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# TNPSC –HO

*Equip for Learning... Prepare for Unlearning... Practice for Relearning...*



## Paper I HORTICULTURE

As per the Revised & Updated Syllabus of TNPSC

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## Foreword

Dear Aspirants,

Greeting from SAAI Academy!

- **DON'T USE THIS BOOK, IF YOU HAVE JUST APPLIED FOR TNPSC-HO POST!**
- **STUDY IF YOU ARE WILLING TO SUCCEED AND BE A HORTICULTURE OFFICER AS YOUR CAREER!**

This is the **Fifth Book** on the series for TNPSC – HO Exams. It contains the Core Paper such as *Fundamentals of Horticulture, Growth and Development of Horticultural Crops, Propagation of Horticultural Crops, Management Techniques for Horticultural Crops, Production Technology of Fruit Crops, Production Technology of Vegetable Crops, Floriculture & Landscape Gardening, Production Technology of Species and Plantation Crops, Production Technology of Medicinal and Aromatic Crops and Post-Harvest Technology of Horticultural Crops* with special references to TNPSC Revised Syllabus for the candidates of B.Sc., and M.Sc., Horticulture. It is systematically compiled in a student-friendly manner and updated by keeping in mind on the present trends in TNPSC-HO Exam patterns.

You are expected to be self-disciplined and self-motivated, and are **requested to prepare different models of questions as explained during the orientation programme. Self-Confidence with Systematic and SMART preparation would definitely make you a frontrunner.**

Kindly refer previous year's question, which is provided in our website to understand the pattern and type of questions asked and perform the class test and online tests regularly.

Wish you **ALL THE BEST** for your success in TNPSC - HO exam. For further details please contact [saaiacademy@gmail.com](mailto:saaiacademy@gmail.com) or call +91-93821 32593.

Regards

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- 1. Olericulture:** The term Olericulture is originated from Latin word 'oleris' meaning pot herb and the English word culture meaning raising of plants. Thus, olericulture is the science of vegetable crops. OR The cultivation of vegetable crops. e.g. brinjal, tomato, potato, radish, carrot, chilli, bottle gourd.
- 2. Floriculture:** It is a science of cultivation of flowers and ornamental plants for commercial purposes or merely for getting pleasure and as a hobby.
- 3. Landscape gardening:** It is a science of designing and laying out home gardens, public gardens, parks, road side plantation, avenues etc.
- 4. Preservation of fruit and vegetables:** It is a science of canning of fruits and vegetables. e.g. fruit juice, jam, marmalade, candy, dehydration etc.
- 5. Silviculture:** Cultivation and management of forest tree e.g. teak wood, neem, ficus, eucalyptus etc.
- 6. Plantation crops:** Cultivation of tea, coffee, coconut, arecanut, rubber, oil palm etc.
- 7. Spices and condiments:** Cultivation of crops which products are used as adjunct in food for flavor, aroma and taste. e.g. cardamom, clove, nutmeg, coriander, cumin etc.
- 8. Aromatic and medicinal plants:** cultivation of aromatic and medicinal plants like gugal, aonla, beheda, harde, lucorice, lemon grass etc.
- 9. Sericulture:** Deals with rearing of silkworm and production of silk.
- 10. Apiculture:** Bee keeping rearing for honey production.
- 11. Mushroom production:** Production of different edible species of mushroom like *Agaricus bisporus* (button), *pleurotus sp.* (oyster), *Calocybe indica* (Milky), *Volvariella volvacea* (paddy straw).

#### **Some Important Terms Explained From Horticulture Points of View**

**Annuals:** As the name indicates annuals are plants that live for one year or less, that is the makes its vegetative growth flowers and produces seed within one year from the sowing date and then the plant dies. Actually in practices we often see that this definition cannot be strictly applied to some plants because they often over live the period of one year. e.g. brinjal, tomato, coleus, geranium etc. They may behave as perennials and yet in context to horticulture, speaking they are annuals.

**Biennials:** Biennials plants are those which require two years or parts of two growing seasons with more or less of a dormant or resting season between to complete their life period. In the first season or year the seed is sown and the plant makes only vegetative growth. In the second season or year the plant produces very little vegetative growth and then flowers produces seed and dies out e.g. onion, beet, carrot, cabbage, radish, chrysanthemum, dahila etc.

**Perennials:** These plants do not finish their life cycle in one or two years. They persist from year to year and go on producing crops of seed from year. Perennials may be herbaceous or woody and perennials may be trees or shrubs or vines e.g. mango, chiku.

**Deciduous:** Deciduous plants shed their leaves once in a year when they go to rest. This happens during the cold season. When temperature starts falling, the leaves change their colour and become yellow and then fall off. The tree becomes bare and looks dry. All growth processes stop until spring when, temperature again raises, climate become warmer and the trees become active once again raises e.g. apple, plum, peach, dhak, siris, amaltas.

Thus horticulture has great scope for the following reasons:

- To exploit great variability of agro-climatic conditions.
- To meet the need for fruits, vegetables, flowers, spices beverages in relation to population growth and nutritional requirement.
- To meet the requirement of processing industries.
- For increasing export and import of horticultural products.
- To improve economical condition of the farmers.
- To generate employment opportunity for labour and human being.
- To protect environment.

**Horticultural Plant Classification**

**A. Edible plants Names of crops given below in a, b, and c should start with small letters**

**a. Vegetables:**

**(1) Plants grown for aerial portion**

- Cole crops: cabbage, cauliflower, broccoli
- Legumes or pulse crops: pea, bean, soy bean cluster bean
- Solanaceous fruit crops: Tomato, Brinjal, Chilli
- Vine crops or cucurbits: Cucumber, Squash, Melon, Bottle gourd
- Green or pot herbs: Spinach, Dandelion, Amaranthus
- Salad crops: Lettuce, Celery, endive
- Miscellaneous: Corn, Asparagus, Okra, Mushroom

**(2) Plant grown for underground portions**

- Root crops: Beet root, Radish, Carrot, Sweet potato
- Tubers and roots: Potato, Yams, Cassava
- Bulb and corm: Onion, Garlic, Shallot, Leek Gladiolus

**b. Fruits:**

**(1) Temperate (Deciduous) fruits:**

- Small fruits: Raspberry, Black berry, grape, cranberry, straw berry.
- Tree fruits: Pomes, apple, pear, quince
- Stone fruits: Peach, plum, apricot
- Nuts: Pecan, filbert, walnut

**(2) Tropical and sub-tropical (Evergreen) fruits:**

- Herbaceous perennials: Pine apple, Banana
- Tree fruits: (i) Citrus fruits: Orange, lemon, grape fruit
- (ii) Miscellaneous: Fig, date palm, mango, papaya, avocado - Nuts: Cashew, Brazil nut, Macadamia

**B. Ornamental plants**

**(1) Flower and foliage plants:**

**a. Annuals:** Petunia, Zinnia, Snapdragon, Dianthus, Balsam

**b. Biennials:** Sweet William, holly hock, evening primrose, Gladiolus

**c. Perennials:** Chrysanthemum, philodendron, Aster amellus, Gerbera, Tulip

**(2) Nursery plants**

**Reasons for development horticulture in India:**

1. Most horticulture crops are grown with assured Irrigation & therefore, are more resilient to monsoon deficits.
2. Eight vegetables that make up 74% of total vegetable production in country have 73% access to irrigation.
3. In comparison, only 50% of the area under food grain has access to Irrigation.
4. Technology – led gains in the productivity of horticultural crops have given the farmers an opportunity to diversify from food and other crops to horticulture.
5. Small and marginal farmers have brought sizable chunk of land under horticultural crop.
6. Better agronomic practice (Improving soil quality, water use manage crop residue).
7. Improved varieties.

**Price Stabilization Fund Scheme...**

1. The government has approved the setting up of a Price Stabilization Fund (PSF) as a Central Sector Scheme, with corpus of Rs.500 crores.
2. This is support market interventions for price control of Perishable Agri-horticultural commodities during 2014-15 to 2016-17.
3. PSF Scheme provides for advancing interest free loan to State governments/UTs and Central agencies to support their working capital.
4. This will be managed centrally by a Price Stabilization Fund Management Committee (PSFMC).
5. Funds from this Central Corpus will be released in two streams, one to state government/UTs as a onetime advance to each State/UT.
6. The revolving Fund is being mooted so that Requirement for all further interventions can be decided and met with at a state level itself.
7. Procurement of commodities will be undertaken directly from farmers / farmers organisations of farm gates/mandi.
8. Total Horticulture production in 2019-20 (1st Advance Estimates) is expected to be 0.84% higher than 2018-19. Increase in Vegetables, Aromatics and Medicinal and Plantations is envisaged but decrease in Fruits, Flowers and Spices is expected.
9. The Fruits production is expected to be lower by 2.27% in 2019-20 over 2018-19. It is mainly due to loss in production of Grapes, Banana, Mango, Citrus, Papaya and Pomegranate.
10. Increase of 2.64 % in production of vegetables in 2019-20 over 2018-19. Increase is mainly due to increased production of Onion, Potato and Tomato. Onion production is expected to be 24.45 Million Tonne (increase of 7.17%) as compared to 22.82 Million Tonne in 2018-19.
11. Potato production is expected to be 51.94 Million Tonne (increase of 3.49%) as compared to 50.19 Million Tonne in 2018-19. Tomato production is expected to be 19.33 Million Tonne (increase of 1.68%) as compared to 19.01 Million Tonnes in 2018-19.

**Highlights of 2018-19**

Total Horticulture Production of country is estimated to be 310.74 Million Tonne in 2018-19, which is marginally higher than Horticulture Production in 2017-18. Increase in Fruits, Flowers, Spices & Honey while decrease in Vegetables, Aromatic & Medicinal Plants and Plantation Crops. Fruits Production is estimated to

**Fruit crops recommended:** Mango, Cashew, Citrus, (Sweet Orange, Mandarin orange, and limes), Grape, Guava, Sapota, Banana, Sithapahal, Fig, Ber, Pomegranate, Jamun, and Jackfruit.

