Fundamentals of Horticulture (HORT-111)

Horticulture - Its definition and branches

The term (word) Horticulture is derived from the Latin word, "***hortus***" meaning **garden** and "***cultura***" (*colere*) meaning **cultivation** (to cultivate). In ancient days the gardens had protected enclosures with high walls or similar structures surrounding the houses. Garden crops traditionally include fruits, vegetables, flowers and all ornamental plants as well as spices, plantation, medicinal and aromatic crops. Therefore, in original sense "Horticulture refers to cultivation of garden plants".

Horticulture can be defined as the branch of agriculture concerned with intensively cultured plants directly used by people for food, for medicinal purpose or for aesthetic gratification.

At present the horticulture may be defined as the science and technique of production, processing and merchandizing of fruits, vegetables, flowers, spices, plantations, medicinal and aromatic plants.

Branches of Horticulture

Horticulture can be divided in several branches depending upon crops it deals with. The following are the branches of horticulture:

1. **Pomology**: refers to the science of cultivation of fruit crops. The term Pomology is derived from the Latin word *pomum* meaning 'fruit' and the Greek term logy meaning 'science'. India is the second largest producer of fruits after China. A large variety of fruit crops are grown in India. Of these, mango, banana, citrus, papaya, guava, pineapple, sapota, jackfruit, litchi, grapes, apple, pear, peach, plum, walnut etc. are the important ones.
2. **Olericulture**: refers to cultivation of vegetables. The term Olericulture is originated from the Latin word *oleris* meaning 'pot herb' and the English word *culture* meaning 'raising of plants'. India ranks second in vegetable production next to China. More than 40 vegetables belonging to Solanaceaeous, cucurbitaceous, leguminous, cruciferous, root crops and leafy vegetables are grown in Indian tropical, sub-tropical and temperate regions. Important vegetables grown in India are onion, tomato, potato, brinjal, peas, beans, okra, chilli, cabbage, cauliflower, bottle gourd, cucumber, watermelon, carrot, radish etc.
3. **Floriculture/Landscaping gardening**: refers to the science of cultivation of flower crops. Landscape is appearance of land as it appears to the eye. Landscape gardening is the art of beautifying a piece of land using garden design, methods and plant materials. It is an important/integral part of socio-cultural and religious life of Indian people. India is known for growing traditional flowers such as jasmine, marigold, chrysanthemum, tuberose, crossandra, aster, etc. Commercial cultivation of cut flowers like, rose, orchids, gladiolus, carnation, anthurium, gerbera is also being done.
4. **Plantation crops**: refers to cultivation of crops like coconut, arecanut, rubber, coffee, tea etc. The major plantation crops include coconut, arecanut, oil palm, cashew, tea, coffee, rubber cocoa, betel vine, vanilla etc.
5. **Spices crops**: refers to cultivation of crops like, cardamom, pepper, nutmeg etc. These are used for flavouring, seasoning and imparting aroma in foods. India is known as the

home of spices (Land of spices) producing a wide variety of spices like black pepper, cardamom, ginger, garlic, turmeric, chilli, coriander etc.

6. **Medicinal and aromatic crops**: deals with cultivation of medicinal and aromatic crops. Demand for these crops is increasing progressively in both domestic and export markets. Important medicinal plants are Isabgol, Senna, Opium poppy, Periwinkle, Coleus, Ashwagandha, etc. and aromatic plants are Lemon grass, Vetiver, Patchouli, palmarosa, geranium, lavender, basil, jasmine, Japanese mint, Citronella, Davana, etc.
7. **Post harvest technology:** deals with post harvest handling, grading, packaging, storage, processing, value addition, marketing etc. of horticulture crops.

Importance and scope of Horticulture

Horticultural crops cover an area of 234.17 million hectares and production 283.468 million tonnes with productivity 12.11 tonnes/hectare. **Fruits and vegetables** contributing highest in both area and production. Fruit crops cover an area of 63.58 million hectares and vegetable crops 95.41 million hectares. Accordingly, 88.819 million tonnes of fruits and 168.3 million tonnes of vegetables are produced in the country annually (Indian Horticulture Database, 2015).

Apart from fruits and vegetables, **floriculture** industry in India comprising of florist trade, nursery plants, potted plants, seed and bulb products, is being observed as sunrise industry. There is roaring business of flowers in almost all metropolitan cities of the different states. The traditional flowers are grown on a large area on a commercial scale. These flowers are mostly grown for loose flower purpose. Area under modern cut flowers like rose, chrysanthemum, gladiolus, carnation, anthurium, gerbera, lilies and orchids is increasing day by day.

Plantation crops are another potential sector with lot of opportunities for employment generation, foreign exchange earnings and overall supporting livelihood sustenance of mankind at large. These plantation crops form the mainstay of livelihood in coastal areas of the country where predominating stands of plantation crops are found.

Spices constitute an important group of horticultural crops. More than 90% of the spices produced in the country are used for domestic consumption and the rest exported as raw as value-added products. Almost all the states grow one or more spices in our country.

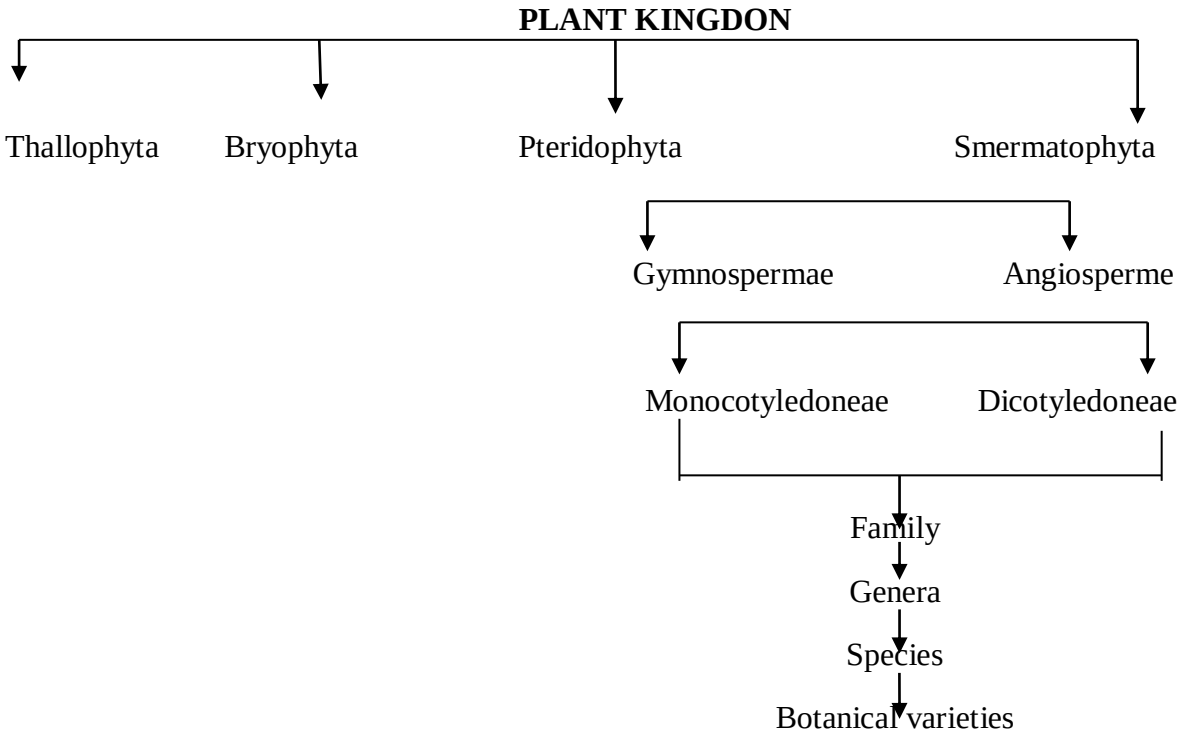
India having a vast area of land with varied agroclimatic conditions is ideally suited for the cultivation of **medicinal and aromatic plants**. The cost of production is considerably low and since many of these can be grown and harvested round the year, provide steady employment to agricultural labour and steady income to farmers. Most of the herbs can be grown as intercrops in the perennial orchards.

Requirements of export and processing industry further add to the requirements of horticultural produce. In view of these, there is lot of scope of increasing production and potentiality of horticulture crops.

