Harvesting, Handling and Storage of Fruits

One of the most important periods in the life of fruits is from the time it picked until it is disposed to the consumer. This period is commonly referr as 'post harvest life'. Fruits and vegetables are living organisms and high perishable commodities. These are affected by a number of factors leadi to the post harvest spoilage. The total losses in fruits are estimated to 20–30% amounting to nearly Rs. 8000 crores annually depending upon fruit varieties and post harvest handling systems. This may vary from f to fruit; 14% in apple, 20–80% in banana, 40–100% in papaya and 35–10 in potato and 60–85% in onion. The magnitude of these losses in develop countries like India is comparatively higher due to a variety of reasons; ma lack of infrastructure needed for post harvest management of the perisha and poor utilization of the fruits and vegetables by processing industry

The various causes for losses are

1. Loss of moisture, causing wilting/ shrinkage
2. Loss of stored energy
3. Loss of food constituents
4. Physical loss through pest and disease attack
5. Loss due to physiological disorder
6. Fibre development

7. Greening
8. Root/shoot growth
9. Seed germination
10. Other causes–Micro organism, Insects, Rodents and action of enzymes.

POST HARVEST TECHNOLOGY

The post harvest technology may be defined as those techniques (methods) which reduce the post harvest losses and help economic utilization of crops (including waste) to the maximum as fresh produce or to make nutritious, safe and stable products. To reduce the losses, we must understand the biological and environmental factors involved in deterioration of the perishables and secondly to use the post harvest technological procedures to achieve the same. Basically, enzymes, micro organisms, pests and the environmental factors are responsible for spoilage of these crops. From this point of view, any method which prevents enzymatic activity of plant or microbe and their activities would increase the post harvest life. Thus, post harvest technology involves multi disciplinary approach with horticulture, plant nutrition, pathology, microbiology, biochemistry and physiology, food science and technology and engineering.

PRE-HARVEST FACTORS

Many pre-harvest factors decide the post harvest life of horticultural produce.

1. Maturity and maturity indices

The post harvest quality and storage life of fruits are controlled by maturity. If fruits are harvested at a proper stage of maturity, their quality is excellent. Vegetables are harvested as and when they attain maximum size and yet are tender. Over maturity in root crops causes sponginess and pithiness. Their harvesting should not be delayed. Delay in harvesting of onion and garlic reduces their storage quality.

Maturation is the stage of development leading to the attainment of physiological maturity (when a plant or plant parts will continue ontogeny even if detached). On the other hand, horticultural maturity refers to the stage at which a plant or plant parts possesses the pre-requisites for utilization by the consumer for a particular purpose.

Methods to Determine the Proper Time to Pick the Fruits

1. *Maturity tests*

Following are the rough but ready maturity tests of fruits employed to pick the well matured fruits:

(a) Colour change is one of the criteria to judge the maturity of fruits. The change of peel colour from green to yellow is the main criterion to test maturity in mangoes. Similarly in papaya change of colour at apical end of the fruit indicates the full maturity stage. In the case of pineapples nearly 25% of the fruit surface should have turned to yellow colour.

(b) Increase in size.

(c) Softening of the tissue of the fruits. e.g. Figs and grapes.

(d) Ease of detachment from the stalk. e.g. Sapota and annona.

(e) Shriveling of fruit stalk. e.g. Watermelon.

(f) Sound by tapping-jack and watermelon when ripe produce hollow and dull sound on tapping but produces metallic sound if unripe.

(g) Days from full bloom i.e. **DFFB** is based on the apparent effect of temperature on flowering and fruit development which suggests the use of degree days or heat summation for the more accurate prediction of harvest data. Accumulated heat units for a fruit crop's optimum maturity is computed by calculating the time in relation to temperature above a certain minimum base temperature. For example, in apple the base temperature is fixed as 50°F and a day with an average temperature of 68°F (20°C) would provide 18 degree days F (10° days C) of heat units. A day with an average temperature of 41°F (5°C) would provide zero degree days of heat units. Based on this, heat requirement of certain fruit crops is worked out as below:

Fruit	*Cultivar*	*Cut out or base temperature*	*Degree days*
Apple	Red Delicious	50°F	1659-1705
Grape	Thompson Seedless	50°F	1600-2000
Mango	Banganapally	18°F	1426±5
Banana	Cavendish	9.8°C	1930

2. Accurate tests

(a) Colour charts

Charts are prepared for indicating colour at different stages of maturity. By referring to this ready chart, one can easily judge the correct stage of maturity

(b) Penetrometer

It is an instrument which indicates or measures the softening of tissues as an index of maturity. It chiefly helps in determining when fruits are too soft and ripe to storage rather than when picking should begin. Firmness of the flesh can be assessed by removing a thin slice of the skin and flesh with a knife and using a special hand operated tester which records the kilogram of pressure (kg/sq. cm) for the plunger to penetrate the flesh.

(c) Sugar/acid or Brix/acid ratio

This is based on the principle that acid content reduces and sugar increases on ripening. The fruit growers should bestow more attention and considerable care during the picking season to reduce to a minimum level of careless handling of fruits by pickers.

1. Picking must be commenced from the lower branches of a tree advancing towards the top in order to reduce dropping of fruits to the minimum.
2. As far as possible, dropping of the fruits from the tree should be avoided to avoid any possible physical damage.
3. During picking, care must be taken to avoid any possible damages to the branches especially to the spurs as the subsequent cropping depends upon them.
4. Picking early in the morning is always best. Picked fruits should be kept in shade and excluded from sun. After picking, the fruits must be kept in the coolest place available which is well ventilated to arrest respiration and break down as much as possible.
5. There should not be any bruises in the fruits while picking as it will lower the marketable quality.
6. If picking is done in mid-day or hot weather, fruits should be kept in a shed overnight to cool.
7. The time of picking depends upon the following factors:
   - (i) **Variety:** Certain varieties will ripen only in trees and certain others will ripen even when they are harvested 3/4th maturity stage.
   - (ii) **Purpose:** For which it is meant, for example, tomatoes meant for table purposes can be harvested at red ripe stage whereas for distant market they may be harvested during breaker's (colour changing) stage.
   - (iii) **Distance to market:** The closer is the market; ripe fruits may be picked and distant is the market, mature green stage may be

harvested so that when the fruits reach the point of consumer, it will be ripe. In order to maintain good quality, storage capacity and commercial value, it is highly important that they should be picked at the proper stage of maturity. Prematurely picked fruits are generally small, poorly coloured, sour, tough and inferior in quality. Therefore, it is important that fruits should be allowed to remain in the tree as long as it is possible as it continues to increase in size when it remains upon the tree.