**Southern tropical zone:** Andhra Pradesh excluding Telengana, Tamilnadu, Kerala and Karnataka states comes under this zone.

**Fruit crops recommended:** Mango, Coconut, Banana, Cashew, Sapota, Pineapple, Mangosteen, Breadfruit, Jackfruit, Sitaphal, Areca nut, Rubber, Pepper, Turmeric, Clove, Nutmeg, Cocoa, Coffee, Citrus (Sweet Orange, Mandarin orange, and limes).

**Coastal tropical humid zone:** Areas covering all along the coast of different states of peninsular India up to about 160 km inside to the sea shore line. The climate will be always humid and warm. Temperature will not be mild in winter when compared to southern tropical zone.

**Fruit crops recommended:** Coconut, Banana, Cashew, Jackfruit, Mango, and Pineapple.

**Sub-Tropical Zone:** The area above the Vindhya hills comes under this zone. Occasionally frost occurs in this zone. This zone is sub-divided into TWO sub-zones basing on the direction. They are:

**North-Western Subtropical zone:** States like Rajasthan, Punjab, Haryana, Gujarat, Parts of Bihar, U.P, M.P and west Bengal comes under this zone.

**Fruit crops recommended:** Litchi, citrus (sweet orange, mandarin oranges), dates, guava, sapota, Papaya, phalsa, fig are some typical subtropical fruits grown but other tropical fruits like Mango, jack, banana can be grown etc.

**North-eastern sub-tropical zone:** Areas like parts of UP, Bihar, West Bengal, Assam, Meghalaya, Manipur, Nagaland, Mizoram, Arunachal Pradesh, and Tripura.

**Fruit crops recommended:** Litchi, Citrus (Sweet Orange, Mandarin oranges), Dates, Guava, Sapota, Papaya, Phalsa, Fig, Mango etc.

**Temperate Zone:** Areas comes in this zone are Jammu and Kashmir, Kulu, Katrain, Kangra valleys of Punjab, parts of Himachal Pradesh and kuman hills and high altitude regions in South India- Nilagiris and Palani hills of TamilNadu. This zone frequently experiences frosts. This zone is further sub-divided in to two sub zones based on elevation. They are:

1. **Higher elevation** and 2. **Lower elevation**

**Higher elevation:** Elevation ranges from 1500—2500 m MSL.

**Fruit crops recommended:** Apple, Pears, Walnut, Almond, Cherry and Strawberry etc.

**Lower elevation:** Elevation ranges from 1200—1500 m MSL.

**Fruit crops recommended:** Peaches, Persimmons, Japanese plum etc.

Although Peach is a temperate fruit crop, a no. of varieties like Sharbati, Honey stone, Sunred and Safeda can be successfully grown in the northern plains of subtropical zone. Similarly Rome beauty an apple variety is grown around Bangalore. Elevation is not only the factor which decides the prospects of fruit cultivation in temperate zone. Other factors like hail storms, rainfall etc which should be considered for selection of site for fruit cultivation in temperate zone. Eg. Simla and Solan at 2100 and 1400 m of elevation from sea level respectively. But they are not suitable for growing fruits because of hail storms. But Kulu valley and Kotagarh regions in Punjab are free from hailstorms and are suitable for growing temperate fruits.

- Earlier this month APEDA participated in the 84th Thessaloniki International Fair (TIF) in Thessaloniki, Greece held from 7th to 15th September 2019.
- Agriculture and processed food products like ready to eat vegetables, curries and rice, mango pulp, organic products, herbs etc. were displayed and promoted through sampling and tasting at the TIF.
- APEDA is promoting export of basmati rice through sampling and tasting campaign of basmati rice biryani in vegetarian and non-vegetarian versions.

#### **Functions of Commodity Boards in India<sup>6</sup>**

Commodity Boards are statutory in character and Operate under the administrative Control of the Ministry of Commerce. Their major functions are:

- (a) To take active interest in production, development and exports of respective Commodities.
- (b) To introduce new methods of cultivation of commodities.
- (c) To offer advice to the government on export matters such as fixing quota for exports and significant trade agreements.
- (d) To provide trade information, guidance and various other services to their members and help them in their export promotion efforts.
- (e) To participate in trade fairs and exhibitions abroad.
- (f) To sponsor trade delegations and conduct market surveys.
- (g) To arrange pre-shipment inspection for export items.

**Operating Commodity Boards:** At present, there are six Commodity Boards in India.

**Coconut Development Board:** is a statutory body established by the Government of India for the integrated development of coconut production and utilization in the country with focus on productivity increase and product diversification. The Board which came into existence on 12<sup>th</sup> January 1981, functions under the administrative control of the Ministry of Agriculture, Government of India, with its Headquarters at Kochi in Kerala and Regional Offices at Bangalore in Karnataka, Chennai in Tamil Nadu and Patna in Bihar. There are six State Centres situated Bhubaneswar in Orissa, Calcutta in West Bengal, Guwahati in Assam, Agartala in Tripura and Hyderabad in Andhra Pradesh and Port Blair in the Union Territory of Andaman & Nicobar Islands. The Board has established 9 (Demonstration cum Seed Production) DSP Farms in different locations of the country and now 7 farms are maintained.

#### **Functions of the board**

1. Adopting measures for the development of coconut industry, inter alia.
2. Imparting technical advice to those engaged in coconut cultivation and industry.
3. Providing financial and other assistance for the expansion of area under coconut.
4. Encouraging adoption of modern technologies for processing of coconut and its products.
5. Adopting measures to get incentive prices for coconut and its products.
6. Recommending measures for improving marketing of coconut and its products.
7. Recommending measures for regulating imports and exports of coconut and its products.
8. Fixing grades, specifications and standards for coconut and its products.
9. Financing suitable schemes to increase production of coconut and to improve quality & yield.

<sup>6</sup> [http://agritech.tnau.ac.in/horticulture/horti\\_schemes\\_commodity%20boards.html#spices](http://agritech.tnau.ac.in/horticulture/horti_schemes_commodity%20boards.html#spices)

extremely low temperatures. Plants in these areas can withstand both freezing temperatures and a lot of direct sunlight throughout day.

Table 2: Plants according to photoperiodic requirements.

1.	<b>Short-day plants</b>	Strawberry, Chrysanthemum, <i>Cosmos bipinnatus</i> , Aster, Poinsettia, <i>Impatiens balsamina</i> (Balsam), <i>Salvia occidentalis</i> , <i>Euphorbia pulcherrima</i> , <i>Xanthium pensylvanicum</i> , Rice, Some soyabean varieties and Tobacco.
2.	<b>Long-day plants</b>	Spinach, Beet, Radish, Potato, <i>Hibiscus syriacus</i> , <i>Hyoscyamus niger</i> , <i>Anethum graveolens</i> (Dill), <i>Plantago lanceolata</i> and Wheat.
3.	<b>Day-neutral plants</b>	Most of the fruit crops, Tomato, Pepper, Cucumber, <i>Mirabilis</i> (Four O Clock plant), Cotton, Certain varieties of peas, Buck wheat and Snapdragon.
4.	<b>SL plants</b>	Strawberry, <i>Primula malacoides</i> and <i>Cineraria hybrid</i> .
5.	<b>LL plants</b>	<i>Chrysanthemum leucanthemum</i> , <i>Silene pendula</i> .
6.	<b>LS plants</b>	<i>Physocastegia virginiana</i> , <i>Rottelia latifolium</i>
7.	<b>SS plants</b>	<i>Pharbitis nil</i> , <i>Cosmos bipinnatus</i> and <i>Glycyne max</i> .
8.	<b>LI plants</b>	<i>Phlox paniculata</i> .
9.	<b>SI plants</b>	Late varieties of rice.
10.	<b>IS plants</b>	<i>Chrysanthemum arcticum</i> .
11.	<b>IL plants</b>	Spinach and Wheat
12.	<b>II plants</b>	<i>Capsicum frutescens</i> (Bell Pepper) and Early varieties of rice.

### Kitchen gardening<sup>9</sup> / Nutrition gardening

Kitchen garden is the growing of fruits and vegetables at the backyard of house by using kitchen waste water. Otherwise called as Home garden / Nutrition garden / Kitchen gardening /Vegetable gardening.

#### Site selection :

- Backyard of house
- Preferably open areas with plenty of **sunlight** near the **water** source

Size and shape of vegetable garden depends on

- Availability of land
  - Number of persons in family and
  - Spare time available for its care
- Nearly **five cents of land (200 m<sup>2</sup>)** is sufficient to provide vegetables throughout year for a family consisting of five members

<sup>9</sup> [http://agritech.tnau.ac.in/horticulture/horti\\_Landscaping\\_kitchengarden.html](http://agritech.tnau.ac.in/horticulture/horti_Landscaping_kitchengarden.html)

A market garden employs more manual labor & gardening techniques, compared to large-scale mechanized farming. Because production is relatively low-volume, sales are often through local fresh produce outlets, viz., on-farm stands, farmer's markets community-supported agriculture subscriptions, restaurants & independent produce stores. Market gardening & orchard farming are closely related to horticulture. This is a section of agriculture in which fruit & vegetables are grown.

Under the system of vegetable farming, vegetables are grown for the local market only. Formerly the market gardens were located near the cities within 16-24 KM. radius but now days, within the building of good roads and the development of automobiles, the area has been extended considerably"

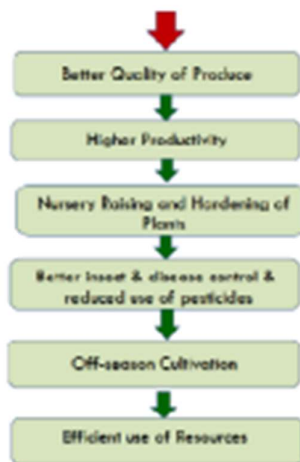
### Vegetable forcing

It is the method of growing the vegetables out of their normal season in net houses, green houses, glass houses and under other artificial growing conditions. In Indian condition vegetable forcing is not possible because the consumers cannot afford the prices of such vegetables. The following are the characteristics of this type of farming.