Horticultural and botanical classification

CLASSIFICATION OF HORTICULTURAL CROPS

Thanks to range of factors varying in eco-edaphic attributes prevalent in one or the other part of country, India is endowed with rich vegetational wealth. Encompassing 356 domesticated species of economical importance and 326 species of their wild form/relatives, Indian subcontinent enjoys rich diversity of plant wealth. Besides, about 9500 other species of entobotanical interest have been recorded. Out of these more than 50 types of individual fruits and vegetables, many individual types species, plantation crops etc. are under commercial cultivation in different parts of country, under different sets of growing conditions. An attempt of deat with all these plants separately becomes tedious, cumbersome and infeasible and more so repetitive. To avoid these difficulties, it is better to classify the plants groups, based on similarity or dissimilarity of attributes. Plants having similarity in either of the traits are placed under one group. Such type of grouping in plants in different categories, is referred as classification. The overall objective of classification is to systematize the presentation and make the remembrance of the plants easy and convenient. Generally, bases on botanical relationship, the plants are classified as under:



The detailed classification of various kinds of horticultural plants is as under:

CLASSIFICATION OF FRUITS

1. BASED ON NATURE OF GROWTH

(a) **Herbaceous**. Banana, Pineapple

(b) **Shurbaceous**. Karonda, Phasla, Pomegranate

(c) **Woody**. Mango, Ber, Sapota, Jamun, Guava, Apple, Peach, Pear and many other fruits

2. BASED ON CLIMATIC REQUIREMENT

(a) **Temperate Fruits.** Apple, Pear, Peach, Plum, Almond, Walnut, Apricot, Pecanut, Hazelnut, Cherry etc.
(b) **Sub-tropical fruits.** Fig, Guava, Ber, Citrus, Pomegranate, Bael, Date-palm, Loquat, Phalsa etc.
(c) **Tropical Fruits**. Manga, Banana, Pineapple, Sapota, Jackfruit.

3. BASED ON CONTINUATION OF GROWTH

(a) **Evergreen**. Mango, Citrus, Litchi, Sapota.
(b) **Deciduous**. Apple, Pear, Peach, Plum, Apricot.

4. BASED ON TYPE OF FRUIT

(i) **Pome**. Apple, Pear, Quince, Loquat.
(ii) **Stone/Drupe** Plum., Apricot, Peaches, Almond, Ber, Mango, Coconut, Jamun.
(iii) **Berry.** Grape, Guava, Banana, Papaya, Date, Sapota
(iv) **Hesperidinum.** Oranges
(v) **Psorosis.** Pineapple, Jackfruit, Mulberry.
(vi) **Cyconus.** Fig.
(vii) **Nut.** Litchi, Rambutan, Cahew
(viii) **Capsule.** Aonla, Carambola.
(ix) **Etaerio of berry.** Raspberry, Custard Apple

5. BASED ON PARTS USED

Citrus	Juicy placental hairs
Banana	Mesocarps and endocarp
Coconut	Endosperm
Custard apple	Fleshy pericarp of indidual berries
Fig	Fleshy receptacle
Guava	Thalamus and pericarp
Apple	Fleshy thalamus
Grape	Pericarp and placenta
Mango	Mesocarp
Litchi	Aril
Pomegranate	Juicy covering of fruits
Pear	Stalk of fruit and thalamus
Almond	Seed
Walnut	Cotyledon
Pineapple	Fleshy axis, bracts, pedicel, pericarp
Jackfruit	Fleshy axis, bracts, perianth and seed
Bael	Fleshy layer of pericarp
Jamun	Pericap and thalamus

6. BASED ON BOTANICAL RELATIONSHIP

(A)Monocot

Musaceae	Banana
Bromeliaceae	Pineapple

(B)Dicot

Anacardiaceae	Mango, Ambada, Chranji, Cashewnut

Myrtaceae	Guava
Caricaceae	Papaya
Saindaceae	Litchi
Euphorbiaceae	Aonla
Musaceae	Banana
Moeaceae	Jackfruit, Breadfruit, fig
Sapotaceae	Sapota, Khirni
Rutaceae	Citrus, Woodapple, Bael
Rhamnaceae	Ber
Arecacae	Date
Vitaceae	Grape
Apocynacae	Karonda
Rosaceae	Loquat, Apple, Pear, Peach, Plum, Apricot
Punicaceae	Pomegranate
Juglamdaceae	Walnut
Annonaceae	Custard apple
Tiliaeae	Phalsa
Caesalpiniaceae	Tamarindn

7. BASED ON SALINITY TOLERANCE

Tolerant (8 mmhos)	**Moderatly Tolerant (6 to 3 mmhos)**	**Sensitive (3 to 1.5 mmhos)**
Date	Fig	Peach
Ber	Orange	Apricot
Pomegranate	Lemon	Avocado
Phalsa	Mango	Almond
Aonla	Grapefruit	Plum
Custard apple	Grape	
Kair		
Pilu		
guava		

Source: Arid fruit culture by B.S. Chundawat

8. BASED ON RIPENING BEHAVIOUR

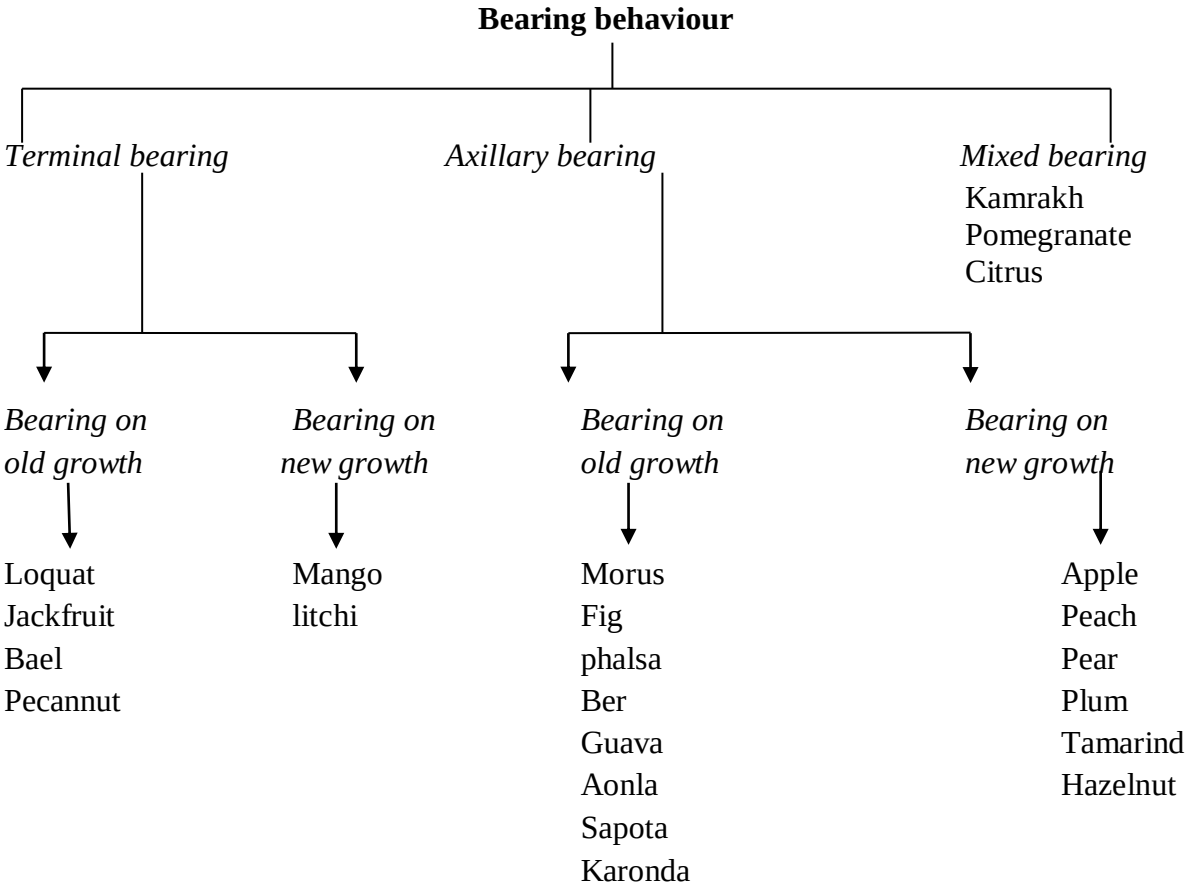
Climacteric: Fruits experiencing sudden upsurge in rate of respiration at the time of ripening: Mango, Guava, Papaya, Jackfruit, Fig, Sapota, Passion Fruit