Handling

Handling includes all processes from picking to delivery or disposal at the consumer point. This includes the treatments given for getting the fruits ready for the market *viz.*, packaging and wrapping, ripening and storage. One of the important treatments is the dipping the fruits in antiseptic solutions like 1–2% caustic soda to remove the dust and infestation of scale insects and washing with 1–1.5% of Hydrochloric acid to remove any spray residue and to improve the appearance.

Pre-cooling

It refers to the rapid removal of the field heat from the freshly harvested fruits and vegetables in order to slow down ripening and reduce deterioration prior to storage and shipments. Different methods are adopted to precool the fruits, the important ones are (i) air cooling in which the fruits are kept in a cold room, (ii) hydro cooling-dipping of the fruits in cold water or by spraying cold water on the fruits and (iii) vacuum cooling—a costlier technique in which the atmospheric pressure is reduced so as to reduce the pressure of water vapour in chamber which results in evaporation of water from fruits which bring down the temperature. Vacuum cooling causes about 1% weight loss in the produce.

Grading

Grades or grading refers to the assortment of the fruits into different groups based on certain characters. This includes colour, firmness, soundness, free from blemishes and size of the fruit. Grading is a good market practice which improves the mutual confidence of salesman and consumer.

In India, grading is mostly done on the basis of size. But in the developed countries, grading is a rule and for example, the U.S. Department of Agriculture prescribes the following grades to apples in the U.S.A.

(i) U.S. Extra fancy
(ii) U.S. Fancy
(iii) U.S. No.1
(iv) U.S. Commercial

In India, grading of fruits like apple, plum, pear and mango varieties like Alphonso, Rumani, Bangalora and Sathugudi is done by Agmark mainly based on size only. For vegetables like tomato and brinjal grading is being followed to some extent for specialized city markets. The Indian standards Institute has specified four grades *viz.*, Super A, Super, Fancy and Commercial for tomato and three grades *viz.*, Super, Fancy and Commercial for brinjal.

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 tissue papers, waxed paper, pliofilm, cellophane paper, aluminium foils and alkathene paper etc. Wrapping has the following advantages:

(i) It minimizes the loss of moisture in shriveling,
(ii) It protects against the spread of diseases from one to the other,
(iii) It reduces bruises,
(iv) It reduces damage during transport or in storage and
(v) It makes the fruit more attractive.

Care must be taken to see that wrap is not too impervious to the passage of oxygen and carbon-di-oxide. Pre-packing of banana fruits is done in 100 gauge polythene bags under room temperature and cold storage.

Waxing

Another treatment given to the fruits during handling is waxing. Waxing of fruits helps in reducing the moisture loss, improving the appearance of fruits and reduces the incidence of storage diseases. Wax emulsion is prepared by melting microcrystalline paraffin or cranaube wax along with emulsifiers. Boiling water free from hardness is slowly added to the molten ingredients and thoroughly stirred in order to make a stable emulsion. The harvested fruits are dipped in dilute wax emulsion for a minute and then these fruits are completely dried for 10–15 minutes. Care must be taken that excessive quantities of wax are not applied to the fruit. If the wax is not sufficiently diluted or if it is so thick, CO_2 and O_2 cannot readily pass through to and from the fruit. Mango fruits treated with wax emulsion containing 8 to 12% solids have one or two weeks longer storage life than the untreated ones.

Packaging and Packing

The term packaging encompasses both the direct or primary packaging around the product and the secondary and tertiary packaging, the over packaging such as over warts, cartons and crates etc. Proper packaging is essential otherwise the spoilage of fruits and vegetables are more in our country.

A packing material should be sturdy and it should protect the fruits in transport, more specifically it must be economical. The materials that are generally used in India for fabrication of package of fruits and vegetables are bamboo, wood, gunny bags, plastic films, fibre and plastic corrugated boards etc. Bamboo baskets and wooden crates of different shapes and sizes are used for a number of perishable commodities. Mupots, gunny bags and palmyrah mats are also used for a variety of purposes. Bamboo baskets are though relatively cheaper, they have many disadvantages like (i) the low dimensional stability and inability to withstand stacking load (ii) they are not strong enough to withstand rough handling. Packaging of grapes in mud pots is quite common in South India. It is often observed that during transport, the mud pots break and the contents get damaged. Though the mud pot has its own advantages as a container for grapes and such other fruits, it has to be handled very carefully thus affecting the speed of handling. In some cases like mango, pineapple, banana etc., a straight load is practiced in certain regions. For example, banana in bunches are loaded without any packaging into the railway wagons or trucks and transported from Maharashtra to Delhi. Similarly, mangoes are transported from South to North and pineapples are shipped from North East India and Kerala to different regions. In these cases, it has been observed that the losses due to spoilage are considerable.

Prepackaging

Prepackaging 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. The packaging material used should have the following properties:

(a) Sufficient permeability to oxygen, carbon dioxide and water vapour
(b) Desired protective physical properties
(c) Transparency.

The permeability requirement depends upon rate of respiration of the produce, the package bulk density and temperature of the storage. The prepacking of fruits and vegetables has multiple advantages:

1. It reduces the transportation cost by eliminating unwanted and inedible portion of fruits and vegetables.
2. The space required for shipping and storage is less.
3. It has a better eye appeal as the produce is prepacked in attractive film and the quality of the produce can be seen from outside without opening the pack.
4. Prepackaging reduces the shopping time of the consumer as the produce is graded before being prepacked.
5. By increasing the shelf-life both at room temperature and refrigerated conditions, prepackaging helps the grocer to market his produce over a longer period and thereby, avoid losses due to spoilage.
6. Prepackaging has a very quick turnover because of the recent development of automatic machine.
7. It saves labour costs and also makes the produce easy to handle.

Among the different types of packaging films, polyethylene film finds the maximum use. The shelf-life of asparagus is extended to 5–6 days or upto 2 weeks under ideal conditions when wrapped in special plastic film. Polyethylene bags of 100 gauge thickness even without ventilation could be used as prepackaging of brinjal, okra. Perforated polyethylene bags are also found to be suitable as prepacking material for packaging of Alphonso mangoes.

Cushioning Materials

The cushioning materials used for packaging fruits and vegetables are dry grasses, paddy straw, leaves, saw dust, paper shavings etc. The properties of good cushion materials are

1. It should have a resilient property.
2. It should have the ability to dissipate the heat of respiration of produce.
3. It should not carry any infective pathogens or it should not injure the soft fruit in any way.
4. It should be physiologically inactive.

Recently pulp tray, comb partition, cell pack etc. are used as the cushioning materials.