- Cost of production is higher than other method of vegetable production.
- Various structures viz., green house, cold frames etc are required for forcing vegetables.
- The cultivation is most intensive.
- It requires special technical knowledge.
- Environment is controlled artificially.
- It is a sort of specialized demand oriented programme. Few vegetable crops such as tomatoes, cucumbers, peas, asparagus etc are grown in this type of farming.

### Protected and precision horticulture<sup>10</sup>

#### Why Protected Cultivation...



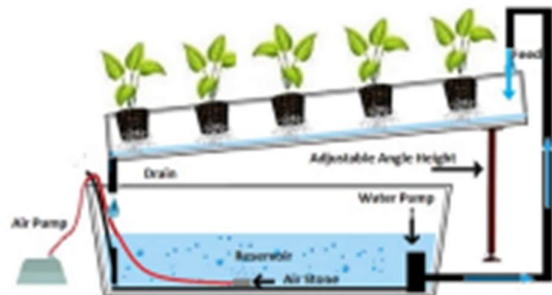
#### Govt. Initiatives on Protected Cultivation

Water Management: Drip Irrigation System–  
Sprinkler Irrigation System  
Protected Cultivation–Greenhouse–Plastic Tunnel–  
Shade net House–Walk in Tunnels–Plant Protection Nets  
•Surface Cover Cultivation– Plastic Mulching–Soil  
Solarisation  
•Water Resource Management–Farm Pond &  
Reservoir lined with Plastic Films  
Vermi Bed –Organic Farming  
Protected Cultivation – Greenhouse & Shade net  
House  
Green house is framed structures covered with UV  
stabilized plastic films in which crops are grown  
under partially / controlled environment  
conditions.

<sup>10</sup> <http://agricoop.nic.in/sites/default/files/midhPPT10.pdf>

You can either place seedlings directly into the holes of your PVC pipe or channel or for greater stability plant them in net pots and place the net pots in the holes. Most people do not use a growing medium with NFT, but let the roots fall directly through the net pots and onto the film. If you choose to use a growing medium, use it sparingly and make sure that the roots have plenty of room to fall through the bottom of the pot. Whichever way you choose to plant your seedlings, make sure to check and trim the roots often to prevent out of control growth that can clog the system.

Another important consideration is length of your grow tray. As the nutrient solution flows over roots, it decreases in nutrient concentration & oxygen levels. "Short-run" trays offer advantage over long ones because they ensure that plants at end of line receive nutrient solution with the same composition as those at beginning of line. Long channels can be used successfully, just make sure that you regularly check the nutrient levels & pH & replenish your solution. If you notice plants at end of line growing more slowly or not producing as much, consider switching to short run system.



**The Reservoir:** The reservoir is placed in the grow tray, connected to the channel by a pump on the high end and a drain tube on the low end. You must place an air stone in the reservoir, connected to an air pump outside, to oxygenate the water. Unlike other systems, the NFT does not use an automatic timer connected to the water pump because the pump runs

constantly. This can be a big problem in the case of power outages, blockages or system failures so make sure to check the pump and fill tube regularly and have a backup ready.

One way to mitigate the risk of power failure is to use two reservoirs—one placed above the high point of the channel that feeds the solution via gravity, and another at the lowest point to collect the used solution. The spent solution can either be discarded and replaced or recycled by pumping from the low reservoir to the high reservoir. The advantage to this technique is that it doesn't require electricity to deliver nutrition to the plants—if there is a power outage or pump malfunction, you will at least have as much time as it takes for the reservoir to empty before you need to worry about the plants suffering.

### Horticulture therapy<sup>11</sup>

There are many different types of horticultural therapy, reaching different patient groups and carried out in differing settings and with different aims. Examples of professions that can be involved in a horticultural therapy team are psychologists, psychiatrists, occupational therapists, physiotherapists, and medical doctors. It is possible to study to become a specialist in horticultural therapy.

Examples of what can be included in horticultural therapy:

<sup>11</sup> <http://www.jtcm.org/horticultural-therapy/>

## Unit - II: Growth and Development of Horticultural Crops

Important phases of growth and development - Bearing habits - Classification of horticultural crops based on life cycle - Annual, biennial perennial (woody and herbaceous perennials) - Fruitfulness and unfruitfulness - External and internal factors associated with unfruitfulness - Physiology of flowering, fruit set, ripening and senescence - Fruit drop - Causes and control measures - Plant growth regulators - Functions and role in horticultural crops - Bud dormancy - Dormancy breaking - Parthenocarpy - Parthenogenesis - Polyembryony - Stenospermocarpy - Vivipary - Apomixis.

### **Important phases of growth and development**

Growth is the most fundamental characteristic of any living organism. It is defined as "an irreversible, permanent increase in size of organ or its parts, or even of an individual cell". Generally, growth is accompanied by metabolic processes (catabolic and anabolic) that spend energy.

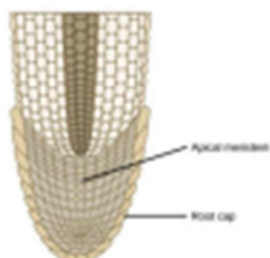
#### **Characteristics of Plant Growth**

**Plant Growth Is Indeterminate:** Plants have the unique ability to grow indefinitely throughout their life due to the presence of 'meristems' in their body. Meristems have cells that can divide and self-propagate. This is called 'open form of growth' because new cells are constantly added to the plant body by the cells in the meristem.

Meristems in the roots and shoots of plants are responsible for 'primary growth of the plant'. These increase the height of the plant. On the other hand, lateral meristems increase the width of the plant. This is known as the 'secondary growth of the plant'.

**Plant Growth Is Measurable:** At a cellular level, growth simply means increase in amount of protoplasm. Since this is hard to measure, growth is measured in quantity proportional to this increase. Growth is measured in terms of increase in cell number, area, volume, length etc.

Did you know that the cells in a watermelon can increase in size up to about 3,50,000 times! On the other hand, a single apical meristem in maize roots can produce about 17,500 new cells per hour! In first case, growth is in terms of size of the cell whereas in second case, it is in terms of cell number.



#### **Phases of Plant Growth**

**Meristematic Phase:** The cells in the root and shoot apex of a plant are constantly dividing. They represent the meristematic phase of growth. The cells in these regions have large nuclei and are rich in protoplasm and their cell walls are thin and contain cellulose.

**Elongation Phase:** The cells in the zone just after the meristematic region represent the phase of elongation. The characteristics of cells in this zone are cell enlargement, increased vacuole formation and new cell wall deposition.

andromonoecious: Tree with staminate and perfect flowers.

Gynomonoecious: Tree with pistillate and perfect flowers.

#### Bud position

Axillary bud: born laterally at axils of the leaves

Apical bud: born terminally on tips of the shoots

#### Bud Types:

Simple: Which developed to vegetative organs (shoot and leaves) / reproductive organs (flower / inflorescences)

Mixed: Which developed to vegetative and reproductive organs

Compound: there are primary, secondary and tertiary buds in the same eye. The primary developed to vegetative and reproductive organs

#### Shoot types

One year old shoot (1-year old shoot): shoot grew the previous season

Current growth: shoot grow this season

Fruit spurs: very short stem upon which flowers and fruit develop

#### Pome Fruits: Apple, Pear, Quince, Loquat

Apple: *Malus domestica*

Pear: European pear: *Pyrus communis* L.

Asian pear: *Pyrus pyrifolia* Bum.

Quince: *Cydonia oblonga* Mill.

Loquat: *Eriobotrya japonica* L.

Family: Rosaceae

Tree sexuality: Synoecious

Flower bud: mixed      Fruit: pome

Flower buds: Apple and Pear: it developed terminally on 1-year old shoot and spurs and rarely laterally on 1-year old shoot. The bud developed to inflorescence

Quince: it developed laterally and terminally on 1-year-oldshoot. Flowers are solitary (each bud produce 1 flower).

Loquat: it developed terminally on 1-year-old shoot. The bud developed to inflorescence

#### Stone Fruits: Almond, Apricot, Cherry, Plum, and Peach and Nectarine.

Peach and Nectarine: *Prunus persica* L (nectarina)

Almond: *Amygdalus communis*

Plum: European plum, *Prunus domestica* L.

Japanese plum, *Prunus salicina* L.

Apricote: *Prunus armeniaca* L.

#### Cherry: Sweet cherry *Prunus avium* L.

#### Sour cherry *Prunus cerasus* L.

Family: Rosaceae      Tree sexuality: Synoecious      Flower bud: Simple      Fruit: drupe

Flower bud: Almond, Apricot, Cherries and Plum: it develops laterally on 1-year old shoot and spurs

Peach and Nectarine: it develops laterally on one year old shoot

#### Nut trees

##### Walnut

Persian walnut: *Juglans regia* L., major species      Black walnut / American walnut: *Juglans nigra* L.

Family: Juglandaceae

Tree sexuality: Monoecious.

Flower bud Male: It is simple and developed laterally on 1-year old shoot, bud developed to inflorescences.

Female: It is mixed and developed terminally and/or laterally on one year old shoot, the bud developed to shoot at the end developed inflorescence.      Fruit: nut

breakage. To improve fruiting, right pruning is given every year. Summer dormant ber is pruned in May-June to get more fruit. Intensity of pruning varies from cultivar to cultivar and species to species.

**6. Plant Age:** Some fruit plants have long juvenile period than others. These plants cannot be made to bear fruit early. The Citrus medical *and* C. jambhiri plants bear only male flowers in the first few years. Slowly hermaphrodite flowers appear with age. Young grape vines produce less pollen than the aged vines of the same cultivar. Very healthy plants bear less flowers than semi- healthy plants. Declining plants bear profusely than healthy trees.