Non-Climacteric: Fruits experiencing simple gradual decline in rate of respiration at the time of ripening: Litchi, Lemon, Lime, Orange, Grape, Pomegranate, Pineapple

9. BASED ETHYLENE EVOLUTION

Class	**Range at 20º C µl C_2H_4 per kg-hr.**	**Name of fruits**
Very low	Less than 0.	Citrus, Grape, Pomegranate
Low	0.1-1.0	Pineapple
Moderate	1.0-10.0	Banana, Fig, Guava, Mango
High	10.0-100.0	Avocado, Papaya
Very high	More than 100	Passion fruit, Sapota

10. BASED ON BEARING BEHAVIOUR



2. CLASSIFICATION OF VEGETABLES

1. BASED ON BOTANICAL RELETIONSHIP

A. Monocot

Family> ALLIACEAE	
Allium cepa	Onion
Allium sativum	Garlic
Allium cepa var. Aggregatum	Multiplier onion
Allium cepa var. Viviparum	Top onion
Allium porrum	Leek
Allium fistulosum	Welsh onion
Allium ascalonicum	Shallot
Allium schoenoprasum	Chive
Family > LILIACEAE	
Asparagus officinalis	Asparagus
Family > ARACEAE	
Amorphophalus companulatus	Elephant foot yam
Colocasia esculentum	Arvi
Family > DISCOREACEAE	
Discorea alata	Yam
B. Dicot	

Family > AIZOACEAE	
Tetragonia expansa	New Zealand Spinach
Family > CHENOPODIACEAE	
Beta vulgaris	Beetroot or Sugarbeet and Palak
Beta vulgaris var cicla	Swiss chard
Spinacia oleracea	Spinach
Family >	COMPOSITAE
Lactuca sativa	Lettuce
Chichorium intybus	Chicory
Chichorium endivia	Endive
Cynara scolymus	Artichoke
Family > CONVOLVULACEAE	
Ipomoea batatas	Sweet potato
Family > CRUCIFEREAE	
Brassica oleracea var botrytis	Cauliflower
Brassica oleraea var capitata	Cabbage
Brassica oleracea var. caulorapa	Knolkhol or Kohlrabi
Brassica oleracea var. italica	Sprouting broccoli
Brassica oleracea var. gemmifera	Brussels sprouts
Brassica oleracea var. napobrassica	Rutabaga
Brassica camestris var. rapa	Turnip
Brassica pekinensis	Chinese cabbage
Brassica chinensis	Chinese cabbage
Armoracia rusticana	Horse radish
Raphanus sativus	Radish
Family > CUCURBITACEAE	
Cucurbita pepo	Summer squash
Cucurbita moschata	Pumpkin
Cucurbita maxima	Winter quash
Citrullus lanatus	Watermelon
Cucumis melo	Muskmelon
Cucumis sativus	Cucumber
Cucumis ustissimus	Long melon
Citrullus vulgaris var. fistulosus	Tinda
Luffa acutangula	Ridge gourd
Luffa cylindrica	Sponge gourd
Lagenaria siceraria	Bottle gourd
Momordica charanita	Bitter gourd
Momordica cochin-chinensis	Sweet-gourd, Kakrol
Trichosanthes diocia	Parwal
Trichosanthes anguina	Sanake gourd
Sechium edule	Cho-Cho
Momordica dioica	Spine gourd, Kartoli
Family > EUPHORBIACEAE	
Manihot esculenta	Topioca
Family > LEGUMINOSAE	
Pisum sativum	Pea
Phaseolus vulgaris	French bean

Phaseolus lunatus	Lima bean
Vicia faba	Broad bean
Dolichos lablab	Bean
Vigna sinensis	Cowpea
Vigna sinensis var. sesquipedalis	Asparagus bean
Glycine max	Soyabean
Psophocarpus tetragonolobus	Winged bean
Family > MALVACEAE	
Ablemoschus esculentus	Bhindi
Family > POLYGONACEAE	
Rheum rhaponoctum	Rhubarb
Rumex vesicarius	Sorrel
Family > SOLANACEAE	
Solanum tuberosum	Potato
Solanum melongena	Brinjal
Lycopersicon esculentum	Tomato
Capsicum annum	Chilli and sweet pepper
Capsicum frutescens	Pungent chilli
Family > UMBELLIFERAE	
Daucus carota	Carrot
Petroselinum crispum	Parsley
Apium graveolens	Celery
Pastinaca sativa	Parsnip

2. BASED ON HARDNESS OR TEMPERATURE TOLERANCE

Based on sustenance to varying temperature, vegetables have been placed into groups: cool season vegetables and warm season vegetables.

COOL SEASON VEGETABLES

These are the vegetables of which roots, stems, leaves, buds, or immature flowers of parts other than fruits eaten. Root and tuber crops, cole-crops (cauliflower, cabbage, knol-khol, brussels sprouts, sprouting broccoli etc.), leafy vegetables etc. are important cool season vegetables. However, sweet potato and New Zealand spinach are not come under cool season vegetables though their roots and leaves respectively are edible.

WARM SEASON VEGETABLES

The vegetables of which immature fruits are consumed are counted under warm season vegetables; e.g. brinjal, okra, cucurbits, french bean, cluster bean, cowpea etc. Pea and broad bean have been excluded from this group though fruit part of these vegetables are eaten. Both are vegetables are cool season crops.

3. BASED ON TOLERANCE TO SOIL ACIDITY

The soil having pH less than 7.0 are acidic in nature. Acidic conditions are not congenial for the production of majority of these vegetables. But some vegetables can tolerate acidic conditions to some extent as per tolerance to soil acidity, the vegetables have

categorized into three groups: slightly tolerant, moderately tolerant and very tolerant. The details are as under:

Slightly tolerant pH 6.8 to 6.0	**Modretely tolerant pH 6.8 to 5.5**	**Very tolerant pH 5.5 to 5.0**
Bhindi	Brinjal	Potato
Cabbage	Pea	Sweet potato
Cauliflower	Pumpkin	Watermelon
Muskmelon	Radish	Rhubarg
Onion	Tomato	Endive
Spinac	Garlic	
Palal	Cucumber	
Leek	Kohlrabi	
Lettuce	Squash	
broccoli	Turnip	
Beet		
Asparagus		

4. BASED ON TOLERANCE TO SALT

(Molar Concentration of NaCl)

Sensitive	**Medium Tolerant**		**High Tolerant**	
0.25	**0.50**	**0.75**	**1.00**	**1.25**
Tomato	Chilli	Amranthus	French bean	Bitter gourd
Snake gourd	Okra	Cauliflower	Ash gourd	
	Cabbage	Onion		
	Sweet potato	Radish		
		Bottle gourd		

5. BASED ON PARTS USED AS FOOD

The parts which are used for consumption forms the basis for this classification.

i. Leafy vegetables- Palak, Spinach, Amaranth, Portulaca, Basella (Poi), Bathua, Lettuce, Mustard, and greens like radish leaves, tender gram, pea twigs and others.
ii. Stem vegetables- Potato, Kohlrabi, Asparagus
iii. Root and Tuber vegetable- Elephant Foot Yam, Potato, Sweet potato, Colocasia, Yam, Tapioca, Carrot, Radish, Turnip.
iv. Bulb vegetables- Onion, Garlic
v. Fruit vegetables- Tomato, Brinjal Sweet pepper, Beans, Cucurbits, Bhindi
vi. Flower vegetables- Cauliflower, Broccoli, Globe artichoke.

6. Based on methods of raising

i. Direct sown crops- Okra, Carrot, Radish, Beans, Peas, Garlic
ii. Transplanted crops- Tomato, Brinjal, Chillies, Cabbage, Cauliflower

7. BASED ON FORCING

(**a) Cool forcing vegetables:** Asparagus, Beet, Carrot, Cauliflower, Radish, Spinach, Pea, Onion, Lettuce, Celery.

(b) Warm forcing vegetables: Brinjal, Bean, Tomato, Cucumber, Muskmelon.