The expansion of horticultural industry has created a crisis with respect to the availability of wooden packaging cases. With the existing scare resources of wood, the ever increasing demand for wood cases cannot be met. Hence, considerable work has been done by different agencies on the introduction of alternative packaging. This included wire bound wooden cases, hard board, ply board, fibre board, pine needle case, corrugated fibre boards (CFB) and plastic board etc. The CFB boxes can be fabricated from draft paper made from bamboo, long grasses and many other types of agricultural residues like paddy and wheat straw, cotton and jute stick and recycled paper and cardboard. On account of severe shortage of fuel wood, timber boxes to a large extent find their way for use as firewood while all the CFB cartons are recycled as pulp or paper. CFB is also the suitable package material for cut flowers since they have isothermic properties. The CFB cartons offer added advantages like (1) Minimal bruising damage-research conducted showed that apples in CFB cartons had only 5% loss as against 30% in conventional packing (2) 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 at 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 empties (9) can be used under cold storage conditions after giving water-proof treatment (10) can be made by reinforcing with hessian or nylon fibre.

Another important alternative to wood for packaging is plastics. Various plastic materials which can be used to package fruits and vegetables are

(a) Polypropylene boxes
(b) Molded expanded polystyrene boxes
(c) Stretch film
(d) Film wrap and
(e) Polyethylene net

Among them, polypropylene corrugated box has very good properties and can be used for horticultural produce, especially for apple. One main added advantage of this material is that this can be reused quite a few times.

Pelletization

Loading and unloading are done manually in India. Due to low unit load, there is a tendency to throw, drop or mishandle the package, damaging the commodity. This loss can be considerably reduced by using pellet system. However, this requires the standardization of box dimensions. For each commodity it should be worked out. Once this is accomplished, mechanical loading and unloading become very easy with the fork-lift system.

Storage of Fruits

Production of horticultural produce is limited by certain climatic conditions and through proper storage of fruits; the availability of the produce is extended. In this way, the reasonable prices are ensured to the fruit growers and the dumping of fruits (glut) in the market is avoided. Consumers on the other hand are able to get fruits at reasonable price.

Factors influencing storage: In general horticultural produces contain large amount of water as compared to cereals. Fruits and vegetables contain about 85% and 95% moisture content respectively. All the fruits and vegetables are living tissues and the act of harvesting upsets the balance of living processes existing during the growth. The physiological processes like photosynthesis and water uptake stop in the harvested produce but the transpiration (loss of water) continues. The development of certain diseases can progress unhindered and the chemical changes progress rapidly (starch to sugars). Any storage procedure should aim at slowing down, regulating or preventing these changes taking place.

Following factors are associated with storage of fruits.

1. Temperature

Fruits are alive and they continuously carry on respiration even after harvest. The faster a fruit respires faster it ripens. Therefore, the basic objective in the storage should be to keep this destructive process minimum. This rate of respiration can be controlled by temperature. Low temperature can also slow down the respiration considerably and prolong the storage life of fruits. Each fruit has a specific critical temperature which has to be determined for successful storage.

2. Humidity

As fruits and vegetables relatively contain a large percentage of moisture, maintaining a high humidity during storage will minimize transpiration. Otherwise the produce will shrivel and lose quality. A relative humidity ranging from 85-95% is essential.

3. Storage atmosphere

In addition to oxygen and carbon-di-oxide, other gases may affect the storage of fruits or damage the fruits. Ethylene gas which is released during ripening of fruits will hasten ripening of other fruits also. CO_2 is continuously produced by the respiration of the produce kept in the storage and may accumulate to a dangerous extent. This storage atmosphere can be improved by ventilation which means introduction of outdoor air into the storage room. Ideal storage temperature and relative humidity for some of the important crops are given in Table 11.1.

Table 11.1 Storage requirement for important fruits and vegetables

Name of the fruit/vegetable	*Storage temperature °C*	*Relative humidity %*	*Approximate storage life*
Apple	0.2.0	85–90	4–8 months
Grapes	0.2.0	80–85	2–4 weeks
Peaches	0.2.0	80–85	2–4 weeks
Plums	0.2.0	85–90	4–8 weeks
Bananas	12.5–14.5	85–95	3 weeks
Mangoes	9.0–10.0	85–95	4 weeks
Oranges	6.0–6.5	85–90	18 weeks
Papayas	4.5–6.0	80–85	5 weeks
Guavas	9.0–10.0	85–90	3 weeks
Tomato-ripe	0–4.5	85–90	10 days
Tomato-mature green	10.0–15.0	85–90	30 days
Peas	0–0.5	90–95	2 weeks

Methods of Storage

1. **Air cooled storage:** Fruits are placed in racks in the insulation building. By keeping the ventilators open at night to admit the cool night air and shut down during the day to keep off the warm dry air, the storage rooms can be kept cool. Fruits should not be heaped but spread at racks. Affected fruits should be removed.
2. **Air cooled storage-refrigerated with ice:** A few storages are filled with ice and salt and equipped with fans for quick cooling of the fruit during warmer periods.
3. **Treating with wax emulsions:** In the absence of cold storage facilities, certain fruits and vegetables can be stored by this method. Fruits are dipped for a minute in a wax emulsion and dried completely for 10 to 15 minutes.
4. **Refrigerated storage:** It has many advantages. (1) Prompt cooling of products. (2) Maintenance of optimum relative humidity (3) an even holding temperature with 1.0 to 2.0°C fluctuations. (4) No need to depend upon the external conditions of air, their movement etc. and (5) Most efficient and scientific way of storing. Refrigerated storage involves the use of **refrigerant**. It is a liquid that evaporates or boils at temperatures and relatively at low pressure. When the liquid refrigerant boils and changes to gas in the storage room coils, it absorbs heat from the stored product. The gas with the heat is then piped outside storage room where it is compressed and passed through a condenser which absorbs and dissipates the heat and then changes

the gas back liquid for repeated use. Refrigerants commonly used are Freon, ammonia and methyl chloride. Freon is most popular, odourless, and not toxic but leaks are difficult to locate. Ammonia gas is toxic if it escapes in large quantities. The commonly used temperature and relative humidity to store fruits and vegetables are furnished in Table 11.1.

5. **Controlled atmospheric storage (CAS storage):** By reducing the O_2 supply available to the fruit and by increasing the amount of CO_2 around the fruit or by lowering the temperature, the respiration rate can be slowed down in fruits and vegetables. A combination of all the above principles is involved in the controlled atmospheric storages. Sometimes, oxygen is replaced by nitrogen in the storage room. Apple can be stored in CA storage with 10% of CO_2 and 11% O_2 with a temperature of 4°C. A modification in the controlled atmospheric storage is the use of sub atmospheric pressure to store the horticultural produce. This method is known as 'hypobaric storage' (HBS). In this method, all partial pressures of the various gases including water vapour are reduced. This atmosphere reduces the respiration rate, ethylene synthesis (a gas which hastens ripening) and the rate of other metabolic processes. Therefore, shelf life of many fruits and vegetables including ornamental flowers get extended.

