflora edulis*	18	Brazil	Berry
Punicaceae	Pomegranate	*Punica granatum*	18	Iran (Persia)	Balausta
Rhammaceae	Chinese jujube	*Ziziphus jujube*	48	China	Drupe
	Indian jujube	*Ziziphus mauritiana*	-	-	Drupe
Rosaceae	Loquat	*Eriobotrya japonica*	34	Central East-China	Pome
Rutaceae	Bael	*Aegle marmelos*	18	India	Amphisarica
	Mandarin	*Citrus reticulate*	18	South Eastern Asia	Hesperidium
	Sweet orange	*Citrus sinensis*	18	Indio-China	Hesperidium
	Acid lime	*Citrus aurantifolia*	18	Iran (Persian)	
	Grape fruit	*Citrus paradisi*	18	West Indies	Hesperidium
	Wood apple	*Feronia limonia*	18	India	Amphisarica
	Lemon	*Citrus limon*	18	South East Asia	Hesperidium
Vitaceae	Grapes	*Vitis vinifera*	38	Western Asia and Central Europe	Berry
Tiliaceae	Phalsa	*Grewia subinequalis*	36	India	Drupe
Sapindaceae	Litchi	*Litchi chinensis*	30	South China	
	Rambutan *lappaceum*	*Nephelium*	22	Malayan Archipelago	Nut
Sapotaceae	Sapota	*Achras zapota*	26	South Mexico	Berry

EXERCISE-2

Objective: Selection of site and planting system of tropical and subtropical fruits

Selection of site: Proper selection of site is important. Selection may be made based on the following criteria.

1. The location should be in a well-established fruit growing region because one could get the benefit of experience of other growers and also get the benefit of selling the produce through co-operative organizations with other fruit growers.
2. There should be a market close to the area.
3. The climate should be suitable to grow the chosen fruit crops.
4. Adequate water supply should be available round the year.
5. Suitability of soil, its fertility, the nature of subsoil and soil depth.
6. Site must have proper drainage and no water stagnation during rainy season
7. Irrigation water must be of good quality.
8. There must be proper transport facilities either by road or rail within the reach.
9. Whether the climatic conditions are suitable for the fruits to be grown and are whether site is free from the limiting factors such as cyclones, frost, hailstorms and strong hot winds.
10. Whether there are seasonal gluts or over production in any particular period of the year.
11. Whether there is assured demand in the market for the fruits to be grown.
12. Whether his orchard is a new venture or whether there are already other growers.
13. Availability of labour.

Planting systems are used for planting fruits orchard.

Square system: In this system, as the name indicates, the distance from plant to plant and row to row is the same. he plants are at right angle to each other so that every unit of four plants forms a square. This is the most common system and is easy to layout. This facilitates intercultural in two directions.

Rectangular system: The trees are planted in straight rows running at right angles on one side of the field. The distance from plant to plant and row to row is not the same and four trees joined at the base give a rectangle. Like square system, cultivation, irrigation and other intercultural operations can be done in two directions.

Hexagonal system: In this system, the trees are planted in each corner of an equilateral triangle, thus six trees in a hexagon and seventh in the centre. This system differs from a square system in a way that the distance between the row is less than the distance between the trees in a row, but distance from tree to tree in six directions remains the same. This permits cultivation in three directions. This system can be employed where the land is very fertile with assured irrigation.

Diagonal or Quincunx system: It is the same as the square system with an additional plant in the centre of a square. The central tree is usually not a permanent tree and is planted to fill the central space. This is known as filler. Filler serves as a source of additional income till the main trees come into bearing. Papaya in mango and peach in apple orchards can be planted as filler trees. For laying out this system, the field is laid out in similar ways as in square system. Then, the rope is stretched through the diagonal points of the squares and additional pegs are fixed at the points where diagonals cross each other.

Triangular system: The trees are planted as in the square system except the plants which are in the even numbered rows are midway between, instead of opposite to those in the odd numbered rows. Every second row accommodates one plant less than the square system. For laying out an orchard according to the triangular system, A large triangle with a ring in each corner as used in hexagonal system. The sides of this triangle are equal to the distance to be kept for the plants in the orchard. Two of these rings are placed on the stakes of base line. The position of the third ring indicates the position of plant in the second row. This row is then used as a base line. The whole area is laid out in this manner. However, this system is not of practical importance.

Contour system: This system is usually followed in the hilly areas with undulating topography. The positions of plants are marked at various heights from mean sea level. The points having the same altitude are connected together by a line and trees are given spacing on this line. The rows are represented by line passing through the same contour.

Terrace planting: This is also commonly followed in hilly areas. On the steeper slopes, terraces are made along the contour and then planting is done. The width of contour terrace varies according to the nature of the slope. If the slope becomes steep, the width of terrace is narrower and vice versa. Bench terracing is the most popular system in hilly areas

EXERCISE-3

Objective: Training and pruning of grapes

Training: It is an important operation in grapes. It helps to maintain the stature and spread of the vine and facilitates operations like pruning, intercultivation, spraying and harvesting. There are many systems of training. The common systems in India are Bower, Kniffin, Telephone and single stake system.