8. BASED ON RATE OF RESPIRATION

Very high	High	Moderate	Low	Very low
Asparagus	Bean	Beet	Cabbage	Onion
Broccoli	Lettuce	Carrot	Sweet Potato	Potato
Pea	Limabean	Celery	Turnip	
Spinach		Cucumber		

3. CLASSIFICATION OF FLOWERS

1. BASED ON SEASON OF GROWING

(i) **Summer season annuls**: Zinnia, Kochia, Portulaca, Tithonia, Gaillardia, Gomphrena, Sunflower.

(ii) **Rainy season annuals**: Balsam, cock's comb, amaranthus, gaillardia.

(iii) **Winter season annuals**: Aster, corn flower, lark spur, sweet sultan, phlox, verbena, candytuff, tetunia, nigella.

2. BASED ON COLUR OF FLOWER

(i) White Flowering: Alyssum, Dianthus, China Aster, Nigella, Zinnia

(ii) Purple, Lavender or Blue Flowering: Ageratum, Anchusa, Browallia, Clitoria, Delphinium, Petunia, Viola, and Verbena.

(iii) Yellow Or Orange Flower: Caledula, Dimorphotheca, Zinnia.

3. BASED ON PURPOSE OF GROWING

(I) For Rocker: Agetatum, Brachycome, Phlox, Portulaca, Linum, Nemesia, Saponaria, Godetia, Euphorbia.

(II) For Hanging Baskets: . Dwarf Ageratum, Petunia, Portulaca, Verbena. Torenia, Begonia, Sansevieria.

(III) For edging of beds or path. Dwarf Ageratum, Alyssum, Hrachycome, Dianthus, Nigella, Portulaca, Saponaria, Iresine.

(IV) For fragrant flowers. Sweet Alyssum, Sweet Sultan, Sweet Pea, Slock. Phlox, Carnation. Rose, Jasmine, Tuberose.

(V) For bedding purpose. Dahlia. Marigold, Phlox, Verbena, Carnation, Petunia. Ice plant. Candytuft, Balsam, Portutaca.

(VI) Fur aromatics. Rose. Jasmine, Tuberose.

(VII) For pots. Carnation, Antirrhinum, Petunia, Aglaonema, Alocasia, Anlluiriums, Aralia, Begonia, Chlorophytum, Dracaena.

(**VIIl) For dry Flowers**. Statice, Helichrysum, Acrolinum, Nigella, Lady's lace.

(IX) For loose flowers. Marigold, Chrysanthemum, Aster, Sunflower

(X) For hedge purpose. Lawsonia, Duranta, Tecbma, Bougainvillea, ihi'Vi'lm, Hibiscus, Murraya, Dodonea.

4. BASED ON NATURE OF GROWTH

Annulas. Niislurtium, Ice plant. Hollyhock, Sweet pea, Chrysanthemum, Carnation, Corn flower, Sweet Alyssum, Dahlia, Marigold, Nasturtium, Verbena, Phlox.

Perennials. Rose, Jasmine, Chrysanthemum.

5. BASED ON MODE OF PROPAGATION

(i) **Bulbous plant.** Lily, Narcissus, Tulip,

(ii) **Cormellous plant.** Gladiolus, Crocus.

(iii) **Rhizomatous plant.** Canna, Iris.

(iv) **Toberiferous plant.** Dahlia.

6. BASED ON GROWTH BEHAVIOUR

Herbs. Nasturtium, Verbena, Candytuft, Corn flower, Lady's Lace, Clianthus, Gladiolus,

Shrubs. Rose, Jasmine, Bougainvillea, Tecoma, Nyctanthes, Chandani,

Trees. Plumaria, Amaltas, Dhak, Palas, Kadamb, Pride of India. Gulmohar.

4. CLASSIFICATION OF SPICES

1. BASED ON COMPLETION OF LIFE CYCLE

(i) **Annual.** Cumin, Fennel, Coriander, Fenugreek.

(ii) **Biennial**. Onion. Garlic

(iii) **Perennial.** Cardamom, Cinnamon, Clove, Saffron, Tejpat.

2. BASED ON GROWTH BEHAVIOUR

(i) **Herbaceous spices.** Cumin, Coriander, Fenugreek, Onion, Garlic, Turmeric, Ginger.

(ii) **Shrubaceous spices.** Black pepper, Cardamom.

(iii) **Tree spices.** Cinnamon, Tejpat, Nutmeg, Clove.

3. BASED ON IMPORTANCE

(i) **Primary spices.** Chilli, Cardamom, Ginger, Turmeric,

(ii) **Secondary spices.** Cumin, Fennel, Coriander, Fenugreek, Clove, Nutmeg. Mace, Cinnamon.

4. BASED ON PART USED

(i) **Seed** spites, fenugreek, Ajwain, Cumin, Coriander, Fennel, Dill.

(ii) **Fruit spices.** Cumin, Coriander, Fennel, Black pepper. Chilli, Dill,

(iii) **Flower spice.** Saffron

(iv) **Bud spice.** Clove,

(v) **Underground rhizome.** Turmeric, Ginger, Onion, Garlic.

(vi) **Bark spices.** Cinnamon, Tejpat,

(vii) **Leafy spices.** Mentha, Coriander, Tejpat, Fenugreek.

5. BASED ON UTILITY

(i) **Taste imparting spices.** Cardamom, Ginger, Coriander, Cumin, Garlic, Onion, Tamarind, Black pepper. Chilli.

(ii) **Flavour imparting spices.** Clove, Cardamom, Coriander leaf, Curry leaves. Cinnamon, Asafoetida, Garlic,

6. BASED ON CULTURAL MANAGEMENT

(i) **Horticultural spices.** Spices grown on small scale are counted under this group e.g. Ginger, Turmeric, Chilli, Onion, Garlic, Mentha, Ocimum, Curry leaves. Fennel,

(ii) **Plantation spices.** The spices which are planted permanently and remain dedicated on the soil for many years are termed as plantation spices. ex. Black pepper, Cardamom, Clove,

Nutmeg, Mace, Cinnamon, Tejpat, All Spice,

(iii) **Agronomic spices.** The spices which are planted on large acreage are called agronomic spices *e.g.* Coriander, Cumin, Ajwain, Dill, Chilli, Fennel,

7. BASED ON BOTANICAL RELATIONSHIP

(A) Monocot

i. **Zingiberaceae.** Ginger, Turmeric, Cardamom,

(B) Dicot

i. **Piperaceae.** Black-pepper, f'iplamool.
ii. **Umbclliferae.** Cumin,, Coriander, Fenrtel, Ajwain, Asafoetida, Black, cumin. Dill, Celery, Parsley.
iii. **Labiateae.** Ocimum
iv. **Solanaceae**. Chilli.
v. **Alliaceae.** Onion, Garlic
vi. **Myrtaceae**. Clove
vii. **Myristicaceae.** Nutmeg, Mace.
viii. **Lauraceae.** Cinnamon, Tejpat.
ix. **Papaveraceae.** Klias-khas
x. **Rutaceae.** Curry leaves
xi. **Crutifereae.** Mustard
xii. **Iridaceae.** Saffron
xiii. **Orchidaceae.** Vannila
xiv. **Guttifcrae.** Kokam
xv. **Araceae.** Buchh
xvi. **Papilinnaceae.** Fenugreek

5. CLASSIFICATION OF PLANTATION CROPS

1. BASED ON BOTANICAL RELATIONSHIP

(A) *Monocot*

(i) Arecaceae- Coconut, Arecanut

(B) *Dicot*

Theaceae	Tea
Rubiaceae	Coffee
Moraceae	Rubber
Sterculiaceae	Cocoa
Piperceae	Black pepper
Lauraceae	Cinnamon
Myrtaceae	Clove
Myristicaceae	Nutmeg
Anacardiaceae	Cashewnut

2. BASED ON GROWTH BEHAVIOUR

(i)	Vine	Vanilla, Black-pepper
(ii)	Shrub	Tea
(iii)	Tree	Cashewnut, Nutmeg

3. BASED ON UTILITY

(i)	Food	Coconut, Cashewnut
(ii)	Industrial	Rubber, Arecanut, Oil-palm

4. BASED ON EXTENT OF GROWING

(i)	Homestead plantation	Coconut, Black- pepper
(ii)	Estate plantation	Tea, Coffee, Rubber

5. BASED ON INTENSITY OF CULTIVATION

(0	Single-storeyed	Clove, Nutmeg
(ii)	Multi-storeyed	Coconut

Climate and soil for horticultural crops

CLIMATE

Climate is the most important factor on which choice of the crop for a region depends and therefore, understanding about soil and climate and their requirement for different crops for optimum production on sustainable basis is important for horticulturists.