   Recently in modified atmospheric storage method maintaining the relative humidity at 90 to 95% is recommended for the storage of green vegetables and other root and tuber vegetables to prolong the storage life. This method reduces the loss due to decay and moisture evaporation.

6. **Preservation by irradiation:** Potato, onion, garlic and other root crops lose their commercial value by sprouting or rooting during storage. These processes can be delayed by irradiating the produce with gamma rays. Potatoes treated with 10 KR of gamma rays prolong the storage life upto one year with least loss in weight. In small onion, gamma ray treatment keeps the bulb fresh upto 150 days in storage. This irradiation treatment also checks the infectivity of storage pathogens. Irradiation at low dose levels can delay ripening and over-ripening of tropical fruits like bananas, mangoes and papayas, when treated mature but unripe. Various studies conducted at BARC have revealed that at ambient temperature, shelf-life of irradiated mangoes (0.25 kGy) is enhanced by 5–7 days and there is an increase of about ten days in shelf-life of bananas when irradiated at 0.25 to 0.35 kGy.

7. **By use of chemicals:** There are certain chemicals other than fungicides which increase the shelf-life of fruits by delaying the ripening

and senescence. Potassium permanganate, an ethylene absorbent proves effective in the complete absorption of ethylene from banana held in sealed polyethylene bags. Mangoes dipped in 1000 to 2000 ppm of Maleic hydrazide delays ripening. Storage life of citrus fruits is prolonged by the application of 2,4-D and 2,4,5-T. The storage potential of fruit is largely dependent on the level of calcium. Any other nutrients which disturb the calcium content also adversely affect the shelf life of the fruits. The higher levels of N, P and Mg and low levels of K and B leads to the calcium deficiency in fruits and reduce its storage life. Calcium treatment delays ripening and senescence and improves the quality of fruits and vegetables. Pre-harvest spray of Calcium chloride (0.6%) and Calcium nitrate (1%) helps in the enhancement of shelf-life of mango and guava. Exogenous calcium application is known to get incorporated into protopect in molecules in the middle membrane and retard hydrolysis during post harvest ripening, inhibit fruit softening and extend storability of fruits.

8. **Evaporative cooling (cool chambers):** Evaporation of water produces a considerable cooling effect and this evaporative cooling occurs when air that is not already saturated with water vapour, is blown across any wet surface. Cooling chambers work on the principles of evaporative cooling. This structure essentially contains a single layer of bricks as floor and a double layer of bricks as side wall with an interspace of 7.5 cm wide filled with river sand. The top of the storage space is covered with plaited vetiver roots or gunny cloth in a bamboo structure (Fig. 11.1). Once the cool chamber is saturated with water, sprinkling of water once in the morning and once in the evening is enough to maintain the temperature and humidity. These storage chambers maintain a very high humidity of about 95% throughout the year and it can reduce the temperature during summer months and increase the temperature during peak winter months. These chambers are ideal for storage of fresh fruits and vegetables for a short period. Firm ripe mangoes can be stored upto 10 days as against 4 days under room temperature. Similarly, citrus fruits like grapefruit and orange can be stored upto 60–90 days as compared to 8–15 days in ambient room temperature.

Ripening of Fruits

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

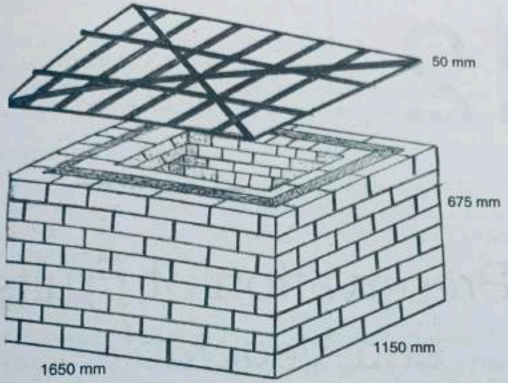

Figure 11.1 Cool chamber.

Accurate quantity of ethylene should be used in the ripening room at regular intervals. A concentration of CO_2 above 1% delays ripening. Hence, thorough ventilation is essential. By use of Ethephon commercially known as ethrel or CEPA (7 fluid ounces release 1 cft of ethylene), making it alkaline using caustic soda (3 g of caustic soda for 20 ml of Ethephon). Calcium carbide can also be used for ripening (100 g for 100 kg fruits).

DEGREENING

Degreening is the process of decomposing green pigments in fruits usually by applying ethylene or other similar metabolic inducers to give a fruit its characteristic colour as preferred by consumers. It is applicable to banana, mango, citrus and tomato. The time required to degreen a fruit depends upon the degree of natural colour break and maturity. The higher the green colour and more mature a fruit is, the less time is required to reduce the chlorophyll to a desired level.

Degreening is carried out in special treating rooms with controlled temperature and humidity in which low concentration of ethylene (20 ppm) is applied. The ethylene should be supplied from a gas cylinder. These rooms are thoroughly ventilated to keep the CO_2 level below 1% which does not allow higher colouring.

Preservation of Fruits and Vegetables

Most fruits and some kinds of vegetables are available during specific seasons at a cheaper rate and during the other seasons they may not be available or available in a limited quantity and hence they may be costly. Their availability can be extended by cold storage but it is highly expensive. Therefore, it is essential to preserve the fruits and vegetables by some means so that they can be made available in a form throughout the year. The spoilage of fruits and vegetables are caused by microorganisms like moulds, yeasts and bacteria. So, any preservation technique aims at preventing the above type of spoilages. Several types of preservations are used and are discussed briefly here.

1. Drying

Sun-drying or mechanical drying of fruits and vegetables involves complete removal of the moisture from them. They are then treated with sulfur fumes to maintain colour and also to avoid spoilage by microorganisms. Dates, grapes, jack, peaches, beans, bitter gourd, garlic, onions, potatoes etc., are preserved by this method.

2. Freezing

When fruits and vegetables are brought suddenly to a very low temperature at which all the chemical reactions stop. But it requires rather expensive equipment and shipping and storing under refrigeration.

3. Preservation by heat

It consists basically of the application of heat in varying degree to the food in closed containers for a sufficient long time to sterilize contents before they are hermetically sealed. This method of preservation by heat is also known as processing. Canned fruits and vegetable come under this category.