1. **Bower or Arbours or Pandals system:** In this method, the cross piece connecting the pillars are made of thick bamboos or trek-wood or palmyra rafters or iron tubing. The wires are spaced (30 x 45 cm) or 30 x 30 cm. apart forming a network. The rooted cutting planted in the field reaches a height of 180 cm. (6 feet) in about three months. When the main stem is pinched at the top that is about 15 cm below bower. Two to four side shoots are allowed to grow and are trained on either side of the trunk or on four sides to from the arms subsequently. These side shoots or main arms as they are called are allowed to reach the periphery of the pandal and they are then tipped. On these arms secondaries are produced and allowed to grow on the main arms at intervals of 45 cm from each other alternately in opposite directions. These branches are trained to cover the framework uniformly. These secondaries in turn give rise to 'tertiaries' on which canes develop and produce the shoots carrying, bunches. Some growers allow only one arm to develop in one direction with the secondaries spaced at convenient intervals. Many of the growers allow the arms to grow long and unchecked, twist them back so that the vine is full of wood of all kinds and it is difficult to train the vine properly.
2. **Kniffin system:** In this method, the vine is allowed to put forth a single shoot which is trained erect and tipped at a height of about 45 cm from the ground level. Only three shoots are allowed to grow from this point, all others being removed. Two of the retained shoots are trained horizontally and the remaining is trained vertically to a height of another 60 cm. When it is tipped to a height of another 60 cm. When it is tipped again to produce two more shoots, which are trained horizontally. All the four horizontal arms are supported by bamboo poles or wire tied horizontally to posts fixed at regular intervals of 3 metres. Primary laterals are allowed to develop from these four main arms at fairly regular intervals and these are pruned to produce the crop every season. For every fruiting cane, a renewal spur of 2 to3 buds is left. Normally only four canes are allowed in the 4-cane kniffin system and 6 canes in the 6-cane system. Under tropical conditions it is possible to have doubled the number.
3. **Single-stake system:** A single shoot is allowed to develop from the vine of rooted cuttings and is trained vertically by staking to a support. When this shoot reaches a height of 120 cm. it is tipped and allowed to produce 4 to 5 secondary branches or canes, which are pruned after every bearing season. The main stem and the primary laterals are supported by a bamboo post planted nearby.
4. **Telephone/ over head trellis system:** In this system two or three wires are strung in rows from vertical posts. A single stem in between the posts is trained as far as the top of the wire 2.1 m. and two arms are allowed to develop along the wire on either side. Each arm will meet the arm from the adjacent vine and will have two arms with six tertilaries. The spurs on the fruit bearing shoots growing on these canes are seasonally pruned for fruit every year. Because of its resemblance to the telephone pole with its flat

topped mast bearing the supporting wires, this is called as Telephone Trellis system. In this system there is large flat-topped T-Trellis above ground level. The horizontal cross is 120 to 150 cm wide with wires strung on the top 30 to 45 cm apart. The vines are trained along the wire in the direction of the row. Steel angle iron or waste structural steel is used when available and the cross arm is welded to the upright. In a few vineyards the flat top is modified by bending each half of the mast upwards about 30° so that a trough shaped or 'H' shaped form is obtained. The disadvantage in this system is that there are no cross- supports to the rows to withstand strong winds. Cultivation and movement is limited tone direction. But they are provided with better exposure to light.

Pruning: Removal of any vegetative part in a vine is called pruning. It is a critical operation in grape cultivation. Therefore, much care and precision needs to be exercised in pruning a vine. The main objective of pruning grapevine is to increase productivity, facilitate interculture operations and maintain desired vine framework and vitality of the vine for consistent productivity. In organic grape cultivation, the vines are forced to undergo rest for about a month immediately after harvest. This helps in storing the food material in the mature parts of the vine. The canes are cut back in April by keeping 1-2 buds which develop into canes in 4-5 months. The removal of dried canes is called ‘back pruning’ or ‘growth pruning’. In the month of September-October these canes are pruned for fruiting. This pruning is called ‘forward pruning’ or ‘winter pruning’. Vines, which have attained the age of one year can be subjected to this pruning.

The following are some of the technical terms used:

Shoot: Young growth of green stem of the current season, which bears the grape cluster.

Cane: A well mature and ripened shoot of the past season or that of the previous year which gives rise to shoots.

Spur: A portion of the cane or ripened shoot left behind on the plant after pruning.

Fruiting spur: A cane or well ripened shoot leaving 304 buds, producing a bunch after pruning.

Foundation spur or Renewal spur: A well-ripened shoot or cane bearing bud. This normally remains after the shoots are pruned in March-April or summer in Hyderabad. It is called a foundation spur as it forms the base of the foundation wood on which next year's canes and fruiting spurs are formed or on which both growth of the year are borne.

Trunk: Main stem of the plant.