Climate is defined as the whole of average atmospheric phenomena for a certain region calculated for a period of thirty years. These phenomena are **light, heat, water and air**.

LIGHT:

 Electromagnetic radiation to which the organs of plant react ranging in wavelength from 4000 to 7700 angstrom units, and is propagated at a speed of about 540 kilometres per second.

- ✓ It is essential for the process of photosynthesis and therefore, for growth and development of plants.
- ✓ There are two aspects of light, its intensity and duration which are important for plant development.
- ✓ The light intensity can be estimated from the number of hours of bright sunlight or from the cloudiness of sky. Generally horticultural crops need a lot of light and must be grown in sunny climate, but there are some crops which can tolerate shade. Eg. Turmeric and ginger. There are others like young mangosteen, coffee, cocoa and tea need shade during part of their development. A third group requires permanent shade like salak palm, duku, and carambola.
- ✓ The duration of light for the time elapsing between dawn and dusk referred as **photoperiod or day length**. This exerts considerable influence on flowering.

Based on the response by plants the major classes are following. However, fruit crops for such categories are not known.

1. **Long day plants:** Cabbage, Cauliflower, Onion, Beetroot, Radish, Carrot, Spinach, Potato, Dill and Plantago.

2. **Short day plants:** Strawberry, Pineapple, Chrysanthemum, Poinsettia, Aster, Balsam, Salvia, Euphorbia and Xanthium.

3. **Day neutral plants:** Tomato, most fruit crops, Pepper, Cucumber, Snapdragon, Mirabilis and certain varieties of peas.

HEAT:

- ✓ Heat is a non-mechanical energy transfer with reference to a temperature difference between a system and its environmental surrounding. It is measured as temperature by thermometers.
- ✓ The growth of the plants depends primarily on temperature.
- ✓ Availability of heat units decide the crop for a given place and the average temperature of a place gives an idea about heat units available on the basis of which crop can be decided.
- ✓ Temperate fruit crops like apple, pear, peach, plum and almond become dormant due to short day conditions in the region and need chilling of various lengths to break dormancy.

- ✓ Frost and chilling are harmful for tropical and subtropical plants. On the other hand extremely high temperatures found in arid region cause wilting, sunscald, necrotic spot and even death of plants.

Therefore, under such conditions appropriate choice of plants and provision of protection become important.

Based on temperature variations on the surface of the earth we have the following climates.

1. Tropical equable climate with no distinct winter.
2. Subtropical Climate with distinct winter and summer.
3. **Temperate**: Distinct winter, summer and autumn with temperature below freezing during winter is common.

1. **Tropical :** Mango, Banana, Papaya, Sapota, Pineapple, Coconut, Cashew, Arecanut, Breadfruit, Jackfruit and Avocado.

2. **Subtropical:** Guava, Grape, Citrus, Date palm, Phalsa, Pomegranate, Litchi and Loquat.

3. **Temperate:** Apple, Pear, Peach, Plum, Quince, Apricot, Walnut, Almond, Strawberry and Cherry.

Classification of vegetable and flower crops according to seasons

	Warm Season	**Cool Season**
Vegetables	Bottle gourd	Cabbage
	Water melon	Cauliflower
	Brinjal	Pea,Radish, tomato
	Tomato	Beans
	Clusterbean	Potato
	Okra	Onion
	Sweetpotato	Carrot
		Radish
		Tomato
Flowers	Marigold	Aster
	Zinnia	Poppy
	Chrysanthemum	Dianthus
	Sunflower	Dahlia
	Gomphrena	Salvia
	Gaillardia	Petunia
	Portulaca	Pansy
	Kochia	Phlox
	Amaranthus	Coreopsis
	Celosia	Verbena
	Coreopsis	Diamorphotheca
		Calendula

SOIL:

Soil is the upper most crust of earth surface which supports plant growth.

- ✓ It is defined as a three phase system in which plants grow. These phases are solid, liquid and gas and are essential. Solid part is frame which provides space for other two. This consists of minerals, clay minerals and organic matter.

 The soil is also a living system with millions of microbes that breakdown organic matter and builds it again.

 Microbes are essential and survive only when soil is well aerated and rich in organic matter and devoid of waterlogged conditions.

 Texture of soil depends on the size of solid particles and classified as gravel, coarse and fine sand, silt and clay.

 Soils are classified according to relative distribution of these particles and there are 12 textural classes.

 Likewise, arrangement of these particles is referred as structure, and both texture and structure lend soil physical properties like water holding capacity, aeration and bulk density.

 Generally loamy soils and crumb structure are most preferred for fruit crops.

 According to level of organic matter, soils are classified as mineral soil or organic soil and soil having more than 20% organic matter is organic soil like peat and muck.

 Minerals and salts lend chemical properties to the soil like pH, alkalinity, sodicity, salinity and cation exchange capacity which influence the availability of nutrients in soil.

 Therefore, for making choice for soil, soil analysis in terms of following criteria is essential to decide on land capability.

Criteria for land capability class:

i. Slope and erosion hazard.
ii. Soil depth.
iii. Drainage.
iv. Workability.
v. Stoniness and rockiness.
vi. Water holding capacity.
vii. Permeability.
viii. Nutrient availability.
ix. Fertility status.
x. Salinity, alkalinity and acidity hazards.

Based on these criteria there are 8 capability classes of which (i) to (iv) are suitable for cultivation and (v) to (viii) are not suitable for cultivation.

The soil provides support for the plant and act as storehouse of nutrients and water as well as oxygen for root growth. The ability of the soil to support plant growth is often referred to as its productive capacity which depends on fertility and physical condition. Therefore, the soil has to be a good soil.

A good soil is one which has the capacity to nourish and sustain plant growth by providing mineral particles (nutrients) in an available form to plants by their interaction with soil air, moisture, microbes and humus. Generally a loam soil is considered to be a good soil.

Generally fruit crops need porous, aerated, deep (2 m) uniformly textured soils and the pH of soil should be within range of 6-8. Soil with hardpan within 120 cm from surface, soil with high clay content at surface and very less at subsurface or vice-versa are not suitable for fruit crops. Fruit crops are susceptible to waterlogged condition and growth is adversely affected by salinity, sodicity and alkalinity.

It is, therefore, important that soil be analyzed for its quality and then choice of the crop is made for sustainable production. If the soils are problematic like poor aeration or drainage, sodicity, alkalinity, acidity and salinity, they require improvement or reclamation before taking up crop production or the venture would fail. Alternatively tolerant or resistant crops can be choosen for different problems.

Salinity tolerant crops: Kair, Khirni, Woodapple, Date palm, Ber, Aonla, Fig, Sapota etc.

Sodicity tolerant crops: Ber, Tamarind, Woodapple, Date palm, Aonla, Karonda, Fig, Phalsa,
Pomegranate, Guava, Bael and almond.
Drought tolerant crops: Ber, Aonla, Ahalsa, Lasoda, Kair, Custard apple, Karonda, Fig, Guava etc.
If we know the soil and the requirement of soil for the crops, then choice of the crop can easily be made.
Grouping of fruits according to their tolerance to salinity:
a. **High salt tolerance :** Date palm, Ber and Aonla.
b. **Medium salt tolerance :** Pomegranate, Fig and Grape.
c. **Low salt tolerance :** Apple, Orange, Almond, Lemon and Avocado.

 In making choice of soil for fruit crops physical properties should he emphasized, more as chemicals can be added from outside to improve nutrient status and chemical properties of the soil.
 Generally the depth and the drainage-ability are very important for crop production.
 To upkeep soils for sustainable production following things are to be done before and after planting a crop:
Soil analysis in terms of its physical and chemical attributes.
 Bring the soil to its optimum potential by applying organic matter, chemical fertilizers, micronutrient and amendments depending on soil analysis report.
 Adoption of soil conservation technique like green manuring on regular basis.
 Use of improved water management techniques like drip irrigation and check basin or Furrows.
 Incorporation of large quantity of bulky organic matter each year.