4. Preservation by sugar

No organisms can grow in a substance which contains sugar concentrations above 65% as microorganisms get desicated at higher concentrations by osmosis. Jams, jellies, marmalades and crystallized fruits are preserved by virtue of the above said principle.

5. Preservation by salt

A product which contains about 15% salt makes it most unfavourable for the growth and multiplication of microorganisms. Salt acts both by osmosis and as a poison on microorganisms. Pickles are preserved by this method.

6. Preservation by chemicals

Chemicals like benzoic acid and sulphur-di-oxide at specific concentration help to preserve the fruit juices, squashes or cordials. Benzoic acid in the form of 0.06 to 0.10% sodium benzoate is sufficient and is effective against yeast and its action is effective in the presence of CO_2 Potassium metabisulphite (KMS) when added liberates sulphur-di-oxide which reacts with water to form sulphurous acid. The concentration of SO_2 is recommended around 350 ppm. It is more active against moulds, spores and bacteria.

7. Preservation by fermentation

Fruit juices containing sugar are fermented to produce alcohol. These fermented substances keep off the spoilage organisms due to the presence of alcohols. e.g., wine making. Methods and techniques involved in the preparation of selected products like jam, jelly, squashes, syrup and pickles are discussed below.

Jam

Jam is more or less a concentrated fruit pulp possessing a fairly heavy body form. It is rich in flavour. Pectin in the fruit gives it a good set. It contains not less than 68% soluble solids and thus high concentration of sugar facilitate preservation. A jam manufacturer can choose fresh fruit, frozen, chilled or cold stored fruit, fruits or fruit pulp preserved by heat, sulphited fruits or fruit pulp and or dried fruits. Fresh fruits make good jams, the difficulty being regular supply. Good fruits free of any damage should be alone selected and for better jellying effect, green fruits should be mixed with the ripe fruits. Over ripe fruits should not be used.

Preparation of the fruits for jam making:

1. The fruit must be washed thoroughly to remove any adhering dust or dirt.
2. Leaves, stalks and other undesirable portions of the fruits must be removed.
3. Fruit is then subjected to preliminary treatment which varies from fruit to fruit. For instance, apples are peeled, cut into pieces and then pulped. Strawberries are crushed between rollers but in stone fruits like peaches, they are lye peeled (i.e. dipping the fruits in boiling water few minutes to facilitate the removal of the skin) and stones are then removed and the pulp is cut into pieces.

Addition of sugar

Cane sugar is generally used. Preparation of sugar to be added depends upon the degree of ripeness and acidity of the fruit. To get a minimum of 68.5% of sugar in the jam, generally 55.0 g of sugar is added to every 450 g of fruit. The finished jam should contain 30 to 50% invert sugar or glucose to avoid crystallization of cane sugar during storage. If the percentage of invert sugar is less than 30, cane sugar may crystallize out and if it is higher than 50%, the jam becomes gummy and sticky. Corn syrup or commercial glucose may be used to avoid crystallization.

Addition of acid, colour, favour

Generally citric, tartaric or maleic acids are used to supplement the acidity of fruits for jam making, if the fruits are deficient in acids, because appropriate combination of pectin, sugar and acid is essential to give a set to the jam. A good result is obtained if the pH of mixture is about 3.0. Only permitted edible colours should be used, if necessary and these should be added towards the end of the boiling process. Ordinarily, jams do not require addition of flavours if desired, may be added when jam boiling is nearing completion. Fruit and sugar mixture are boiled to concentrate the soluble solids to about 68.5% and also to bring about necessary degree of inversion of sugar. Determination of soluble solids is easily carried out by using a hand refractometer, while boiling is in progress. A sample of the boiling mixture is taken and is immediately cooled. A portion of the cooled material is squeezed through a muslin cloth directly on to the prism of the refractometer and the percentage of total soluble solids is read directly on the scale.

Packing

Soon after the end point is reached, the jam should be cooled in cooling pan to about 93°C and filled into jars at this temperature either mechanically or by hand. The surface of the jam in the jars should be covered with a thin disc of waxed tissue paper and allowed to cool. The jars should be stored in a dry place. Jams can be prepared from fruits like apple, tomato, papaya, strawberry etc.

Jelly

In jelly making, pectin is the most essential constituent. This pectin is present in the cell walls of fruit. While boiling, precipitation of pectin causes jelly formation. Precipitation takes place only when pectin, acid, sugar and water are in definite equilibrium range.

Fruits for jelly

Many fruits are rich in pectin as well as acid and are thus well suited for jelly making. A fruits rich in pectin but deficient in acid may be combined with a fruit deficient in pectin but rich in acid or *vice versa* to make a good jelly, the only drawback being that the flavour of the jelly is affected. Apple, grape, guava, lemon, orange, plum are examples of fruits rich in pectin and acid.

Selection of fruits

The fruits should be sufficiently ripe (but not over ripe) and should have good flavour. Fruits are washed thoroughly with water to remove any adhering dirt. Such selected fruits need not be peeled as in the case of guava and apple while fruits like lemon and oranges require peeling before they are used for extraction of pectin.

Extraction of pectin

Only a minimum quantity of water should be used to the fruit for a simple extraction of pectin. If necessary a second or even a third extraction may also be taken and these extracts may be mixed with the first one. The amount of water to be added would depend on the kind of fruit and usually it is added at the rate of 1.5 kg to a kg of apple and 2.5 kg to a kg of oranges or guavas. In the case of grapes, no water is added, the fruit being boiled in its own juices. Fruit juices when extracted in cold do not contain the required amount of pectin and hence do not form a jelly. To get the desired pectin requirement the fruit should be cooked. The cooking time also varies from fruit to fruit as given below:

Name of fruits	*Time in minutes*
Apples	20–25
Grapes	5–10
Plums	15–20
Oranges	45–60
Jaman	20–25
Guavas	30–35

The pectin extract obtained can be clarified by allowing to settle overnight and the supernatant pectin liquor separated or it may be filtered through muslin cloth. For boiling, copper and iron kettles should not be used for obvious reasons *viz.*, reaction of these metals with the acids and salts of fruit. Aluminum vessels are satisfactory for this.

Pectin requirement

Usually about 0.5 to 1.0% pectin of suitable quality in the extract is sufficient to produce a good jelly. If the pectin is in excess of this, a firm and tough jelly is formed and if it is less the jelly may fail to set. Pectin, sugar, acid and water must be present approximately in the following proportions:

Pectin	1.0%
Sugar	60–65%
Fruit acid	1.0%
Water	33-38%

To the volume of the pectin extract, equal quantity of sugar is added. The sugar should be sprinkled on the fruit extract while it is boiling and should be thoroughly mixed by stirring to ensure complete dilution. During boiling, scum which rises to the top is removed.