Long spur: A ripe shoot, carrying more than five buds. Normally it is 25-30 cm long with about 5-10 buds on it.

Medium spur: It is a cane cut back keeping 3-5 buds.

Spur: It is cane pruned to 1-2 buds.

EXERCISE-4

Objective: Training and pruning of citrus, guava and mango

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

The trees at planting time are headed back more severely to a height of 70-80cm from the ground level. Usually, 3-5 well spread laterals are selected as the future scaffold limbs. Further, these shoots are again pruned for initiation of new shoots below the points. These shoots are more prone to flowering and fruiting. In bearing, mandarins are considered to be over bearers and also alternate bearers to some extent. Pruning or cutting back of one year old shoots to half length (50% of the total) or to full length is recommended for obtaining proper yield of high quality fruits. The pruning, therefore, is done to keep the balance between fruiting and vegetative growth. The pruning of some of the shoot certainly removes a part of fruiting area and helps maintain regular cropping. The dried up branches found in the lower part of the plant too are removed. Under south and central Indian conditions, mandarin produces 3 flowerings in a year during Feb (Ambebahar), June (Mrigbahar), and October (Hastabahar) of which Mrigbahar is preferred. So, flower regulation is done by withholding water a month or two before flowering till the plants wither and drop some of their leaves. Then they are manured and irrigated which results in profuse flowering.

Guava: Training is done primarily to give form to the tree. For development of a strong framework, the first 60 to 90 cm from base of the trunk should be cleaned followed by 4 to 5 scaffold branches at an interval of 20-25 cm. When the plants attained a height of about 1.5m to 1.8 m, it is headed back to make the center open. In some parts of India (Maharashtra and west Bengal), the branches are bent down ward and tied to each other. Thus, forcing the dormant buds to grow. This results in increased yields. The trees are rarely pruned in North India, but light annual pruning after harvesting to promote vegetative growth and flowering is desirable. All dead, diseased, crowded growth and suckers sprouting from the base and sides of the framework are pruned back annually. Pruned trees give larger fruits and early ripening.

Mango: Tree canopy management, especially size control, has become a priority for reducing production cost and increasing fruit yield and quality. However, unlike temperature fruits, where tree

management technologies have been developed and refined for over a century, the similar tools and experiences can be applied with a few modifications in mango. Tree management techniques, specifically for mango have been developed and are being used in different parts of the world, which can be adopted after certain modifications in different mango growing regions. Early height control and tree canopy management are important techniques and should be practiced in India. Similarly, the problem of large tree size in mango can be tackled by using topping and hedging because large and crowded trees pose many disadvantages. Appropriate height, topping and hedging, cutting angles, as well as time and frequency of hedging determined for mango, which are common practices in Israel, USA, Australia and South Africa, can be used for increased efficiency and production in India. Shaping the mango tree immediately after planting has its own importance for keeping desirable plant height at first branching, so that proper clearance for equipment is possible.

EXERCISE-5

Objective: Manure and fertilizer application including bio-fertilizer in fruit crops

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

Fertilizers and manures

1. **Bulky organic manures**-FYM, Compost, Green manure.
2. **Concentrated organic manures**-Oil cakes
3. **Artificial fertilizers -** Nitrogenous, Phosphatic and Potassic

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

Artificial fertilizers:-

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

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

Potassic fertilizers –The potash like nitrogen is readily soluble and easily available to the plants and its method of application is similar to that of nitrogen application. Care to be taken while manuring and fertilizer application –

1. The manure and fertilizer should not be allowed to come into direct contact with stem of the plant. They should be applied sufficiently away from the main trunk.
2. The field should be irrigated after manuring if soil is not moist.
3. The application of nitrogen is done when the leafy growth is desired. For flowering and fruiting the quantity of nitrogen is reduced and that of phosphorous and potassium is to be increased.
4. The raw or undecomposed manure should not be applied to the crops as they may cause damage to the tender roots.

5. Heavy dose of inorganic fertilizers should not be given to young plants frequently.

Bio-fertilizers –

Genetic manupulation through biotechnology to develop more efficient strains of nitrogen fixing and phosphorous solubilising micro-organism is likely to increase bio-fertilizer efficiency. Horticultural crops require large quantity of N and P which can be considerably replaced through use of nitrogen fixing organisms *Rhizobium, Azatobacter* and *Azosprilla* and phosphate solubilizing bacteria *Pseudomonas* and *Aspergillus.*

The VA mycorrhizal association in horticultural crops is also now known. In papaya, citrus, mango, banana and pomegranate VAM fungi can be effectively inoculated with beneficial effects. Association of endomycorrhiza starting material is ready for potato seed production with litchi is known since long. Standardization of quick detection technique of more efficient strains of beneficial micro-organisms for bio-fertilizer use seems to be possible. The PGR amplification technique to identify genera of VAM fungi has already been standardizes.