**7. Chilling Requirements:** Some fruit trees need desired chilling hours requirement for spur formation and flowering. Bartlette and conference pears do not flower in plains; whereas low chilling requiring 'Leconte' and other pears bear heavy fruit. Apple remains vegetative for long in lower hills than higher altitudes. Southern cultivars of mango shoots get killed due to frost / low temperature in north hence no fruiting. In 'Leconte' pear profuse flowering is observed every year but fruit set is irregular due to change in season.

**8. Spraying at Full-bloom:** Insecticide sprays at flowering time are not recommended. Sometimes due to prolonged flowering particularly in litchi, mango and pear, it becomes necessary to control aphids, etc. Insecticide is sprayed, which adversely affect fruit set. In mango disease 'Jhumka' has surfaced due to poor pollination. Fungicides normally do not affect pollination. Insecticide sprays should be avoided on full- bloom. Spray may be advanced or delayed for week / so.

**B. Internal Factors:** Some fruit species produce abundant flowers and set little fruit. Sometimes there may not be any fruit on a tree. Pollination failure, sterility or deficiency of nutrients may be the major cause of unfruitfulness.

**The internal factors are:** (1) Impotency, (2) Incompatibility, and (3) embryo abortion. Some other factors are related to flower structure and form. **These are:**

**1. Dicliny or Uni-sexuality:** The stamens and carpels lie in separate flowers. Male or female flowers borne on same or different trees.

(a) Male and female flowers on the same plants are called monoecious, e.g., walnut, pecan nut, chestnut, banana and coconut.

(b) **Dioecious:** male and female flowers are borne on two different plants. To set more fruit male flowers from male plants are placed close to female flowers on other plant, e.g. Date palm and papaya.

**Papaya has 8 types of flowers:** (1) Pure pistillate flowering plants (2) Pure staminate (3) Both staminate and perfect flowers (4) Plants with sterile pollen (Pseudo hermaphrodite) (5) Plants producing staminate and perfect flowers but neither pollen nor pistil is fertile (Sterile hermaphrodite) (6) Plants producing staminate, pistillate and perfect flowers (7) Plants with staminate and perfect flowers (8) Plant with pistillate and perfect flowers.

**2. Dichogamy:** In many bisexual flowers the anthers and stigma mature on different times. This condition is known as dichogamy. It acts as a barrier to self-pollination hence; unfruitfulness in such plants is the result. When the gynoecium matures earlier than the anthers of the same flower the condition of the flower is protogyny.

When the anthers mature first and discharge their pollen earlier than the stigma of the same flower, the condition is protandry. Avocado flowers are protogynous in nature and in mango stigma are receptive for

**Respiratory climacteric:** Kidd and West (1930) observed that in apple fruits, major change occurs in respiration rates during their ripening. They found lowering of respiration rate in maturing fruits followed by large increase in respiration during ripening. After reaching climacteric peak, rate of respiration falls.

Period of occurrence of climacteric peak in fruits show variation in different fruits, e.g. at time of optimum eating quality as in pear, it slightly precedes this optimum in banana and apple / just before fruit is fully ripe as in tomatoes. Earlier it was suggested that climacteric is associated with hydrolysis of food reserves, but it has not been found true in all cases, e.g. orange, lemon, grapes and fig in which case climacteric rise in respiration is not found during fruit ripening. Process of fruit ripening proceeds slowly in these crops. Hence, these fruits are termed as non climacteric fruits. As regards occurrence of climacteric, fruits may be divided into 2 types:

1. Climacteric fruits,

2. Non climacteric fruits,

Climacteric Fruits	Non-climacteric Fruits
Apple	Chillies
Apricot	Orange
Avocado	Lemon
Banana	Mandarins
Sapota	Watermelon
Custard apple	Grapes
Fig	Pineapple
Mango	Strawberry
Melon	
Olive	
Peach, Pear	
Persimmon	
Plum	
Tomato	

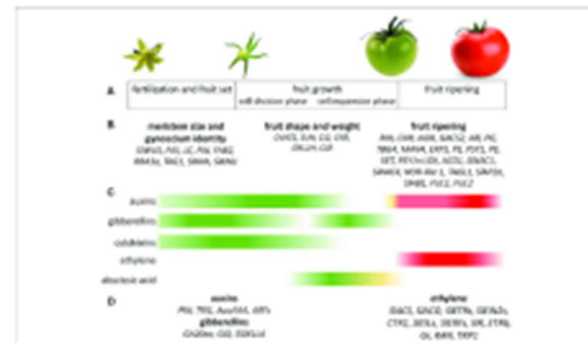
In non-climacteric fruits, the rate of respiration remains steady during their ripening.

Climacteric rise has been found affected by low oxygen and increased concentration of carbon dioxide. Both these factors prevent climacteric rise and thus improve storage quality of fruits. Storage of fruits in polythene bags produces nearly the same effect because plastic can lower oxygen and elevate carbon dioxide around fruits.

In climacteric fruits, the respiratory climacteric initiates after the fruit growth is complete. Gane (1937) established that ethylene stimulates climacteric rise and that ripe banana stimulates it in the same manner as ethylene.

Some further researches established that there is a marked rise in ethylene formation in fruits either just at or just before the onset of climacteric rise. It has been found that the ability of ethylene to induce climacteric rise is found in climacteric fruits.

**Hormonal control of ripening:** Ethylene has been established as ripening hormone. Massive doses of ethylene can bring about ripening changes in immature fruits. So, it is hormone which plays most



powerful regulatory role in ripening. It has been observed that rise of ethylene level occurs at onset of climacteric rise and can be assigned role of trigger of ripening.

They proposed that onset of ripening is associated not only with rise in ability to biosynthesize ethylene but marked increase in ethylene responsiveness. It has been found that ethylene can induce

respiratory climacteric in some leaves and develop many of pigments commonly developed in fruit ripening. In general, ethylene may be bringing about formation of new types of enzymes in fruits.

2. Gibberellins
3. Cytokinenins
4. Etylene
5. Dormins {Abscissic Acid (ABA), Phaseic Acid}
6. Flowering Hormones {Florigin, Anthesin, Vernalin}
7. Phenolic Substances {Coumarin}
8. Miscellaneous Natural Substances {Vitamins, Phytochrome Tranmatic Substances}
9. Synthetic Growth Retardants {Ccc, Amo, 1618, Phosphin - D, Morphacting, Malformis}
10. Miscellaneous Synthetic Substances {Synthetic Auxins, Synthetic Cytokinins}

#### Auxin

- Auxin is a greek word which means to *increase*.
- It is a generic term for chemicals that typically stimulate cell elongation, but auxins influence a wide range of growth and development response.
- The chemical isolations and characterization was done by Kogi *et al.* (1934).
- Auxins are the first identified hormones of which IAA seems to be the major naturally occurring, endogenous auxin in crops.
- Besides IAA, plants contain 3 other compounds which are structurally similar and elicit many of same response as that of IAA, 4, chloroindole acetic acid (CIAA), phenylacetic acid (PAA), indole butyric acid (IBA).
- Synthetic compounds are classified into five major categories; indole acids, naphthalene acids, chlorophenoxy acids, benzoic acid and picolinic acid derivatives.

#### Role of Auxin

1	Cell divisions and enlargement Eg. cambial growth in diameter	.IAA + GA
2	Tissue culture	Shoot multiplications (IBA and BAP), callus Growth (2,4,-D), root multiplication IAA and IBA (1-2 mg)
3	Breaking dormancy and Apical dominance	NAA
4	Shortening internode	Apple trees (NAA) (dwarf branch-fruit)
5	Rooting of cuttings	(10-1000 ppm - NAA, IAA, phenyl acetic acid)
6	Prevent lodging	NAA- develop woody and erect stem
7	Prevent abscission	Premature leaf, fruit, flower fall (NAA, IAA and 2,4-D)
8	Parthenocarpic fruit	Grapes, banana, orange - (IAA)
9	Flower initiations	Pine apple -uniform flowering - fruit ripening (NAA). Delay flowering (2,4-D)
10	Weed eradications	2,4,D and auxin compounds

#### Gibberellin

- It is the active substance isolated from the soil borne fungus *Gibberella fujikuroi* the concentration of GA 3 is usually highest in mature seeds.
- Reaching up to 18 mg / kg fresh weight in *Phaseolus* species, but it decreases rapidly as seed mature.
- In general, roots contain higher amounts of GA3 than shoots.
- Gibberellins have been found effective in overcoming both kinds of dormancy, buds and seeds.

- **For Function:-** • **Vegetative:-** If only containing vegetative pieces: embryonic shoot with leaves (a leaf bud is the same) • **Reproductive:-** If containing embryonic flower. (a flower bud is the same). • **Mixed:-** If containing both embryonic leaves and flowers.
- **Factors Affecting Dormancy** • Factors Affecting seed germination : External and internal factor • Some of the important factors are: • External factors such as water, oxygen and suitable temperature. 2 internal factors such as seed dormancy due to internal conditions and its releases.
- **External Factors:** • **1. Water:** A Dormant seed is generally dehydrated and contains hardly 6-15% water living cells. Active cells, however, require about 75-95% of water for carrying out their metabolism. • Therefore the dormant seed must absorb external water to become active and show germination • water brings in the dissolved oxygen for use by the growing embryo.
- **Oxygen:-** oxygen is necessary for respiration which releases for respiration which releases needed for growth • Germinating seeds respire very actively and need sufficient oxygen. **SUITABLE TEMPERATURE:** Though— germination can take place over a wide range of temperature (5-4<sup>0</sup>c), the optimum for most of the crop plants is around 25-30c. • The germination in most cases stops at 0c and 45<sup>0</sup>c.
- **Internal Factors** • Seed dormancy due to internal conditions its release: • In some plants the embryo is not fully mature at the time of seed shedding • Such seed do not germinate till the embryo attains maturity. • The freshly shed seed in certain plants may not have sufficient amounts of growth hormones required for the growth embryo.
- The seeds of almost all plants remain viable or living for specific period of time. • Seeds of lotus have maximum viability period of 1000 year. • Seeds germinate before ending of their viability periods.