Cooking of Jelly

The mixture is boiled for about 20 minutes and the end point is that the brix reaches 65° brix. The end point can be also determined easily by the test. In this case some portion of a jelly is taken in a large spoon and cooled slightly. It is then allowed to drop. If it drops like syrup, it requires further concentration or if it falls in the form of flakes or a sheet the end point has been reached. Jelly is then cooled slightly and poured into hot and dry containers.

Marmalades

They are similar to jelly in all respects, the only difference being they contain the peels of the fruits. The shredded peels previously boiled in water to remove the bitter principles are used to boil along with pectin-sugar mixture. Marmalade preparations are common for like oranges.

Squash

Preparation of grape squash or pineapple squash is given below:

The stalks are removed first and the fruits are washed in cold water. In the case of pineapple, the skin is removed and cut into pieces and they are washed. The juice is extracted in a pulper. Required quantity of sugar is dissolved in water. Add citric acid and they are heated to boil. This sugar syrup is strained with a muslin cloth and cooled. Juice is added to the syrup and mixed well. Sodium benzoate (for grapes) or potassium meta bisulphite (for pineapple) is dissolved in a little quantity of the juice separately and mixed well with the squash. Essence is then added and stirred well. This squash is then filled into already sterilized bottles leaving about 2 to 2.5 cm head space and the bottles are then sealed with a cap. These bottles are to be labeled and stored. This can be diluted with water in the ratio of 1:2½ and served. Normally squash keeps well for 1 to 1½ years without much change in colour and taste.

Squashes can be prepared from oranges, grapefruit, lemon, lime, mango, jamun, passion and peaches. Fruit juice is often clarified by adding gelatin and tannin in proper proportions. Such clarified fruit juice is mixed with sugar, water, colour (if necessary), preservatives and the mixture is then filtered using a filter paper. Such clear solution obtained is known as **'cordial'** and lime juice cordial is very often prepared. Sugar is added in syrup form. The quantity of preservative added to the original juice is taken into account while adding the preservative to the cordial. Colour should be mixed in very small quantities.

Syrups

Syrups of strawberry, pineapple, oranges, mulberry etc., are very popular as summer drinks in different parts of India. They are generally prepared from extracts of natural material or by using artificial flavours and colours. These are added to heavy sugar syrups of 70°–75° brix. The syrup is prepared by heating sugar in water to which a little acid is added to invert the sugar.

Pickles

The preservation of food in common salt or vinegar is called pickling. Spices and oil may also be added. Pickles are good appetizers and add to the palatability of a meal. They aid digestion by stimulating the flow of gastric juices. Salt, vinegar and lactic acid are the three important ingredients used in pickling. These substances when used in sufficient quantities act as preservatives either singly or collectively.

Salt

Vegetables do not ferment when covered with a large amount of salt. Spoilage is prevented by adding sufficient amount of common salt bringing its final percentage in the material to about 15 to 20. At this high concentration mould and lactic acid forming bacteria do not grow. This method of preservation is applicable only to vegetables which contain very little sugar.

Vinegar

It also acts as a preservative in pickles. The final percentages of acid should not be below 2. To avoid dilution of vinegar by water from their tissues, the vegetables are generally put in strong vinegar of about 10% concentration.

Lactic acid

Lactic acid forming bacteria can grow even in the presence of 8–10% of common salt and when this lactic acid is formed in sufficient quantity, the lactic acid bacteria ceases to function and any further change in the composition of the material is prevented provided it is air-tight.

Pickling process

Pickling is done in two stages *viz.*,

1. **Dry salting:** The vegetable is prepared, washed thoroughly in running cold water, drained and weighed. For every 100 kg of the prepared vegetables 3 kg of salt is used. The vegetable is placed about a few cm and a small quantity of salt and another layer of vegetables thick higher is placed. This process of keeping the vegetables and sprinkling the salt is continued till three-quarters of the barrel full. The top of the vegetable is sealed with a cheese cloth and placed over a clean stone to give some weight to the vegetables placed in. The container is kept in a warm dry place and fermentation is allowed to proceed. In a short time, juice from the vegetable forms the brine converting the whole

mass. Fermentation then starts and is usually complete, in about 8–10 days. This may be confirmed by tapping the containers gently.

2. **Fermentation in brine:** Soaking of the vegetables in salt solution of predetermined concentration for a certain length of time is called brining. This treatment is given only to vegetables like cucumber which do not contain sufficient juice to form brine with dry salt. Brined vegetables will keep in vinegar for a long time.

In India, several kinds of pickles (mango, lime, chilli, cauliflower, beetroot, onion etc.,) are sold in the market. Oil pickles, which contain some edible oil, are also highly popular.

Plant Protection

Innumerable pests and diseases attack plants and cause considerable losse
In this chapter, a general account of important causative organisms and the
control measures are discussed.

INSECT PESTS

The term 'pest' is used very broadly to insects, other invertebrates li
nematodes, mites, snails, slugs etc. and vertebrates like rats, birds, jackal et
that cause damage to crops, stored produce and animals. Among them inse
pests are more important and they inflict injury to plants either by directly
ndirectly in their attempts to secure food and almost all portions *viz*., the ro
stem bark, shoots, leaves , buds, flowers and fruits. They cause injury to
plants by anyone of the following methods:

1. **Injury by chewing:** Insects which cause this type of damage ch off external parts, grind them up and swallow them. Larvae of diffe kinds of insects like moths, butterflies, beetles, weevils etc., cause above type of damage.
2. **Injury by piercing and sucking:** The insects which cause type of injury remain outside and with the mouth parts pierce thro the epidermis and suck the sap. Aphids, psyllids, thrips, leaf hop mealy bugs and scale insects cause injury by sucking and hence are generally known as 'sucking pests'. As a result of suckin

general chlorosis of leaves and withering and drying of the affected portions are observed in the case of damage by aphids.

3. **Injury by sucking:** Thrips cause silvering or whitening of leaf surface due to the removal of cell contents below the epidermis. Sometimes, premature shedding of developing fruits is caused by these sucking pests.
4. **Injury by feeding internally:** The internal feeders cause damage by remaining within the plant tissues during a part or all of their destructive stages. This is accomplished by the adults thrusting their eggs into the tissue by their ovipositor or by the larvae eating their way in, after they hatch from the eggs. The internal feeders include borers, grubs or weevil, leaf miners and gall insects. When the larvae feed on the wood or pith of the plant which may be generally large enough to contain the body of the pest, they are referred to as borers. The larvae may bore into the terminal shoots and cause death of the shoots. Grubs of weevils are also borers in flower buds and fruits including nuts and seeds. The larvae of those bore into flower buds and cause shedding are usually called bud worms. Leaf miners are also larvae but being very small in size, they live in between the two epidermal layers of the leaves and feed on the food materials inside. Certain insects in their immature or adult stage cause the formation of special plant deformities known as galls and these galls provide shelter and food to the insects. Due to the formation of galls, the growth of the plants may be impaired and also the setting of fruits and seeds.
5. **Injury by subterranean insects:** Insects which are found in the soil live by feeding on the roots of plants by chewing or boring or sucking the sap or forming galls. Apart from the above type of damages, they may make harvests more difficult or reduce the quality of the produce or may be responsible for spreading many plant diseases caused by bacteria, fungi, MLO and viruses.