Recommended fertilizer dose for different fruit crops -

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

EXERCISE-6

Objective: Use of plastics in fruit production

Introduction: We are aware that plastics contribute from planting to post harvest handling and processing in many fruit crops. Plastic is used at each and every stage of horticultural life cycle right from seeds packaging, planting, propagation, mulching, irrigation, harvesting, fruit packing and preservation. The application of plastics in agriculture sector is popularly known as Plasticulture. Plastics are used in greenhouses to promote growth and production, mulching to suppress weeds and maintain soil temperature and moisture as well as in containers for seedling and soil solarization to reduce pest and diseases. The used of plastics in fruit production by various techniques are as follow.

Mulching- A protective covering (as of plastic film, sawdust, compost, grass, hay, dry leaves, or stones) spread or left on the ground to reduce evaporation, maintain even soil temperature, prevent erosion, control weeds, enrich the soil, or keep fruit clean. These prevent the loss of moisture and acts as a barrier between the soil and atmosphere. It helps in moderating the soil temperature and micro-climate in the plant root zone, which helps to increase yield and early maturity of crops. In addition to this plastic mulch can maintain soil moisture and prevent weed growth around plant. Generally black plastic mulch film is used in fruit production but two sided coloured plastics mulch films such as yellow/black, white/black, red/black or silver/black also used in specific crops, which determine its energy radiating behaviour and also influence the micro climate around the plant. Plastic mulch film having different thickness and choose based on type and age of plant. It available from 7 to 100 micron thickness but for medium duration crop 25 to 50 micron and for long duration crop 50 to 100 micron thickness is suitable. It has some other advantages like provides favourable soil moisture for development of roots and plants and ideal environment for earthworms and other soil micro-organisms beneficial for crops, prevents weed growth, improves soil micro climate, conserves water, effective in dry land farming, increases crop yield and keeps the crop clean, improves quality of produce, prevents soil erosion and run off, reduces soil compaction due to heavy rains. Nowadays LDPE (Low Density Polyethylene) and LLDPE (Linear low-density polyethylene) plastic covers use in mulching. The thickness used for plastic mulch is 25 to 40 micron in fruit cultivation.

DRIP IRRIGATION Precise and regulated application of irrigation water and plant nutrients at low pressure and frequent intervals through drippers/emitters directly into the root zone of plant with the help of close network of pipes is known as drip irrigation system. The advantages of drip irrigation are to improve quality, ensure early maturity of the crops, water saving up to 40% - 70%, controls weed growth, saving of fertilizer (30%) and labour cost (10%), fertigation /chemigation can be made efficiently, control diseases, use of saline water is possible, soil erosion is eliminated suitable for uneven/undulating land, high water use efficiency and increase in production and productivity of fruit crops. The most important feature of plastics in drip irrigation system is the unit made by plastics are rust proof.

Soil solarisation: Soil Solarisation is normally done during summer months when the air temperature more than 35°C. This is done by covering the moist soil with a transparent polyethylene film exposed to

sunlight. Soil solarisation can prevent weeds growth, occurrence of bacteria, fungi, nematodes and other soil borne pathogens and pests, helps in reducing usage of weedicides/herbicides and pesticides. The effectiveness of soil solarisation enhances plant growth by improving soil colour, structure, temperature, moisture etc. Soil moisture, day length, temperature and intensity of sunlight are the factors effecting soil solarisation. Suggested polyethylene film for soil solarisation is 25 micron transparent polyethylene film.

Protected cultivation: Greenhouse is a framed structure covered with glass or plastics film in which plants are grown under the partially or fully controlled environment. The plastics film used in greenhouse act as selective radiation filters. The solar radiations pass through it and trap the thermal energy inside the greenhouse, which is emitted by the objects that are kept inside, this phenomena is known as "greenhouse effect". The properties of cladding material are UV stabilized, transparent to light, anti-fogging and anti-algae. Green house cultivation is very important because it can moderates temperature and humidity, increases yield, quality and reduces crop duration, conserve moisture thus needs less irrigation, cultivation of off-season crops possible, helps to grow crops in different climatic conditions as it provide favourable condition to plant and to grow high value crops for export market. Moreover, it helps in raising early nurseries for different crops and also helps in hardening of tissue cultured plants and grafts. **Packaging:** Packaging is one of the most critical areas in the distribution and marketing of agricultural produce. More than 30% of agricultural produce is lost between the chain of farm and consumer. Plastic packaging is very important because plastics are flexible, light weight, cost effective, hygienic, transparent so product visible from outside, easy printable, reusable, increases shelf-life of the produce. It provides invaluable support during processing, used in making of different packaging materials like flexible plastic films, tray with over wrap, punnets, net bag, foam sleeve, crates and also used in storing, preserving and transporting of fresh as well as processed fruits.

Sleeving: Sleeving technique involves a cylindrical plastic bag of 16-18 micron thickness having both end open and is useful for protection of banana bunch from wind, rain, hail, dust, pest etc. It applies at the stage when finger start curl upward. It protects the skin of the fruit against leaf insect and bird damage as the fruit matures. Due to sleeving fruit size is more uniform and larger throughout the bunch and also fruit gets better colour.