### Dormancy breaking<sup>4</sup>

**Dormancy-breaking treatments:** In some seeds that are dormant at harvest, dormancy breaks down naturally over time. Other species require some form of pre-treatment. There are several methods used for specific genera.

**Breaking seed-coat dormancy:** Puncturing or scarifying the seed coat by piercing, nicking, chipping or filing with a knife, needle or sandpaper are preferred procedures to overcome seed-coat dormancy. %

- Manual scarification is effective at any point on the seed coat, but the micropylar region should be avoided as it is the most sensitive part of the seed where the radicle is located. %
- If seed-covering structures prevent growth of the embryo, remove them to allow germination. %
- If seed coat contains inhibitors that prevent / delay germination, they can be leached out by placing seed under running water for several hours / soaking seed in large volume of water that is changed every 6-12 hours. %
- ISTA recommends using concentrated sulphuric acid for 2-45 minutes depending on species to scarify seed coat. This method is expensive and dangerous, and should be followed with caution. %
- To remove the waxy covering and allow imbibitions, place the seeds in water at 75°C for three to six minutes. Care must be taken not to use high temperatures for long periods or boil the seeds.

**Breaking embryo dormancy:** There are several recommended treatments to overcome embryo dormancy (see guidelines for testing germination of most common crop species). These include pre-chilling (called cold stratification) for temperate and high-altitude species from tropics; preheating; application of Gibberellic acid

<sup>4</sup> <https://cropgenebank.sgrp.cgiar.org/images/file/procedures/dormancy-breaking%20treatments.pdf>

- It may result due to Nucellar embryony e.g., Citrus
- Development of more than one nucleus within the embryo sac (in addition to the egg embryo during the early stages of development) leading to multiple embryos (e.g. conifers).
- Occurrence of polyembryony is widespread in all citrus species but the number of embryos per seed varies from species to species. In rough lemon, it varies from 3 to 5.
- In mango certain cultivars are reported to be polyembryonic with the number of embryos ranging from 2 to 10 and the germination per cent from 40 to 87.
- Polyembryonic seedlings can be identified from its true seedlings by their uniformity and vigorous growth, while the seedling arising from fertilized embryo will be weak.
- The greater vigor in polyembryonic nucellar seedlings is probably due to the elimination of viruses. In mango polyembryony was determined by single dominant gene (Anon, 1996).
- In citrus, all the species are polyembryonic in nature except *C.medica* (Citron) and *C.grandis* (Pumelo) which are monoembryonic.
- Though nucellar embryony in citrus is of great value for producing vigorous, uniform and virus free plants, the phenomenon is an obstacle in hybridization.
- In polyembryonic cultivars, vigorous growth of nucellar embryos inhibits growth of zygotic embryo and causes its degeneration prior to seed maturation. Such abortive embryos can be rescued by tissue culture.

### Stenospermocarpy

- In Black Corinth variety of grapes, pollination and fertilization take place but embryo gets aborted subsequently resulting in seedlessness. This phenomenon of development of seedless fruits is referred to as 'steno-spermocarpy'. Seedlessness / parthenocarpic fruits are advantageous since there is greater preference among consumers for seedless fruits of same kind (e.g. seedless grapes, guava or oranges).
- Besides the problem of unfruitfulness due to pollination failure, sterility and incompatibility may not arise if a fruit develops parthenocarpically and the grower is assured of good crop (e.g. banana). One drawback with the seedless fruits is that they are usually small in size (e.g. Black Corinth variety of grapes) and irregular in shape (guava).

### Vivipary<sup>5</sup>

Vivipary is phenomenon that involves seeds germinating prematurely while they are still inside /attached to parent plant / fruit.

**What is vivipary?** This Latin name literally means "live birth." This phenomenon occurs frequently on ears of corn, tomatoes, peppers, pears, citrus fruits, and plants that grow in mangrove environments.

Most likely to encounter it in tomatoes / peppers that bought in grocery store, especially if you've left the fruit sitting out on the counter for a while in hot weather. To cut it open and find tender white sprouts inside. In tomatoes, sprouts appear as tiny white worm like things, but in peppers they're often thick and sturdy.

**How Does Vivipary Work?** Seeds contain hormone that repress germination process. This is necessary, as it keeps seeds from germinating when conditions aren't favorable and missing their shot to become

<sup>5</sup> <https://www.gardeningknowhow.com/garden-how-to/propagation/seeds/what-is-vivipary.htm>

## Centers of Origin of Crop Plants<sup>1</sup>

### Old world

**I. Chinese Center: Cereals and Legumes:** Chinese yam, Radish, Chinese cabbage, Onion, Cucumber, Pear, Chinese apple, Peach, Cherry, Litchi, *Opium poppy*

**Near East** – Chickpea, Pea, Raisin, Olive, Walnut, Almond, Apricot, Date, Wheat, Fig

**Americas** – Potato, Cocoa bean

**Far East** - Yellow banana, Red banana, Green banana, Coconut, Yam,

**II. Indian Center:** Two subcenters. **A. Main Center (Hindustan):** Includes Assam and Burma, but not Northwest India, Punjab, nor Northwest Frontier Provinces - Eggplant, Cucumber, Radish, Yam, Mango, Orange, Citron, Tamarind, Coconut palm, Kenaf (*Hibiscus cannabinus*), Hemp, Black pepper, Sandalwood, Indigo, Cinnamon tree, Bamboo

**B. Indo-Malayan Center:** Includes Indo-China and the Malay Archipelago - Pummelo, Banana, Breadfruit, Mangosteen, Coconut palm, Clove, Nutmeg, Black pepper

**III. Central Asiatic Center:** Includes Northwest India (Punjab, Northwest Frontier Provinces and Kashmir), Afghanistan, Tadjikistan, Uzbekistan, and western Tian-Shan - Pea, Lentil, Chickpea, Mustard, Onion, Garlic, Spinach, Carrot, Almond, Grape, Apple.

**IV. Near-Eastern Center:** Includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan - Lentil, Alfalfa, Fenugreek, Fig, Pomegranate, Apple, Pear, Cherry.

**V. Mediterranean Center:** Includes the borders of the Mediterranean Sea. Eighty-four plants are listed for this region including olive and many cultivated vegetables and forages - Pea, Rape seed, Black mustard, Olive, Cabbage, Turnip, Lettuce, Thyme, Peppermint.

**VI. Abyssinian Center:** Includes Abyssinia, Eritrea, and part of Somaliland - Coffee, Okra, Indigo

### New World

**VII. South Mexican and Central American Central:** Includes southern sections of Mexico, Guatemala, Honduras and Costa Rica - Common bean (*Phaseolus vulgaris*), Lima bean, Winter pumpkin, Sweet potato, Arrowroot, Pepper, Papaya, Guava, Cashew, Wild black cherry.

**VIII. South American Center:** Three subcenters **A. Peruvian, Ecuadorean, Bolivian Center:** Comprised mainly of the high mountainous areas, formerly the center of the Megalithic or Pre-Inca civilization, Coastal regions of Peru and non-irrigated subtropical and tropical regions of Ecuador, Peru and Bolivia included - Potato, Tomato, Pumpkin, Pepper, Guava, Quinine tree, Tobacco.

**B. Chiloe Center (Island near the coast of southern Chile)** - Common potato, Wild strawberry.

**C. Brazilian-Paraguayan Center** - Rubber tree, Pineapple, Cashew.

### Establishment of nursery – Site selection

A nursery is managed site, designed to produce seedlings grown under favorable conditions until they are ready for planting. All nurseries primarily aim to produce sufficient quantities of high quality seedlings to satisfy needs of users. In existing infrastructure, there are just over 100 big nurseries. At present 30-40% demand for planting material is being met by existing infrastructure. As per report of working group on Horticulture, Plantation crops & Organic farming for XI five year Plan (2007-12), Planning Commission, Government of India (Gol), there are about 6,330 registered nurseries under public & private sectors. The state-wise details of nurseries are given.

**Guidelines for Nursery Raising:** Time of sowing/initiation of propagules production depend on how

<sup>1</sup> Origin of basic crops. Source: J.N. Leonard 1973, First Farmers.

Medium level greenhouses offer compromise between cost and productivity and represent a reasonable economic and environmental basis for the industry. Production in medium level greenhouses can be more efficient than field production. Hydroponic systems increase the efficiency of water use. There is greater opportunity to use non-chemical pest & disease management strategies but overall the full potential of greenhouse horticulture is difficult to attain.

**High technology greenhouses:** High level greenhouses have wall height of at least 4 metres, with roof peak being up to 8 metres above ground level. These structures offer superior crop & environmental performance. High technology structures will have roof ventilation & may also have side wall vents. Cladding may be plastic film (single / double), polycarbonate sheeting / glass. Environmental controls are almost always automated. These structures offer enormous opportunities for economic & environmental sustainability. Use of pesticides can be significantly reduced. High technology structures provide generally impressive sight & internationally, are increasingly being involved in agribusiness opportunities. Although these greenhouses are capital intensive, they offer a highly productive, environmentally sustainable opportunity for an advanced fresh produce industry. Investment decisions should, wherever possible, look to install high technology greenhouses.

**Other classifications:** The greenhouse can also be classified based on type of structures, type of glazing, number of spans, environmental control etc. The various types are as follows.