Methods Adopted for Controlling Pests

The control of insect pests falls under following heads:

(a) **Legislative:** By which the Government prevents the import of produces infested with insects, which if introduced into this country, would become local pests (e.g. potato tubers with nematodes).

(b) **Biological method:** The successful control of a pest species by means of another living organism that is encouraged and disseminated by man is called so. It is inexpensive and as long-term control, causes no pollution and poses no risk to human health. Biological agents are available in nature abundantly. Several pathogens including viruses such as nuclear polyhedrosis virus (NPV) and granulosis virus (GV), bacteria like *Bacillus thuringiensis*, *fungi* like *Metarhizium*, protozoa like *Schizogregarine* cause diseases in insects to destroy them. This method has been successfully used to control many important pests in a number of economic crops.

The other biological method of control involves the use of parasitoids and predators. A parasitoid is an organism which completes its life on a single host and ultimately kills it. A predator, on the other hand is a free living-organism and kills the host (prey) immediately and requires more than one prey individuals to complete its life. If the parasitoid attacks the egg stage of the host, it is then called egg parasitoid, (e.g.) *Trichogramma chilonis* on bhendi borer. When they attack at the larval stage of the host, it is then called larval parasitoid, (e.g.) *Apanteles plutella* on diamond back moth caterpillars in cruciferous vegetables. The predatory group of insects capture and consume another insects as their food (e.g.) green lace-wing, *Chrysoperla cornea* whose grubs and the maggots of Syrphid flies dramatically exert control over several aphids in many crops. The adults and grubs of ladybird beetles such as *Coccinella septempunctata, Menochilus sexmaculatus, Brumoicles suturalis* and *Scymnus nubilus* play important role in the population regulation of several sucking pests and defoliating insects.

(c) **Cultural methods:** The control of insects through adoption of ordinary farm practices at appropriate time in such a way that the insects are either eliminated or reduced in population is called the cultural method of control. Proper crop rotation or tillage operations may help to keep down the insect population.

Some early crops are sown in narrow strips around a major crop to serve as a trap for the pests that might be common to both. For instance, sowing of mustard in every twenty fifth row of cabbage crop will help preventing higher incidence of diamond back moth in cabbage and cauliflower and the preferred mustard plants can be cut and destroyed when the pest appears. This practice is called trap cropping.

(d) **Mechanical method:** Mechanical control is one by which the insect population is directly hit by mechanical devices or manual operations. Mechanical devices include using fly and maggot traps, setting light and bonfires to attract adult moths and beetles. Manual methods involve hand picking of egg masses, larvae and killing them. Mechanical exclusion consists of the use of devices by which insects are physically prevented from reaching the produce (e.g.) wrapping of individual pomegranate fruits with butter paper to save it from the attack of Anar butterfly, *Virachola isocrates*.

(e) **By use of insecticide:** Insecticide is a substance or mixture of substances used for killing, repelling or otherwise preventing insects. The insecticide is referred as a 'repellent' if it prevents the pest species in attacking its host, an 'attractant' if the pest species is attracted to source, trapped and an 'antifeedant' if it inhibits feeding on the host. The insecticides are available in any one of the following formulations:

(i) **Dusts:** The toxicant is diluted by mixing with or by impregnating a suitable finely divided carrier. The carrier may be organic flour clay. The toxicant in a dust formulation ranges from 0.5 to 25% (e.g.) endosulfan 4 D, malathion 5 D.

(ii) **Granular or pelleted insecticides:** In a granulation the particle is composed of a base such as an inert material or vegetable carrier impregnated or used with the toxicant which is released from the formulation in its intact form or as it disintegrates giving controlled release particles in the formulation generally possess a size range of 0.25 mm to 2.38 mm diameter. The formulations contain 2 to 10% concentrations of the toxicant (e.g.) carbofuran 3 G, Phorate 10 G

(iii) **Wettable powders:** It is a powdered formulation which yields a rather stable suspension when diluted with water. The active ingredients in such a formulation ranges from 15 to 95% (e.g.) BHC 50 WP, sulfur 25 WP.

(iv) **Emulsifiable concentrate:** The formulation contains the toxicant, solvent for the toxicant and an emulsifying agent (e.g.) endosulfan 35 EC, dimethoate 30 EC, fenvalerate 20 EC.

(v) **Concentrated insecticide liquid:** The toxicant at highly concentrated level is dissolved in non-volatile solvent. An emulsifying agent is not added here (e.g.) monocrotophos 36 WSC, phosphamidon 85 WSC.

(vi) **Fumigants:** A chemical compound which is volatile at ordinary temperatures and sufficiently toxic is known as a fumigant (e.g.) ethylene di bromide, methyl bromide, aluminium phosphide etc.

Plant Protection Appliances

settle down due to gravity or drift for long distance due to wind. The appliances that are used for applying dust formulations of pesticides are called dusters. They are either manual or power operated.

The spray fluid may be a solution, an emulsion, or a suspension toxicant. To achieve an effective control of pest, the toxicant is well distributed and to meet this requirement the spray fluid is blown down to fine droplets. The spraying machines may be either hand operated or power operated ones. Commonly employed manual operated sprayers are knapsack sprayer (hydraulic or pneumatic) and pneumatic hand sprayer. Rocker sprayers are useful for tall trees and pneumatic hand sprayers are helpful to spray in gardens. The power operated mist blowers are useful in field to cover more area in a limited time. A spray volume of 150 to 200 *l* water is necessary to cover one hectare of land with power operated high volume sprayers but high volume hand sprayers like knapsack sprayers require about 450-500 *l* water to cover one hectare. Insecticides should be applied in the morning or evening hours when the weather is calm or else they will fall on unwanted areas and also may not hit the target. Before applying insecticides, it must be ensured that there are no pollinators (like-bees) in the area; for the same reason insecticides should not be applied during blossoms when bees are likely to be at work. After application of insecticides a time lag (7–10 days in case of organophosphorus compounds and 20–30 days in case of organochlorine compounds) should be given before consuming the produce. During this period, the insecticides will get degraded and become non-toxic.