EXERCISE-7

Objective: Different sex forms in papaya

Papaya is a polygamous species, many forms of inflorescence have been reported. In general there are three types of flowers namely staminate, pistillate and hermaphrodite. Storey (1958), however, classified papaya flowers into eight broad categories based on the modifications of sex expression.

1. **Staminate**
2. **Teratological staminate**
3. **Reduced elongata**
4. **Elongata**
5. **Carpelloid elongata**
6. **Pentandria**
7. **Carpelloid pentandria**
8. **Pistillate**

Staminate flower is produced by male plant, while teratological staminate flower is produced by sex reversing male plants. Pistillate flower is produced by female plants. Elongata, reduced elongata, carpelloid elongata, pentandria and carpelloid pentandria are normally produced by hermaphrodite plants. According to Storey (1958), there are 15 comparable classes found in male plants as well as in hermaphrodite plants. There are 32 heritable sex forms in papaya. Cultivated papaya belong to two major sex forms.

Dioecious : The seeds of dioecious form when grown segregate into male and female trees in the ratio of 1:1. These types are less influenced by environmental conditions. Occasionally during summer months, certain male trees (teratological staminate) staminate produce bisexual flowers which set fruits having viable seeds. This is called sexual ambivalence and such seeds produce male and female trees in the ratio of 1:2

Gynodioecious : The seeds of gynodioecious form when grown segregate in the ratio of 1:2. Andromonoecious tree bears bisexual as well as male flowers in one and the same inflorescence. Like teratological staminate trees, andromonecious trees are also influenced by changes in temperature. When temperature falls below 20ºC at flower development, the stamens of the bisexual flowers adhere to the ovarian wall, giving a mis-shapened fruit called cat-faced fruit or stamen carpellody. When temperature goes above 38ºC with low humidity, the flowers and fruits drop off. This phenomenon is called summer-skip. Gynodioecious varieties, are, therefore, not recommended for commercial cultivation for regions having extremes of temperature.

EXERCISE-8

Objective: Seed production in papaya, latex extraction and preparation of crude papain.

Seed Production: Papaya is commercially propagated by Seed. Quality of seed is most important for successful production and establishing papaya based industries. Soak seeds in 100 ppm GA3 for 16 hours or in 2% fresh leaf extract of arappu or 1% pungam leaf extract or pellet the seeds with arappu leaf powder. Sow seeds at 1 cm depth for better germination and seedling growth. Fruit size or weight has no association with seed quality except that the seed content is more in large fruits and less in small fruits. The seeds from different fruit weight or size classes did not differ in their quality. Hence, all ripened fruits can be used for seed extraction.

Seed extraction: Papaya seeds are produced by controlled cross pollination and maintaining isolation distance. Pollens from male parent are collected and hand pollinated on flowers of female plants of the same cultivar. The female flower is then prevented from foreign pollens by bagging. The bag is removed once the fruit set. Fruits are harvested semi ripe and ripened fruits in the shade. The seeds are extracted from the pulp, washed, dried and stored. The controlled cross pollination was reported to be the best carried out in August – September to maximize seed production. A ratio of 2:1 bisexual: female and male plants was recommended for seed production of Papaya Dry seeds to 8-10% moisture and treat with halogen mixture containing $CaOCl_2$, $CaC0_3$ and arappu leaf powder (at 5:4:1 ratio) @ 3g/kg and pack in cloth bag to maintain viability up to 5 months.

Papain: Papain is the proteolytic enzyme present in the milky latex obtained from green fruits of papaya. This enzyme is exclusively exported and there is great demand in the international market. Papain is used in medicines, cosmetics, tanning industry, tenderization of meat and fish, extraction of animal and plant protein from various animals and plants etc. Several proprietary pharmaceutical preparations using papain are available in the market now.

Papain extraction: Papain has several industrial uses, the important one being in brewing industries. It is used as "meat tenderiser" and in textile and leather "sanforization" processes and drugs. The method of extraction of papain from papaya fruits is simple. The latex should be tapped from immature papaya fruits. Fruits are select 75 to 90 days or 3 months from old fruits.

Tapping and collection of latex –On the selected fruit, give incisions (cut) with a razor blade or stainless steel knife. The cuts should be given from stalk to tip of the fruit. The depth of the cut should not more than 0.3 cm. Four such cuts are given spaced equally on the fruit surface. Tap the latex early in the morning and complete the tapping before 10.00 a.m. Repeat the tapping five times on the same fruit at an interval of four to five days. The cut should be given on the fruit surface in places not covered by previous cuts. Non metallic instruments should preferably be used in tapping and collecting, as the juice upon metals and gets discoloured. The latex should be collected in porcelain, glass or earthen containers. The latex collected from all the trees in a day should be pooled, shade dried in an aluminium pan or tray and passed through a 50 mesh sieve to remove all foreign matter.