 Creation of appropriate drainage around the plot.

 Scrapping of salts and reclamation of soil by application of gypsum, iron pyrites, press mud etc., on regular basis in case of salinity problem.

 Replenishment of nutrients harvested by the crop on regular basis by preparing a balance sheet for nutrients.

 Recycling of organic waste.

Soil is the most important natural resource for fruit culture and it needs to be protected and improved.

Nursery raising and its importance

Nursery is a place where young seedlings or any other planting materials are raised, propagated, multiplied and transplanted in main field.

Importance of Nursery:

1. The young seedlings require special attention during the first few weeks after germination. It is easier and economical to look after the young and tender seedlings growing in nursery bed in a small area than in a large permanent site.
2. Majority of fruit crops are propagated by vegetative means. The propagules require special skill and aftercare before transferring them in the main field. In a controlled condition in nursery all these can be provided successfully by skilled labour.
3. Cuttings are best rooted and grafts are hardened in the mist house chamber which is an integrated part of a nursery.
4. Direct sowing method is not so successful in several crops when compared with transplanting of seedlings raised in nursery.
5. Plants hardened in the nursery are preferred for causality replacement in orchards.
6. Besides these, raising of seedlings or saplings in nursery provides more time for preplanting operations/preparations.
7. Seasoning/hardening of seedlings against natural odds is only possible in nursery.

Classification of nursery:

Nursery can be broadly grouped into two on the basis of its site:

1. Home nursery 2.Commercial nursery

Home nursery: is the area where planting materials specifically grown or raised only to cater the needs of the growers garden. The area is small and the primary consideration is the raising of quality planting material. Costly methods of nursery practices are adopted.

Commercial nursery: Nurseries are larger in size and collection of plants. This is mainly concerned with economic returns from the investments and therefore, very expensive methods are avoided. This type of nursery can be divided into two based on location:

a. Rural nursery b. Urban nursery

Factors affecting the establishment of a nursery:

1. Location and site –
    a. Topography b. climate c. reputation of locality for business d. transport facility
2. Selection of soil
3. Water facility
4. Manures
5. Availability of labour

Components of nursery: A nursery should consist of the following components:

1. **Building structures:** This includes office, sale counter, packing shed, potting shed, store, implement shed and residential quarter.
2. **Progeny tree block:** The current choice of kind and variety of fruit crops and collection of true to type mother plants have strong bearing on the success and goodwill of a nursery industry. Suitable fruit crops should be selected to meet the

demand of the customers. There should be a collection of good number of promising varieties of popular crops to make a wide choice. The progeny tree should be healthy, disease free, genetically true to type and free from pest attack. The pedigree of these plants should be known to the nursery man.

3. **Propagation structures:** structures like green house, glass house, poly house, hot bed, cold frames, lath house, shade house, mist house are used to create congenial condition for the propagation of plants.
4. **Nursery bed.**

Management of young nursery plants:

a. **Irrigation**: the young seedling should be frequently watered with low pressure. Excess and deficit of moisture is harmful. Proper care should be taken to avoid subsoil congestion through provision of proper drainage.

b. **Nutrition:** Proper nutrition has profound effect on growth. The growing media should have liberal dose of manures and decomposed organic manure. A light and frequent dose of nitrogen will boost the growth of young seedlings.

c. **Weed control:** The nursery should be kept weed free including roads and channel to avoid chances of further spread.

d. **Plant protection**: In the initial stages the seedlings are more prone for pest and diseases. Therefore, prophylactic measures should be undertaken.

Common pests: Ants, Snails, Rodents, Cutworms and sucking pests.

Diseases: Collar rot, Damping off, Nematodes, Wilt etc.

Plant propagation-methods

Plant propagation refers to the multiplication of an individual plant or group of plants, which have specific value to mankind. Perpetuation of plants is called propagation. It involves multiplication of one plant into several plants –development of new individuals. New plants or new individuals are required for establishing **new plantings/new gardens/new orchards**.

Methods of propagation: Broadly grouped in to two. (a) **Sexual** and (b) **asexual.**

Sexual (Seed) Propagation

It refers to multiplication of plants by seed. In sexual process male and female gametes are fused to produce seed. Meiosis division takes place in course of fusion and the chromosome numbers, as in parents is reduced to half, which after fertilization becomes normal. In sexual propagation during meiosis segregation, reassortment or rearrangement of characters takes place. So, the plants thus produced may or may not be similar to their parents and the propagated plants may also be different from each other**.** It is called as seed propagation, since the propagation is through seed and also sexual propagation because sexes are involved **Seed** is the result of fusion of male and female gametes. Seeds are fertilized ovules, containing embryos resulting from the union of a male and a female gamete during fertilization. The embryo in the seed gives rise to a new plant on germination. Plants that are produced from seeds are called **seedlings.**

Advantages of Seed propagation:

1) Seedling trees generally live longer, bear more heavily and are hardier than vegetatively propagated trees.

2) Seedlings are comparatively cheap, and can be more easily raised than vegetatively propagated materials.

3) Plants which are difficult to propagate, e.g., papaya and phalsa by vegetative method can only be propagated by seed.

4) In breeding for evolution of new varieties, the hybrids are first raised from the seed and it is, therefore, essential to employ this method in such cases.

5) Seed propagation, sometimes results in the production of **Chance seedlings** with superior characteristics, which may be of great benefit to the horticulture industry.

6) Rootstocks, on which desirable scion variety is budded or grafted, are usually raised from seeds.

7) Seeds of some fruits like citrus and mango varieties are capable of giving out more than one seedling from one seed. They arise from the cells of the nucellus and are called poyembyonic. The nucellar seedlings can be utilized for raising uniform plants, if they can be carefully detected at the nursery stage.

8) Since most virus diseases are usually not transmitted through seed propagation. Hence, it is useful in producing virus free plants.

9) Seeds also offer a convenient method for storing plants for a long time. Seeds when kept properly may remain viable for very long periods. Eg. Indian lotus remains viable for over 1000 years.

Disadvantages of seed propagation:

1) Owing to genetic segregation in heterozygous plants, seedling trees are not uniform in their growth, yielding capacity and fruit quality compared with asexually propagated plants. Seedling trees are not usually true to type and show variation.

2) Seedling trees take more time to come to bearing than grafted plants .For example mango seedlings take 8 -10 years to come to bearing, compared with 3-4 years for grafted trees.

3) Seedling trees, being very large, pose problems for efficient management of orchard trees, i.e., harvesting, pruning spraying etc. become more difficult and expensive.

4) It is not possible to derive the benefits of rootstocks, if the plant is not propagated vegetatively by means of grafting or budding.

5) Continuous seed propagation leads to inferiority in the progeny.

6) Sexually propagated plants have long juvenile (pre-bearing) period.

7) Choice or chance tress or hybrid trees can not be multiplied true to type because of segregation of characters.

8) Seeds loose viability within a short period. Eg. Citrus, mango, jack, papaya, jamun etc.

Asexual propagation It is called with different names - Asexual propagation, Vegetative propagation, Clonal propagation. Asexual propagation is reproduction by means of vegetative parts of the plant such as roots, shoots, or leaves other than seed. In this propagation sexes are not involved–hence it is called **asexual propagation**. It involves the use of any part of the plant, other than seed i.e. vegetative parts –hence **vegetative propagation**. The vegetative organs of many plants have the capacity (ability) for regeneration, to produce new individuals.

For instance: (a) stem pieces (cuttings) produce root system

(b) Root pieces (root cuttings) develop root system.

(c) Leaves generate both roots and shoots.

Vegetative parts possess somatic cells. They divide (multiply) by mitosis –does not involve reduction in chromosomal number, but involves the duplication of chromosome structure -the same genetic constitution is seen in the resultant plants – no variation. Whatever the characters present in the parent –the same are carried in the new plants i.e. duplicated without any change –true to mother plant-variation is eliminated.

Advantages:

As there is no change in the genetic makeup of the plant propagated by this method, the fruit plants propagated vegetatively are true to type, and, as a result, it is possible to get uniformity in growth, yield and quality of fruit, which makes harvesting and marketing easy.

Some fruits sucha as banana, pineapple and some guava varieties being seedless, the only way of further propagation is vegetative method.

Vegetaively propagated fruit trees come into bearing earlier.