**Classification as per type of structure**

- a. Quonset type                      b. Curved roof type                      c. Gable roof type

**Classification as per glazing**

- a. Glass glazing  
 b. Fiberglass reinforced plastic glazing  
 i. Plain sheet                      ii. Corrugated sheet  
 c. Plastic film  
 i. Ultra violet stabilized low density poly ethylene                      ii. Silpaulin

**Classification based on number of spans**

- a. Free standing or single span                      b. Multispan or ridge and furrow or gutter connected

**Classification based on environmental control**

- a. Naturally ventilated                      b. Passive ventilation

**Components of greenhouse**

**Roof:** transparent cover of a green house.

**Gable:** transparent wall of a green house

**Cladding material:** transparent material mounted on the walls and roof of a green house.

**Rigid cladding material:** cladding material with such a degree of rigidity that any deformation of the structure may result in damage to it. Ex. Glass

**Flexible cladding material:** cladding material with such a degree of flexibility that any deformation of the structure will not result in damage to it. Ex. Plastic film

**Gutter:** collects and drains rain water & snow which is placed at an elevated level between two spans.

**Column:** vertical structure member carrying the green house structure

**Purlin:** a member who connects cladding supporting bars to the columns

**Ridge:** highest horizontal section in top of the roof

**Girder:** horizontal structure member, connecting columns on gutter height

**Bracings:** To support the structure against wind

- Cut all scions to a uniform length, keep their basal ends together, and tie them in bundles of known quantity (for example, 50 scions per bundle).
- Label them, recording the cultivar, date of harvest, and location of the stock plant.
- Wrap the base of the bundles in moistened burlap or sphagnum moss. Place them in polyethylene or waterproof paper bags, and seal the bags.
- Store the bundles for short periods, if necessary, either iced down in insulated coolers or in a commercial storage unit at 0 to 1.1°C.
- Never store scions in refrigerated units where fruits or vegetables are currently kept or have been stored recently. Stored fruits and vegetables release ethylene gas, which can cause woody plant buds to abort, making the scions useless.
- The scions should not be frozen during storage.

In grafting, & budding, vascular cambium of scion / bud must be aligned with vascular cambium of rootstock. In woody plants cambium is very thin ribbon of actively dividing cells located just below bark. The cambium produces conductive tissue for actively growing plant. This vascular cambium initiates callus tissue at graft & bud unions in addition to stimulating tissue growth on basal end of many vegetative cuttings before they have rooted.

### Budding types

It is vegetative method of plant propagation & can be defined as an art / technique of inserting single matured bud taken from desired tree in rootstock, in such way that union takes place, bud sprouts & combination continues to grow. When scion part is small piece of bark containing single bud, operation is called as budding.

**Scion:** is the part of mother plant used in budding and grafting to develop the fruit tree. It is an upper portion of the composite plant which forms the fruit bearing part of the tree.

**Rootstock:** It is part of original tree on which the scion is worked upon to produce desirable tree. The scion & rootstock from separate mother plants are considered for budding purpose.

#### Methods of Budding

**T-Budding:** T-budding must be done when bark is succulent & in slipping condition. When cut, bark easily lifts / peels in a single uniform layer from underlying wood without tearing this is "Slipping". The exact time when this condition occurs depends on soil moisture, temperature, & time of year. It varies with species & variety. Dry, very hot / very cold weather can shorten period of bark slipping. Irrigation can be valuable in extending the T-budding season.

The successful budding operation can be obtained when following precaution is taken. Buds should not be inserted when air temperature exceeds 32.2°C.

**Preparing Stock:** Budding knives usually have a curved tip, making it easier to cut T-shaped slit. First, insert point of knife & use a single motion to cut the top of the T. Then without removing point of knife, twist it perpendicularly to original cut & rock blade horizontally down stem to make vertical slit of T. If bark is slipping properly, slight twist of knife at end of this cut will pop open flaps of cut and make it easier to insert bud. In practice, top of T is usually slanted slightly.

This same type of cut can be made using two separate strokes, one vertical and one horizontal, and then using the back of the budding knife tip to pry up the flaps slightly. Although much slower, this technique may be easier to practice.

**Removing Buds from the Bud Stick:** The bud to be inserted is often just shield of bark with bud

propagation protocols are now standardized & commercially used in gladiolus even in our country.

**Pseudo bulbs:** Pseudobulb (false bulb) is enlarged fleshy stem with several nodes. It is produced by some horticultural plants (mostly orchids), mainly for storage of food. Plants producing pseudobulbs are propagated through offshoots, division / from black & green bulbs produced by them. Rooted shoots are cut from mother bulb & planted in nursery. Some orchids, like Cattleya, Laelia, Miltonia etc. are multiplied commercially through division of pseudobulbs. Bulb is cut into different sections by sharp knife during dormant season. Each section is sown & new growth begins at nodes.

### Quality management and nursery certification

<sup>14</sup>Nursery plants require due care & attention after having either emerged from seeds / have been raised from other sources like rootstock / through tissue culture technique. They are grown in open field under protection of Mother Nature where, they should be able to face local environment. It is duty & main objective of commercial nursery grower to supply nursery plants with suitable conditions necessary for their development & growth. This is major work of management in nursery which includes all such operations right from emergence of young plantlet till they are fully grown-up / are ready for uprooting & transplanting in main fields.

**1) Potting the seedling:** - Before planting of sapling in pots, pots should be filled up with proper potting mixture. Now a days different size of earthen pots or plastic containers are used for propagation. For filling of pots loamy soil, sand & compost can be used in 1:1:1 proportion. Sprouted cuttings, bulbs, corms / polythene bag grown plants can be transferred in earthen pots for further growth. All necessary precautions are taken before filling pots & planting of sapling in it.

**2) Manuring & Irrigation:** - Generally sufficient quantity of nutrients is not available in soil used for seedbed. Hence, well rotten F.Y.M / compost & leaf mould is added to soil. Rooted cuttings, layers / grafted plants till they are transferred to permanent location, require fertilizers. Addition of fertilizers will give healthy & vigorous plants with good root & shoot system. It is recommended that each nursery bed of 10 X 10m area should be given 300 gm of ammonium sulphate, 500 gm of Single super phosphate & 100 gm of Muriate of potash. Irrigation either in nursery beds / watering pots is important operation. For potted plants hand watering is done & for beds low pressure irrigation by hose pipe is usually given. Heavy irrigation should be avoided.

**3) Plant protection measures:** - Adoption of plant protection measures, well in advance & in planned manner is necessary for efficient raising of nursery plants. **Disease control in seedbed:-** major disease of nursery stage plant is "damping off". For its control good sanitation conditions are necessary. Preventive measures like treatment with 50% ethyl alcohol, 0.2% calcium hypo chloride & 0.01% mercury chloride is done. These treatments are given for 5 to 30 minutes. Seed treatment is as follows: **i) Disinfection** -infection within seed is eliminated by use of formaldehyde, hot water / mercuric chloride. **ii) Hot water treatment** - Dry seeds are placed in hot water having temperature of 48°C - 55°C for 10-30 minutes. **iii) Protection** - In dry seed treatment organo mercuric & non-mercuric compounds like agallal, aretan -6, & tafasan-6. For this e seeds are shaken within seed container. While in wet method, seeds are immersed for certain period in liquid suspension. **iv) Soil treatment** - Soil contains harmful fungi, bacteria, nematodes & even weeds seeds, which affect growth & further development of plant. These can be eliminated by heat, chemical treatment. For that soil is disinfected by heating to temperature of about 60°C for 30 minutes. **v) Chemical**

<sup>14</sup> [http://oer.nios.ac.in/wiki/index.php/Nursery\\_and\\_Nursery\\_Management](http://oer.nios.ac.in/wiki/index.php/Nursery_and_Nursery_Management)

## **Unit - IV: Management Techniques For Horticultural Crops**

Planning – Layout and management of orchards – Fencing – Wind breaks and shelter beds – Spacing – Planting system – Physical and chemical properties – Soil reaction – acid, saline and alkaline soils – Soil fertility - Essential elements – Functions - Organic manures and inorganic fertilizers, bio-fertilizers, vermi- composting - Applications and management – Nutrient deficiencies and corrective measures - Physiological disorders and remedies - Irrigation – Critical stages of water requirement – Effect of water stress on crop yield – Anti-transpirants – management of irrigation water quality - Conventional and micro irrigation – Fertigation - Mulching – Sod culture – Weed management – Application growth regulators – Training and pruning principles and methods - Rejuvenation of senile and old orchards – Cropping systems - Cover cropping - Multitier cropping – Intercropping – Special horticultural techniques (pinching, thinning, disbudding, blanching, smudging, notching, ringing) - Principles of organic horticulture – GAP and GMP.

### **Planning – Layout and management of orchards**

**Some of the major components of Orchard planning are as follows:**

Orcharding is a long-term investment hence, require planning. Any mistake committed in laying out, planting distance, fruit plant/cultivar choice, procurement of plants, own nursery raising, irrigation system/method shall not be undone without much loss.

The efficiency of the orchard shall be based on in site of the Orchard planner. While planning help of the Orchardist all ready in the profession and horticulture expert cannot undermined.

**The following components should be given due attention:**

**Fencing and Wind Break:** A strong fence with use of barbed wire should be provided around field meant for planting of Orchard. Months to year before actual planting is done karonda (*Carissa carandus*) / Jatti khatti (*Citrus Jambhiri*) can be planted near barbed wire. This will provide impenetrable and strong fence, while protect Orchard against entry of wild/stray animals.

Plant Eucalyptus or Jamun seedlings at a proper distance inside the provided hedge to provide the Orchard a strong wind break. A trench one meter deep may be dug 2 meter away from the wind break to check the wind break plant roots interference with the fruit plant roots in the latter years.

**Land Preparation:** Before actual planting of fruit plants land should be cleared of all bushes & trees. Remove complete root systems of uprooted plants to check their resprouting later on. After levelling & making blocks green manuring by sowing dhiancha, sunhemp, guara / cowpeas should be done. This practice shall provide land adequate organic matter & aeration, required for fruit plants. In arid & foot hills lands are usually undulated. In such situations, land may be divided into blocks before levelling. Level individual block only, this shall avoid unnecessary lifting of upper soil from one point to other.