Drying of latex -The drying must be done in the dry wether at low temperature, as at high temperatures the active principle of papain is destroyed. In large plantations, vacuum driers can be adopted with

advantage. Papain produced by artificial heating will have better colour and high quality. Add potassium meta-bi-sulphite (KMS) at 0.5 % for better colour and keeping quality. The latex should be dried very rapidly at temperatures of 50^0 to 55^0 C. Stop drying when the dried product comes off as flakes having a porous texture. Powder the dried papain by means of wooden mallets or in electrically operated granulators and sieves the powder through 10 mesh sieve. Pack the powder in polythene bags in convenient quantities and seal them. Put the sealed bags in a tin container and seal it after evacuating air. Exposure to air deteriorates the quality of papain and vacuum sealing is therefore necessary. For large scale manufacture of papain, vacuum sealing machine and a granulator will be useful. The green papaya fruits after extraction of papain can be used for pectin manufacture and "tooty – fruity" or they can be allowed to ripen and made into other products. The annual yield of papain per plant or per acre varies greatly according to the variety, its fruiting vigour and the culture adopted in different climatic conditions. The yield of crude papain is as CO 2 : 600 kg/ha and CO 5 : 800 Kg/ha. The market price of papain usually fluctuates between Rs. 300 to Rs. 500 per Kg. according to its quality.

EXERCISE-9

Objective: Preparation and use of plant growth regulators in fruit crops

The term plant growth regulator is relatively new in use. In earlier literature these were mentioned as Hormones. ―*Hormone* is a Greek word derived from ―*hormao* which means to stimulate. Now the term phytohormone is used in place of plant hormone.

Plant growth regulators or plant regulators are the organic compounds other than nutrients which modify or regulate physiological processes in an appreciable measure in the plants when used in small concentrations.

The various types of growth regulating substances are:

1. **Auxins –** IAA, IBA, NAA, 2-4D, 2-4-5T
2. **Gibberellins –** GA_3
3. **Cytokinins –** Zeatin, Kinetin, BA
4. **Ethylene –** Ethrel, Ethephon
5. **Retardents –** CCC, Paclobutrazol
6. **Inhibitors –**ABA, MH

Most important uses are:

1. **Propagation of plants: -** IBA
2. **Control of flowering: -** Ethylene - Pineapple
3. **Fruit set and development: -** NAA, TIBA, GA, PCPA, 2-4D
4. **Fruit thinning: -** DNOC – 4,6-Dinitro-o-cresol, NAA - Apple
5. **Fruit drop: -** 2-4D - Citrus, NAA - Mango
6. **Parthenocarpy: -** IAA, NAA, IBA and GA - Papaya
7. **Fruit ripening: -** Ethylene
8. **Fruit size and quality: -** GA- Grape
9. **Sex expression: -** GA, Etheral
10. **Use plant tissue culture: -** IAA, BA - Banana
11. **Control of vigour: -** CCC or Alar
12. **Weed control: -** 2-4D

Methods of Applications –

1. Solution immersion/prolonged soaking in dilute solutions -
2. Quick dip in concentration solutions-
3. Spraying the plants-

Procedure –

1. Accurately weigh the required quantity of PGR crystals on chemical balance or electronic balance.
2. Take the weighed PGR in volumetric flask.
3. Add 95 % ethyl alcohol slowly till complete PGR crystals/powder is dissolved.

4. Add distilled water and make the required volume.

EXERCISE-10

Objective: Ripening of fruits

Introduction: Ripening is the process by which fruits attain their desirable flavour, quality, colour, palatable nature and other textural properties. Ripening is associated with change in composition i.e. conversion of starch to sugar. On the basis of ripening behavior, fruits are classified as climacteric and non-climacteric fruits.

Climacteric: Climacteric fruits are defined as fruits that enter 'climacteric phase' after harvest i.e. they continue to ripen. During the ripening process the fruits emit ethylene along with increased rate of respiration. Ripe fruits are soft and delicate and generally cannot withstand rigours of transport and repeated handling. These fruits are harvested hard and green, but fully mature and are ripened near consumption areas. Small dose of ethylene is used to induce ripening process under controlled conditions of temperature and humidity. Climacteric fruits are: Mango, Banana, Papaya, Guava, Sapota, Kiwi, Fig, Apple, Passion fruit, Apricot, Plum, and Pear

Non-Climacteric: Non-climacteric fruits once harvested do not ripen further. Non-climacteric fruits produce very small amount of ethylene and do not respond to ethylene treatment. There is no characteristic increased rate of respiration or production of carbon dioxide. Non-climacteric fruits are: Orange, Mousambi, Kinnow, Grapefruit, Grapes, Pomegranate, Litchi, Watermelon, Cherry, Raspberry, Blackberry, Strawberry, Carambola, Rambutan and Cashew. In order to improve external skin colour and market acceptance, citrus like orange, lemon, mousambi and kinnow can be treated with ethylene, as a de-greening agent. Ethylene treatment breaks down the green chlorophyll pigment in the exterior part of the peel and allows the yellow or orange carotenoid pigments to be expressed.