Certain varieties of some fruit plants are susceptible to certain diseases. By budding or grafting them on a resistant root stock, these varieties can be grown with out pest or disease incidence.

Hardiness to cold and other unfavourable conditions such as drought can be secured, e.g.orange do well on trifoliate stock in areas where frost occurrence is frequent.

Trees can considerably dwarfed by using proper root stocks, e.g.,the apple trees can be dwarfed by using MallingIX as the root stock.

Methods like bridge grafting or buttressing can be used for healing of the wounds caused by rodents.

By top working the inferior quality fruit trees can be converted into superior quality fruit trees.

As a fancy, it is possible to grow 2-3 varieties on the same plant, e.g; one can get 3-4 varieties of roses on various branches of the stock plant.

Dis-advantages:

1) No, new variety can be evolved by means of the vegetative method of propagation.

2) Vegetative propagation in many cases is more expensive than seed propagation.

3) Vegetatively propagated plants are comparatively short lived. Lack of tap root system in vegetatively propagated plants results in poor anchorage in the soil. Consequently, such plants are easily uprooted in storms and or other such severe conditions.

4) Vegetatively propagated plants are comparatively less hardy.

5) Transmit viral diseases from plant to plant.

Which method of propagation is the best?

Considering the merits and demerits of both the methods, particularly in fruit crops and other perennial crops, vegetative propagation is more preferable than seed propagation because of uniformity (even in delicate characters like shape, taste, flavour etc.) and precocity.

Plant Propagation by Separation and Division

Many herbaceous species that die back at the end of the growing season have under ground food storage organs that survive the dormant winter period. These organs are also vegetative propagation structures that produce new shoots in the growing season. The variety of under ground storage organs may be grouped into two classes based on how they are propagated; plants propagated by separation and plants propagated by division.

Plants propagated by separation: Separation is a method of propagation in which underground structures of plants are divided not by cutting but by breaking along natural lines between segments. Separation is breaking away of daughter structures from the parent structure to be used to establish new plants. Two specialized underground structures-bulbs and corms-produce such materials.

Onion Bulb

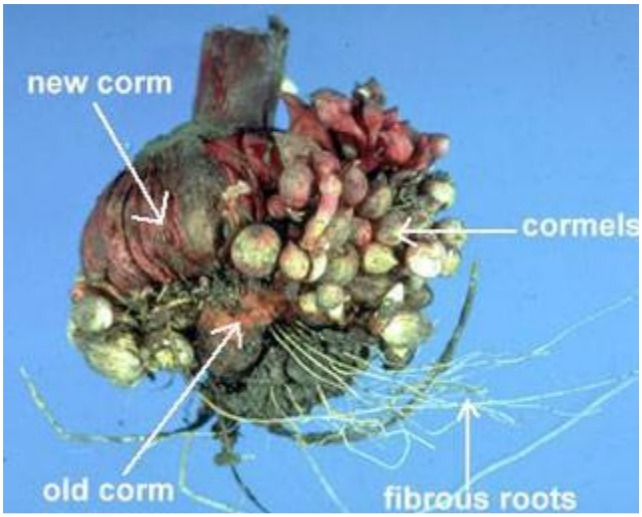
Seperation of bulblets

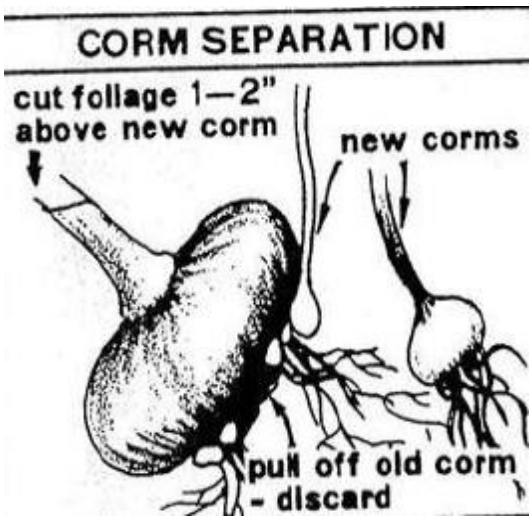
Bulb: A bulb is a specialized underground organ that consists predominantly of fleshy leaf scales growing on a stem tissue (basal plate).The scales wrap around a growing point or primordium to form a tight ball. Lateral bulblets, or miniature bulbs, originate in the axils of some of these scales and when developed (offsets) may be separated from the mother bulb to be planted independently as new plants.

There are two types of bulbs-**Tunicate** and **non-tunicate bulbs**.

Tunicate-These bulbs have outer bulb scales that are dry and membranous. This covering called tunic, provide protection from drying and mechanical injury to the bulb. The fleshy scales are in continuous, concentric layers, called lamina, so that the structure is more or less solid. E.g. Onion, daffodil, tulip etc.

Non-tunicate (scaly) bulbs: These bulbs don‘t possess the enveloping dry covering. The scales are separate and attached to the basal plate. The scales are not tight but loose and can be removed individually from the bulb. In general, the non-tunicate bulbs are easily damaged and must be handled more carefully than tunicate bulbs. The daughter bulbs or bulb lets develop at the base of the of the scales of the mother bulb. Eg. Galdiolus, Lily etc.,

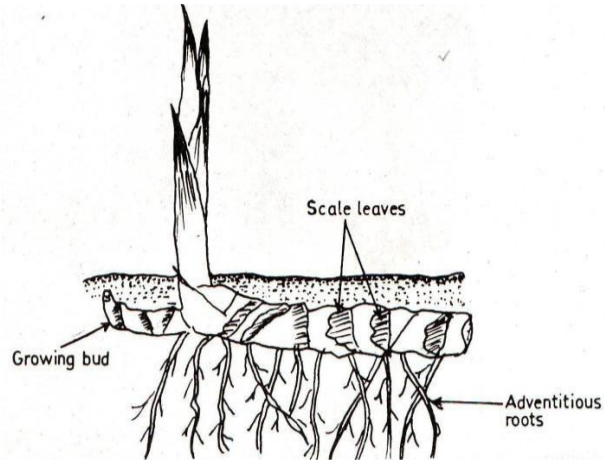


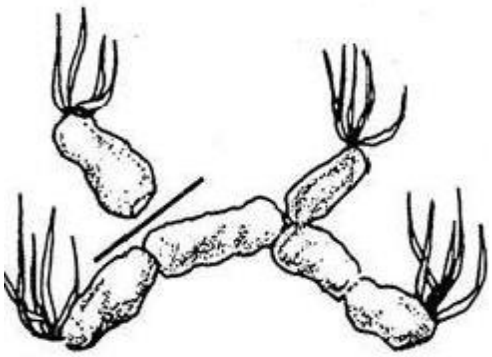


Gladiolus corm

Corm: The bulb consists predominantly of modified leaves; the corm is a modified stem. Food is stored in this compact stem, which has nodes and very short internodes and is wrapped up in dry, scaly leaves. When a corm sprouts into a new shoot, the old corm becomes exhausted of its stored food and is destroyed as a new corm forms above it. Several small corms, or cormels, arise at the base of the new corm. The cormels may be separated from the mother corm at maturity (die back) and used to propagate new plants. Eg. Amorphophallus, Colocasia, Gladiolus etc.

Plant propagation by division: It is a method of propagation of plants using cut section of a particular part like rhizome, tuber and tuberous root etc.