**Roads & Paths:** well laid out network of paths & roads shall be useful throughout life of orchard paths should be provided with plantation of Khabal grass which will keep dust intact & help in penetration of rain water fast. Such paths shall help in controlling erosion of soil by wind & water.

**Tube-well/Tank:** digging of well / tank shall be useful in areas where irrigation water is available only when canals are providing it. Water for use can be lifted from tank/well when ever needed most. Area for boring tub-well / tank may be marked at appropriate place in orchard land.

**Buildings:** In big-sized orchard some buildings are required, to store implements, place fruits after harvesting, for resting of labour & rest house for the owner. These buildings should be prepared beforehand.

mown sward of mixed grasses and broadleaf species / cover crops between rows. Weeds under the trees can be controlled by mulching, chipping and spot-spraying with herbicides.

Mulches used include wheat, barley / rice straw, hay, sorghum stubble & similar materials. Reduce costs by growing mulch material between rows for later slashing. Renew mulch as it breaks down. Keep it well away from trunks as collar rots may develop. Mulches increase soil organic matter, improve soil structure, increase water retention & help reduce fluctuations in root temperature.

Apply herbicides to the border of the mulched area and to individual weeds that grow through the mulch. Use glyphosate at 5 to 10 ml per litre or paraquat at 1 to 6 ml per litre plus a wetter at 1.25 ml per litre to control grasses and broadleaf weeds. Grasses can be controlled with fluazifop-p (Fusilade 212) at 1.25 to 10 ml per litre. Don't allow the herbicides to contact any green part of tree, including the trunk. Drift can be minimized by using shielded, low-pressure fan / flood nozzle, / alternatively, use a rope wick applicator. Herbicides are very expensive in parts of Asia. With relatively low labour costs, chipping is more practical.

**Canopy management:** Plant production depends on conversion of sunlight into chemical energy, for most part, this process takes place in leaves. There has strong move to improve productivity of temperate fruit trees in past 30 years / so, based on understanding of relationship between yield & light interception. Modern apple & stonefruit orchards are planted at high density & trees kept small through use of dwarfing rootstocks & intensive pruning. These systems maximize interception of light by canopy. This philosophy is not well developed in lychee & most other tropical fruit trees, with few dwarfing rootstocks or validated pruning strategies.

**Fertilizer management:** requires soil nutrients & water for satisfactory growth & cropping. Nitrogen (N) is major nutrient & occupies important position in fertilizer programme. Other major nutrients are phosphorus (P), potassium (K), calcium (Ca) & magnesium (Mg). Micronutrients, iron (Fe), boron (B), copper (Cu), zinc (Zn) & manganese (Mn) are required in very small amounts. When concentration of nutrient reaches abnormally low / high levels in plant, characteristic symptoms appear in leaves, stems, flowers / fruit. Normally, growth & yield are reduced long before visible symptoms appear. Only way to avoid this is to monitor concentrations of nutrients in plant & soil, & maintain these within acceptable range established from healthy, high-yielding orchards.

Fertilizers generally have small impacts on production, unless trees have nutrient deficiencies / excesses. Yield & fruit quality are usually adequate over wide range of leaf nutrient concentrations. Trees take long time to respond to fertilizer applications, with new growth more dependent on reserves in tree than on fertilizer applied just recently to soil. On other hand, when leaf concentrations have fallen below critical levels, it may take several years for trees to recover.

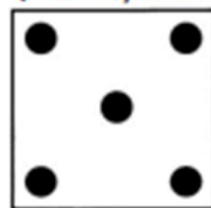
**Irrigation management:** deep root system & can survive long dry periods, although leaf, flower & fruit production are usually reduced. The period from flowering to early fruit development is particularly sensitive to water supply. Most orchards in Region are not irrigated because of costs /lack of infrastructure, but it is generally agreed that yield & fruit quality would be improved with supplementary watering. It is recommended that new orchards should be irrigated. In absence of irrigation, annual rainfall of 1,200 to 1,500 mm is required for satisfactory production.

An acceptable cycle in sandy loam would be 2 weeks, & considerably longer in a clay, with greater water-holding capacity. Irrigation in sandy loam before 50% of available soil water is used, would maintain tree water status in the acceptable range. The profile should be brought back to field capacity with every irrigation. This strategy is dependent on trees being well grown with deep root

the square system, fruit growers do not adopt it, as it is difficult to layout & cultivation in plot cannot be done so easily as in square system.

For laying out the plot, a base line is drawn in one side as in the square system. Then an equilateral triangle having rings at each corner and with sides equal to the length of the required distance is made of heavy wire or chain. Two of these rings are then placed on the stakes of the base line and the position of the third ring indicates the position of a tree in the second row. This row is then used as base line & pegs are set in third row. In this way entire plot is laid out.

**Quincunx system:** This system of planting fruit trees is similar to square system, except that a fifth tree is planted at the centre of each square. As a result the tree number in unit area becomes almost double the number in the square system. The additional tree in the centre is known as "filler". The fillers are usually quick growing, early maturing and erect type fruit trees like banana, papaya, pomegranate, etc., which are removed as soon as main fruit trees planted at the corner of square come into bearing. The planting of filler trees provides an additional income to the grower in early life of orchard.



**Contour system:** It is generally followed on the hills with high slopes. It particularly suits to a land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture so as to make the slope fit for growing fruits. So, the contour line is designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the soil without causing erosion.



## Physical and chemical properties of Soil

### Soil physical properties

**H<sup>3</sup>** - Soil "horizons" are discrete layers that make up a soil profile. They are typically parallel with the ground surface. In some soils, they show evidence of the actions of the soil forming processes.

**Soil color** - In well aerated soils, oxidized or ferric (Fe+3) iron compounds are responsible for the brown,

yellow, and red colors you see in the soil. When iron is reduced to the ferrous (Fe+2) form, it becomes mobile, and can be removed a gray color remains, or the reduced iron color persists in shades of green or blue.



<sup>3</sup> Soil Survey Staff, 2003. Keys to Soil Taxonomy. USDA-NRCS.

SN	Fertilizers	Nutrients (%)				
		N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	S	Other
8	Diammonium phosphate	18	46	-	-	-
9	Rock phosphate	-	18-20	-	-	Ca
10	Phosphogypsum	-	-	-	16	21% Ca
11	Magnesium sulphate	-	-	-	13	16% Mg
12	Borex	-	-	-	-	10.5% B
13	Copper sulphate	-	-	-	13	24% Cu
14	Ferrous sulphate	-	-	-	12	19% Fe
15	EDTA-Fe	-	-	-	-	12% Fe
16	Manganese sulphate	-	-	-	15	30.5% Mn
17	Zinc sulphate	-	-	-	11-16	21 % Zn
18	EDTA-Zn	-	-	-	-	12% Zn

### Bio-fertilizers

"Biofertilizers are substances that contain microorganisms, which when added to the soil increase its fertility and promotes plant growth." Based on type of microorganism, the bio-fertilizer can also be classified as follows:

- Bacterial Biofertilizers: e.g. Rhizobium, Azospirillum, Azotobacter, Phosphobacteria.
- Fungal Biofertilizers: e.g. Mycorrhiza
- Algal Biofertilizers: e.g. Blue Green Algae (BGA) and Azolla.
- Actinomycetes Biofertilizer: e.g. Frankia.

#### Characteristics Features of common Biofertilizers

**Rhizobium** : Rhizobium is relatively more effective and widely used biofertilizer. Rhizobium, in association with legumes, fixes atmospheric N. The legumes and their symbiotic association with the rhizobium bacterium result in the formation of root nodules that fix atmospheric N. Successful nodulation of leguminous crop by rhizobium largely depends on the availability of a compatible strain for a particular legume. Rhizobium population in the soil is dependent on the presence of legumes crops in field. In the absence of legumes the population of rhizobium in the soil diminishes.

**Azospirillum** : Azospirillum is known to have a close associative symbiosis with the higher plant system. These bacteria have association with cereals like; sorghum, maize, pearl millet, finger millet, foxtail millet and other minor millets and also fodder grasses.

**Azotobacter** : It is a common soil bacterium. *A. chroococcum* is present widely in Indian soil. Soil organic matter is the important factor that decides the growth of this bacteria.

**Blue Green Algae (BGA)** : Blue green algae are referred to as rice organisms because of their abundance in rice field. Many species belonging to genera, Tolypothrix, Nostic, Schizothrix, Calothrix, Anoboenosis & Plectonema are abundant in tropical conditions. Most of nitrogen fixation BGA are filamenters, consisting of chain of vegetative cell including specialized cells called heterocyst which function as micronodule for synthesis & N fixing machinery.

#### List of commonly produced bio-fertilizers in India

Name	Crops suited	Benefits usually seen	Remarks
Rhizobium strains	Legumes like pulses, groundnut, soybean	10-35% yield increase, 50-200 kg N/ha.	Fodders give better results. Leaves residual N in the soil.
Azotobacter	Soil treatment for non-legume crops including dry land crops	10-15% yield increase- adds 20-25 kg N/ha	Also controls certain diseases.

**Localized irrigation:** Localized irrigation is a system where water is distributed under low pressure through piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Drip irrigation, spray or micro-sprinkler irrigation and bubbler irrigation belong to this category of irrigation methods.

#### **Micro Irrigation<sup>7</sup>**

Micro irrigation is a modern method of irrigation; by this method water is irrigated through drippers, sprinklers, foggers and by other emitters on surface or subsurface of the land. Major components of a micro irrigation system is as follows.

Water source, pumping devices (motor and pump), ball valves, fertigation equipments, filters, control valves, PVC joining accessories (Main and sub main) and emitters.