Technologies for ripening of fruits Lack of easier and rapid methods for uniform ripening poses a major problem in the fruit industry. Almost all methods of ripening, either conventional or the modern chemical methods, come with their own merits and demerits. There are several simple technologies and methods available today for farmers for proper ripening. Normally, the number of days taken for edible ripening varies for different fruits and prevailing climatic conditions. For instance, it takes about 5 to 6 days for mangoes and 6 to 7 days for sapota to ripen. Under natural conditions, ethylene, a ripening hormone produced by the plant plays a major physiological role in the ripening process.

1. A simple technology practiced in households to trigger ripening is to keep unripened and ripened fruits together inside an air tight container. Since the already ripened fruits release ethylene, ripening will be faster.
2. Another method is to place the fruits intended for ripening inside an air tight room and induce ripening through smoking inside smoke chambers. Smoke emanates acetylene gas. Several fruit traders follow this technique to achieve uniform ripening especially in edible fruits like banana and mango. But the major drawback of this method is that the fruits do not attain uniform colour and flavour. In addition, the persistence of smoke odour on the product impairs its quality.
3. Spreading unripe fruits as layers over paddy husk or wheat straw for a week to ripen is an another alternative. Another practice is that some farmers dip unripe mature fruits in 0.1 per cent ethrel solution

(1 ml of ethrel solution in 1 litre of water) and wipe it dry. The fruits are then spread over a newspaper without touching each other and a thin cotton cloth is covered over this. In this method, the fruits will ripen within two days.

4. In one of the simple and harmless techniques, 10 ml of ethrel and 2 gm of sodium hydroxide pellets are mixed in five liters of water taken in a wide mouthed vessel. This vessel is placed inside the ripening chamber near the fruits and the room is sealed air tight. About a third of the room is filled with fruits leaving the remaining area for air circulation. Ripening of fruits takes place in about 12 to 24 hours. In order to reduce the cost of chemical, some ethylene releasing fruits such as papaya and banana can also kept in the same room.
5. Ethylene gas filled in pressurized cans promote fruit ripening in 24-48 hours
6. Fruit ripening using calcium carbide: Most climacteric fruits in India are ripened with industrial grade calcium carbide. Industrial-grade calcium carbide usually contains traces of arsenic and phosphorus, and, thus, use of this chemical for this purpose is illegal in most countries. In India too, use of calcium carbide is strictly banned as per PoFA (Prevention of Food Adultration) Act [Section 44AA]. Calcium carbide, once dissolved in water, produces acetylene which acts as an artificial ripening agent. Acetylene is believed to affect the nervous system by reducing oxygen supply to brain. Arsenic and phophorus are toxic and exposure may cause severe health hazards.

   The only safe and worldwide accepted method is using ethylene, which is a natural hormone for ripening when done under controlled temperature and relative humidity conditions. Ethylene being a natural hormone does not pose any health hazard for consumers of the fruits. It is a de-greening agent, which can turn the peel from green to perfect yellow (in the case of bananas) and maintain the sweetness and aroma of the fruit, thus value addition in the fruit is possible as it looks more appealing. It has been known for a long time that treatment of unripe fruits with ethylene would merely stimulate natural ripening until the fruit itself starts producing ethylene in large quantities. Method selected for applying ethylene depends on cost, convenience and safety factors. Use of diluted ethylene gas mixtures is safer than using pure ethylene, which is explosive and flammable at concentrations of 3% or higher. Fruit to be ripened ideally is placed in an airtight ripening room maintained at a constant temperature (18-21^{o}C for most fruits, but 29-31 ^{o}C in mango).

   Degreening: Controlled degreening sometimes is carried out on citrus grown in tropics. Many citrus cultivars mature before green colour disappears from peel. Breakdown of chlorophyll and production of a rich orange colour require exposure to low temperature during maturation, and this explains why mature citrus frequently is sold green on markets in humid tropics, where even night temperatures may not drop much below 25 ^{o}C. The ceiling of room is relatively high, allowing boxes to be stacked at least four boxes high. A false ceiling is added to provide for adequate air

EXERCISE-11

Objective: Grading and packaging of fruits.

Grading: It is basically separating the material in different homogenous groups according to its specific characteristics like size, shape, color and on quality basis. It saves time and energy in different processing operations and reduces the handling losses during the transportation. Generally grading is done on the basis of size, shape, weight, color etc. Here a number of studies are demonstrated the application of various types of sorter and grader used in the processing of sorting and grading different types of fruits. Grading, sorting, and sizing are based on soundness, firmness, cleanliness, size, weight, colour, shape, maturity, diseases, insect damage and mechanical injury. They are grouped in size. This is an important procedure to be followed in post-harvest handling, before packaging storage, transport or marketing to minimize loss and maintain quality.

Packaging: Packaging is done for more efficient handling and marketing, greater appeal, more potential life. Packaging requirement vary with different fruits. Packaging cannot improve quality. Hence only best possible produce should be packed. Inclusion of decayed or damaged produced in bulk or consumer packages may become a source of infection and reduce the sale at the market. Packaging is not a substitute for refrigeration; packaging combined with refrigeration is the best methods. A good package is aim to protection of product from physical. Physiological and pathological deterioration causes throughout storage, transport and market.