Non-insect Pests

Besides the different kinds of insects which damage crops, mites, rats, birds and nematodes cause damage to crop plants.

(a) **Mites:** Mites possess four pairs of legs as against insects which do have only three pairs of legs. In recent years the mites have become major pests. They cause damage by way of sucking the cellular materials by forming severe deformities. The chemicals which are used to control the mites are known as 'acaricides'. Sulphur, ethion, dicofol, phosalone and propargite are commonly used as acaricides at the rate of 15–20 ml per 10 litres of water.

(b) **Plant nematodes:** Plant nematodes are small organisms which live in soil around the roots of plants. They are about 0.1 to 1.0 mm in length. They are confined to the top 20 to 25 cm of soil, sometimes even to a depth of 3 to 4 m. They spread from one field to another through percolating water and agronomic practices like ploughing and weeding which involve transport of soil. Most of the symptoms of damage by plant parasitic nematodes are non-specific and often likely to be confused with those caused by other pathogens or soil factors like poor drainage, lack of soil nutrition etc. Some of the commonly observed symptoms are:

1. Stunting and wilting
2. Leaf curl
3. Browning or bronzing of leaves
4. Distortion of leaves, stems
5. Brown lesions in roots
6. Knot-like galling of roots

Control of plant parasitic nematodes is difficult, but nevertheless, necessary for obtaining profitable yields. Crop rotation with a non-host crop or application of large quantities of green leaves or grasses as mulches or summer fallowing and use of resistant varieties will reduce the incidence to some extent. Commonly used nematicides are DD mixture, dibromoethane, dibromo chloropropane, thionazin and aldicarb. In Tamil Nadu, nematode infection is a devastating problem in banana, citrus, potato and in vegetable crops like tomato, chillies and brinjal.

Integrated Pest Management (IPM)

IPM is a new system approach which has been necessitated primarily out of the growing concern about the undesirable side effects of large scale use of inorganic insecticides and often failure of the same to provide for suppression of pests at economic level. Attempts to totally suppress the pests by insecticides may lead to the following problems:

- development of resistance to chemicals in pest population
- outbreak of secondary pests
- resurgence of treated populations
- unacceptable residues on food and forage products and associated legal complications
- destruction of beneficial insect predators, parasitoids and pollinators. hazards to personnel involved in insecticide application, domestic animals and wild life; and
- expense of pesticides, involving the cost of materials, labour and maintenance of equipments.

Thus in any IPM programme, the ecological factors are exploited, the control methods are so designed that they are compatible with natural mortality factors in order to optimize control.

II. Plant Diseases

Fungi, bacteria, viruses and flowering plants cause infectious diseases. The different group of plant diseases caused by the above causative agents are discussed below along with their control measures.

Damping-off: The pathogen infects the collar region of the plants which results in collapse and death of young seedlings. Generally, fungi like *Pythium, Phytophthora, Fusarium* and *Rhizoctonia* are responsible for this. Damping-off at pre- emergence stage kills the seedlings before their emergence over the soil surface. If it manifests at post-emergence stage, the infestation is usually initiated at ground and soft, water soaked areas appear on the young stems. With advancement of the disease, the stem gets constricted and finally collapses. High moisture and thick sowing of the seeds favour the incidence of this disease. This is very common in vegetable crops like tomato, brinjal, chillies and cucurbits and ornamental plants in nurseries.

The control measures comprise of the use of seed protectants (like Thiram or Captan 2 g/kg of seed) to avoid pre-emergence infection. Drenching the soil with any copper fungicide at the rate of 2.5 g per litre of water at 15 days interval will control post-emergence incidence of this disease.

Rots: Rotting of plant parts is caused by a large number of fungal and bacterial pathogens. Fruits, bulbs, tubers and roots are the main targets of attack. The rots may be distinguished as dry rots and soft rots based on the degree of tissue-disintegration, lesser in the case of former one and more in latter one. Rhizome rot of ginger, root rot of turmeric, bud rot of arecanut and coconut palms and stem rot of papaya are some of the examples of rot diseases of economic importance. Most of the fruits suffer with soft rot diseases which are more common during post harvest period. In all these cases, small water soaked areas appear on the host surface which enlarge rapidly and the affected tissues turn soft and pulpy. Rot affecting the stems and roots can be minimized by maintaining proper drainage, Drenching the soil with 0.25% copper fungicides will also check infection. Rot affecting the fruits in storage in the godowns and warehouses may be checked by maintaining proper sanitary conditions and spraying with antibiotics like streptomycin (0.1%).

Downy mildews: In the lower surfaces of the infected leaves a white or grey downy growth is normally seen. This disease is more common in grapes. This is caused by the fungus *Plasmophora viticola.* This can be controlled by spraying 1% Bordeaux mixture or any other copper fungicides.

Powdery mildews: Powdery mildews are easily recognized by the white powdery coating on the plant. Powdery mildew infected plants show stunting and distortion of leaves, surface necrosis of infected tissues, decline in growth and defoliation. This disease infects crops like grapes, apples, cucurbits, roses and few ornamental annuals. This disease is caused by fungi belonging to the genera *Erysiphe, Uncinula, Podosphaera, Sphaerotheca, Phyllactinia and Leveillula.* Powdery mildews are controlled effectively by sulphur dust and certain other fungicides. Wettable sulphur (2 g/lit), Karathane are also recommended to control this disease. For cucurbits, sulphur dust has to be avoided, instead, wettable sulphur alone to be used. Tridemorph has also been found to be effective against powdery mildew in many crops.

Sooty mould: It occurs as a black thin crust covering the leaves, young stems and blackening the fruits too in particular kinds of trees and plants such as the citrus, mango, sapota, guava which are attacked by sucking pests like green bugs. Though the fungi causing sooty mould are only saprophytic, growing upon the excreta cast by the insects feeding upon leaves, they are harmful since they reduce the surface area available for photosynthesis and thereby weaken the trees. This disease is caused by the fungus *Capnodium sp.* This mould can be prevented by spraying starchy solutions which will clear the mould from the affected parts as it dries off.

Rust: This disease can be identified by rusty yellow or brown or dark blotches on the epidermis of the stem and leaves. Rusts are harmful and they are difficult to eradicate once they infect the plants. Attention to plant sanitation, good cultivation and preventive spray are the useful protection measures. Among the vegetables, it is common in beans and peas. Dusting of finely ground sulphur powder will effectively control this disease, if it is dusted even before the appearance of the disease. Spraying mancozeb (2 g/lit.) is also effective.