- In this system water is applied drop by drop nearer root zone area of crop. Drippers are fixed based on spacing of crop. Many different types of emitters are available in market. They are classified as Inline drippers, on line drippers, Micro tubes, Pressed compensated drippers.
- Drip irrigation is most suitable for wider spacing crops. Micro sprinkler irrigation system is mostly followed in sandy or loamy soils. This system is most suitable to horticultural crops and small grasses. In this method water is sprinkled in a lower height at various directions.
- Portable micro sprinklers are also available. They distribute slightly more water than drippers and micro sprinklers. They spray water in not more than one meter. It is used for preparing nursery and lawns in soils with low water holding capacity.

#### **Advantages of drip irrigation system**

- Water saving and higher yield, High quality and increased fruit size
- Suitable for all types of soil, Easy method of fertigation and chemigation
- Saving in labour and field preparation cost

#### **Disadvantage of drip irrigation system**

- High initial investment, Clogging of emitters
- Possible damage of system components due to animals, etc.,

#### **Investment cost mostly differs based on spacing of the crops**

- Generally, the reasons for clogging are solid particles (sand, rust), soft dirt (organic matter, algae, micro organism, salt), sediments (salt in the fertilizers).
- Filtration is the main key factor to the success or failure of the system. The main of filtration is to stop dirt particles which damage any components of the system.
- To remove salt encrustation, 30% commercial hydrochloric acid can be used at rate of one liter per one m<sup>2</sup> area. (One part HCl mixed with 5 parts of water)
- To remove algae & fungal clogging 5 -500 ppm sodium hydrochloride (10% chlorine) can be used.

#### **Maintenance of drip system**

- Back washing and sand filters has to be cleaned
- Frequent cleaning of emitters and drippers
- Flushing at every irrigation
- Cleaning of sub main and main pipes
- Cleaning of PVC pipes and laterals and acid or chlorine may be used to remove clogging.

<sup>7</sup> [http://agritech.tnau.ac.in/agriculture/agri\\_irrigationmgt\\_microirrigation.html](http://agritech.tnau.ac.in/agriculture/agri_irrigationmgt_microirrigation.html)

S. No.	Crop	Mulch material
9	Guava	Organic mulches.
10	Lemon	Dry grasses and Black polythene.
11	Coorg mandarin	Dry leaf mulch and Weed scraping.
12	Sweet lime	Dry grasses.
13	Date palm	Local weed buri ( <i>Aerva persica</i> ).
14	Pineapple	Black polythene, Saw dust and Dry leaves.
15	Apple	Oak leaves, Black alkathene and Conifer leaves.

### Sod culture<sup>14</sup>

- In this system, in space between trees, grasses are allowed to grow without tillage / mulching.
- Sometimes cover is mixed with grasses to improve fertility such as grasses are simply mowed and the surface is kept neat and tidy.
- This system is commonly followed in temperate region of Europe and America for apple and pear orchards and does not exist in tropical and subtropical region of India due to scarcity of available nutrients and soil moisture in most part of the year.
- It is best system for control of soil erosion & maintenance of soil organic matter & soil structure.
- In this case manures and fertilizers are not applied individually to trees but provided with sod all over the field and the system is satisfactory for deep rooted crops.
- This practice is followed in the orchard located on sloppy land, particularly when the gradient of the slope is greater than 10 per cent.
- In this system, grasses are allowed to grow in interspaces between trees without tillage / mulching.
- Mixing of clovers- [red clover (*Trifolium pretense*)], white clover (*Trifolium repense*) with grasses is useful for improving soil fertility.
- The grasses are mowed periodically to reduce competition for water & nutrients with trees. Orchard grass (*Dactylis glomerata*) is suitable for areas facing north, tall fescues (*Festuca arundinaceae*) drought tolerant perennial grass for areas facing south, & Timothy (*Phleum pretense*) for cold temperate region.
- This system prevents soil erosion to the greatest extent; however it should not be followed in orchards of young / dwarf trees because such trees are shallow rooted & compete for nutrients and water with grasses.
- The roots of large trees on the other hand penetrate the soil to a greater depth and are less likely to suffer from such competition.
- Tree basins are kept free of weeds by tillage or application of herbicides.

#### Modifications in Sod System

1. Grasses are allowed to grow without cutting is not desirable because organic matter is lost.
2. Grasses are grown cut as required and removed for making hay not desirable because organic matter is lost here also.
3. Grasses are grown cut and left behind to decompose.
4. Grasses are grown and pastured i.e., animals are allowed to graze.
5. Temporary sod. Sod is allowed for 2 years / so, then soil is ploughed, cultivated & sod is reseeded.
6. Sod is not being followed in India due to lack of cool and moist weather.
7. Lack of aeration, rat holes in sod prove harmful and trees die.

<sup>14</sup> <http://ecoursesonline.iasri.res.in/mod/page/view.php?id=103166>

**Training:** It means developing a desired shape of the tree with particular objectives by controlling habit of growth. Training is start from nursery stage of plant. Some fruit crops like grape vines, ber, fig, guava etc require training.

**Objects of Training:**

- To admit more light & air to centre of tree to expose maximum leaf surface to sun
- To direct the growth of the tree so that various cultural operations such as spraying, ploughing, harvesting can be performed easily and at lower cost.
- To protect the tree from sun burn and wind damage.
- To secure a balanced distribution of fruit bearing parts of the tree.

**Principles of Training:**

- Formation of the mainframe work must be strong. The branches must be suitable spaced apart and the tree must be balanced on all the sides.
- Never allow several branches to grow at one place or very near each other.
- Careful training of main branches is very essential.
- Another important point about training is that if two branches are growing at the same point try to train them to grow at a wider angle. Narrow angle is always weak.

**System of Training:**

- **Central leader system:** In this system the central leader branches are allowed to grow indefinitely so that it will grow more rapidly and vigorously than the side branches and tree became tall. Such a tree bears fruit more near the top. The lower branches are less vigorous and less fruitful.
- **Open centre / vase system:** main stem is allowed to grow only up to certain height about 1.5 to 1.8 m & then it cut for development of lateral branches. It allows full sunshine to reach each branch.
- **Delayed open centre or modified leader system:** It is intermediate between the above systems. It is developed by first training tree to the leader type by allowing central axil to grow unpruned for the first four or five years. Then central stem is headed back and lateral branches are allowed to grow as in the open centre system.
- **Bush system:** An unpruned tree multi stem and dwarf growing habit.
- **Over head trellis or Bower system:** When vines are trained on mandap.
- **Modified bower or Telephone system:** Similar to bower system except that after every two meter as space is kept to walk and carry out cultural operations.

### Rejuvenation of senile and old orchards

The decline of productivity has been attributed to various factors. Most of problems are due to faulty management i.e. unsuitable site & climate, cultivation of intercrops, inadequate nutrition's, improper planting, undesirable planting materials, incidence of insect-pest & disease & other biotic & biotic stresses. Decline of trees starts with sparse appearance, yellowing & different type foliage symptoms, undergrowth and sickly appearance, dried-up top growth with small & less number of fruits. Branches of trees start to die from the top to downwards, resulted poor quality fruits (rough surface, thick skin & less juice). Such type of decline may be seen in whole orchards, on in single tree / patches. It is rare site to get any plantation free of this malady even intensity varies from plant to plant and from month to month in same plant. Growers do not adopt proper management practices in terms of plant protection; manuring, irrigation; mulching, pruning etc. & orchards become sick. In general, canopy of fruit crops has irregular shape. Trees of irregular shape & size are difficult to deal with & even culminate into poor yield in the subsequent years as lower branches of canopy gradually

grape berry maturity and optimum harvest date. Chlorophyll, carotenoids, total phenol and polyphenol oxidase activity may also be taken as indicator for berry maturity. Among the acids, succinic, tartaric and malic acids are the main substances. Succinic acid dominates immediately after fruit set and its concentration dropped sharply as berries matured. Mallic acid content increased gradually until veraison, after which it decreased with fruit ripening.

### Nutrient deficiencies and physiological disorders and its corrective measures

#### Refer Unit 4

#### Harvest and yield

Ber	Skin colour, Days from flowering to maturity	Hand picking
Cherry	Colour development, TSS and flavon	Hand picking
Fig	-Soft slightly wilted at the neck and droop and little or no milky latex flow at the cut end of the stalk	Hand picking
Grapes	Seeded varieties: Dark brown seeds Seedless varieties: Berry colour	Hand picking
Gnava	Skin colour	Individual fruits are harvested by hand
Jama	Skin colour	Hand picking, shaking of branches and collecting fruits in a polythene sheets
Kiwi fruit	TSS 0.2%	Hand picking
Limes and lemons	Colour break stage (mature but still green)	Hand Picking
Litchi	TSS, Days from fruit set	Litchi is harvested by picking fruits along with some leaves with the help of sharp instrument.
Mandarin	Peel colour, TSS: acid ratio	Hand picking
Mango	'Tapla', specific gravity, Days from flowering	Hand picking, using mango harvester
Olive	Skin colour	Hand picking
Papaya	Skin colour, latex become watery	Hand picking
Peach	Days to maturity, calendar date, fruit size, firmness, ease of touch, pit discoloration, freeness of pit, taste, ground colour, sugar: acidity ratio.	Hand picking
Pear	Days to maturity	Hand picking
Phalsa	Fruit colour	Hand picking
Pineapple	15-18 months after planting	Cutting with knife
Plum	Days from full bloom, firmness, TSS, change of ground colour from green to yellow or red depending upon cultivar.	Hand picking
Pomegranate	Closing of calyx, grain cracking sound when pressing from outside.	Hand picking
Sapota	At maturity no green tissue and milky latex is visible	Hand picking
Strawberry	Half to one-fourth of skin develops colour	Hand picking
Sweet orange	Peel colour, TSS: acid ratio	Hand picking
Walnut	PTB (packing tissues turn brown) stage	Knocking of trees after spreading polythene sheets on ground beneath trees

Refer Yield @ Package of practices in earlier pages of same unit