Benefits of packaging:

1. Packaging serves as an efficient handling unit.
2. It serves as a convenient storage unit.
3. Packaging protects quality and reduces waste.
4. To Provides service and sales motivation.
5. Reduces cost of transport and marketing.
6. Facilitates use of new modes of transportation.

Material for packaging: -wooden boxes, bamboo basket are the conventional packs. Fibre board cartoons, corrugated card boards, and several flexible plastic packaging.

Types of packing

1. **Bundles –**
2. Box packing – fruits are poured into the carton, after filling pack is vibrated to tight packing within box (eg. Apple, orange etc.) on a standard weight.
3. **Package insert –**Moulded pulp or plastic trays to isolate the individual fruits.
4. **Wrapping –** covering individual fruits with paper/various film eg. Papaya,
5. **Bags –** Like gunny bag, hessian bag in crops such as ber.
6. **Punnet packing –**Soft fruits such as strawberry, grapes.

Pre-packaging (consumer size packing): Pre-packaging is generally defined as packaging the produce in consumer size units either at producing centre before transport or at terminal markets. Packaging of fresh produce in consumer unit packs protects the produce against the damage and excess moisture loss.

Advantages of pre-packaging of produce

1. Pre- packing in clear plastic bag helps restrict weight loss and acts as a MAP
2. Reduces transportation cost by eliminating unwanted/ inedible portion of produce
3. The space required for shipping and storage is less.
4. It has a better eye appeal as the produce is pre-packed in attractive film and the quality of the produce can be seen from outside without opening the pack.
5. Pre-packaging has quick turnover because of the recent development of automatic machines.
6. It saves labour costs, makes the produce easy to handle and sale.

Disadvantage

1. Consumer sometimes worried about the quality of the pre-packaged items and still opts to select items from an open display (e.g. local market, shandy/santhe).
2. Pre packing is restricted to retail malls in cities and other important places of interest.

Cushioning materials: The cushioning material used for packaging fruits/vegetables are dry grass, paddy straw, leaves, saw dust, paper shreds, thermocol, foam nets (apple, pear, citrus).

Wrapping: Covering the fruits after harvest with any material in order to improve its post-harvest life is known as wrapping. The materials commonly employed as wrappers are old newspaper, tissue paper, waxed paper, shrink film, poly film, Pliofilm, Cellophane paper, aluminium foils and alkathene paper etc.

Vacuum packaging: The vacuum packaging referred to the removal of all air within the package without deliberate replacement with another gas. It widely used for nuts and grains

Corrugated Fiberboard boxes: Corrugated fibreboard is manufactured in many different styles and weights. Because of its relativity low cost and versatility, it is the dominant produce container material.

Advantages of CFB cartons over the conventional wooden boxes:

1. To minimal bruising damage.
2. To Easy handling and stacking.
3. More economical transport.
4. Can be turned quickly into highly precise and accurate size.
5. Can be appropriately punched, ventilated, printed low cost.
6. Made pilfer-proof and reveal tampering at a glance.
7. Offer the most acceptable packaging in the international markets.
8. Collapsible and occupy less volume for storage of empty cartons.
9. Cartons can be used for cold storage conditions giving water proof treatment.

10. It can be made stronger by reinforcing with Hessian or nylon fibre.

Plastic containers and paper trays: Another alternative to the wood for packaging is plastics. Use of plastics in packaging of fresh horticultural produce helps in minimizing the cost of packaging materials and makes the whole process less dependent on scarce materials like wood, thereby, resulting in conservation of environment.

EXERCISE – 12

Objective: Production economics for tropical and sub-tropical fruits

Economics of cultivation –Cost of cultivation is worked out for three years because in the first year only the inputs are involved and return will start from second year on wards.

Sr. No.	**Cost of input**	**1st Year**	**2nd Year**	**3rd Year**
1.	**Raising of nursery -** Bed making, FYM and seeds (500 gm) Transplanting	 300 600	 - 	 -
2.	**Preparatory cultivation –** Ploughing, pits and filling of pits	 10000	- 1200	- 1200
3.	**Manuring** Urea (1600 kg) SSP (4650 Kg) MOP (2600 kg) Labour	 8000 8000 6000 6000	3400 4400 3300 600	3400 4400 3300 600
4.	Intercultural operations	5000	500	- 1200
5.	Plant protection	2000	500	500
6.	Irrigation 40 irrigation @ Rs. 100 /irrigation	4000	500	500
7.	Harvesting	1000	1000	500
	Total input cost	50900	16900	1000

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

Sr. No.	**Income from fruits**	**Rs.**

1.	Total yield for 3 years - 200 t/ha. @ 600/- tonnes	**1,20,00**
2.	Cost of inputs 3 years/ha	**54,300**
3.	Net profit for 3 years/ha	**65,700**
4.	Net profit for 1 years/ha	**21,900**