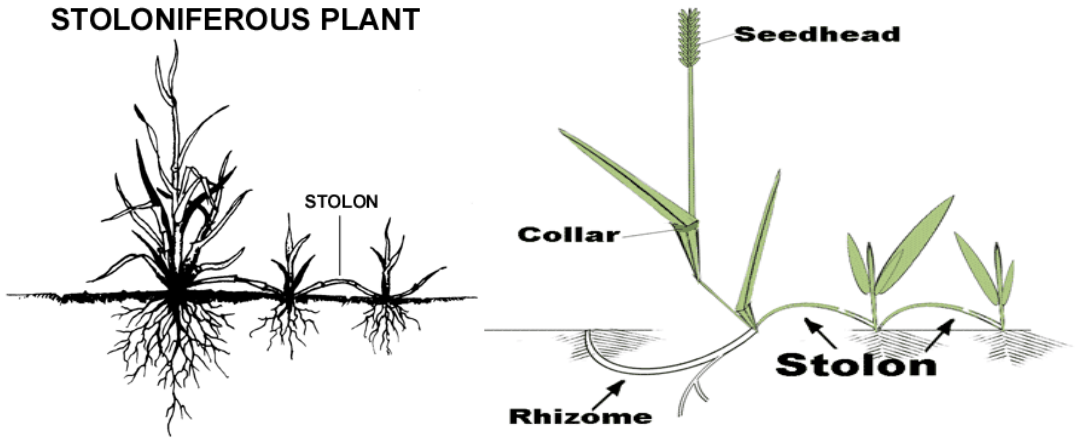


Rhizome of Canna **Rhizome division**

Rhizome: A rhizome is a specialized stem structure in which the main axis of the plant grows horizontally just below or on the surface of the ground. The stem appears segmented because it composed of nodes and internodes. The rhizome appears as a many branched clump made up of short individual sections. The rhizome tends to be oriented horizontally with roots

arising from the lower side. In propagating plants by rhizome by cutting the rhizome into different sections being sure that each section has at least one lateral bud or eye. It is essentially a stem cutting. Eg. Bamboo, Banana, Iris etc.

Stolon: It is a term used to describe various types of horizontally growing stems that produce adventious roots when come in contact with the soil. These may be prostate or sprawling stems growing above ground.

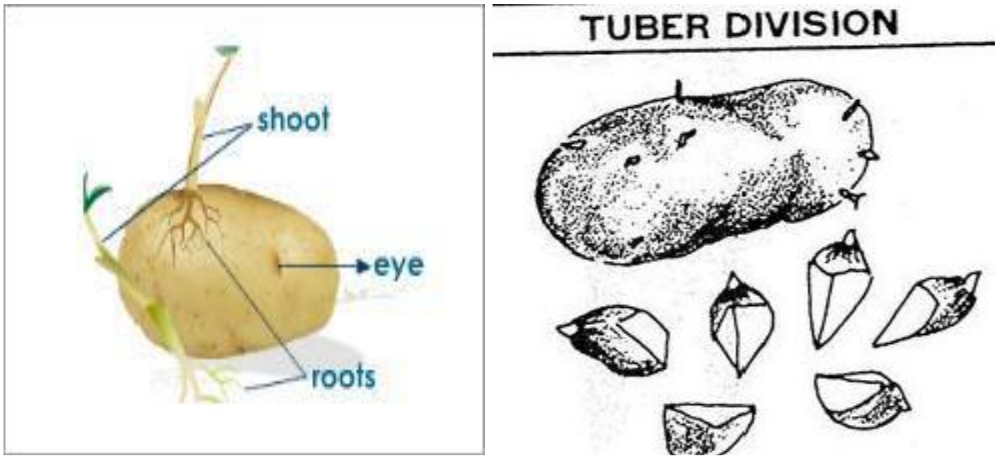


Stolon

In propagating plants by stolon, the stolon can be treated as a naturally occurring rooted layer and can be cut from the parent plant and planted separately. Eg. Mint, Bermuda grass etc.

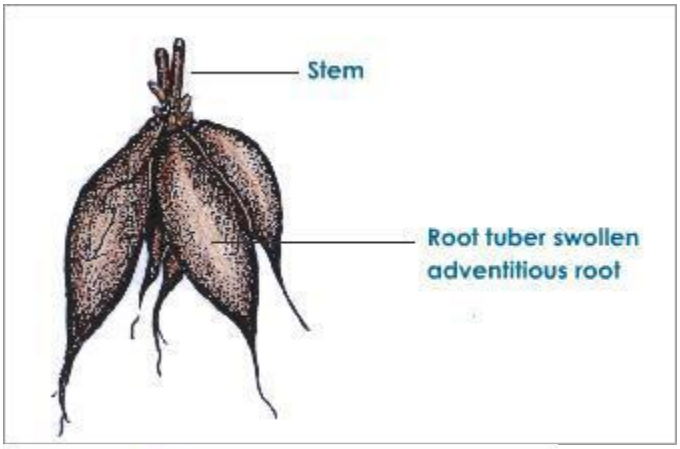
Runner of Strawberry

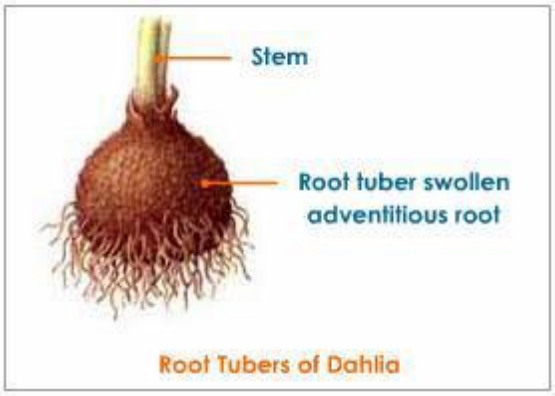
Runner: A runner is a specialized stem that develops from the axil of a leaf at the crown of a plant, grows horizontally along the ground and forms a new plant at one of the nodes. In propagating plants by runners, the rooted daughter plants are dug when they have become well rooted and transplanted to the desired locations. Eg. Straw berry, oxalis, blue berry etc.



Stem tuber of Potato

Stem tuber: A tuber is specialized swollen underground stem which possesses eyes in regular order over the surface. The eyes represent the nodes of the tuber. The arrangement of the nodes is spiral, beginning with the terminal bud on the stolon to produce a new plant, the tuber is divided into sections so that each section has a good amount of stored food and a bud or eye. Propagation by tubers can be done either by planting the tubers whole or by cutting them into section, each containing a bud or eye. Eg. Potato.

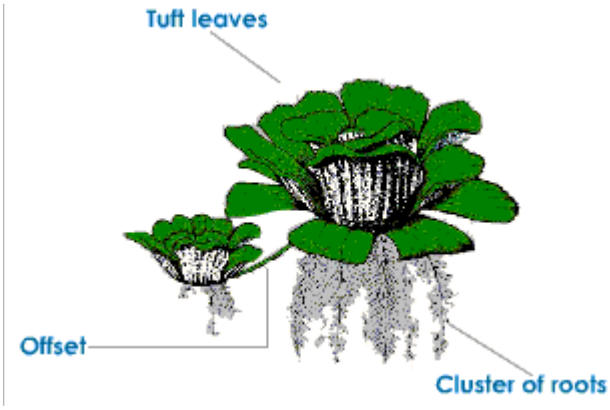




Root tuber of Sweet potato

Tuberous roots: These are thickened tuberous growth that functions as storage organs. These differ from the true stem tuber, in that they lack nodes and internodes. Buds are present

only at the crown or stem end. Fibrous roots are commonly produced towards the opposite end. Most plants with fleshy roots must be propagated by dividing the crown so that each section bears a shoot bud.Eg. Dahlia, Begonia, Sweet potato.



Offset of Pistia

Offset: It is a short thickened horizontal branch growing out of the crown ending at the apex with a tuft of leaves and a cluster of leaves below. These are special type of branches or lateral shoots which are produced from the base of main stem of parent plant. The offset often breaks away from the mother plant and the daughter starts a new independent life. Eg. Pistia, Agave, Water hyacinth, Cycas, Dracaena etc.

Suckers: It is a lateral branch developing from the underground parts of the stem or roots. The suckers arise from below the surface of the soil. There are two types of suckers.

Stem sucker of Mint

a) **Shoot suckers:** These will arise from the base of the stem. The suckers may grow obliquely upwards and directly give raise a leaf shoot. Often it grows horizontally outwards only to certain extent but soon turn up. It strikes roots when it is still attached to the parent plant or when separated and planted.
Propagation by shoot suckers can be done by separating the suckers and planting. Eg. Chrysanthemum, Banana, Pineapple, Yucca.
b) **Root suckers:** The root suckers will arise from the adventitious buds on the roots.

Propagation by shoot suckers can be done by separating the suckers and planting. Eg.Guava, Millingtonia, Curry leaf,Quis quails etc.

PLANT PROPAGATION BY CUTTINGS

The process of propagation of plants by cuttings is known as cuttage. A cutting is a part of a plant that will produce roots when put in soil media and eventually produce a new plant quite true to the parent plant.

A cutting may be a piece of stem, a leaf or part of a leaf, a piece of root, or root stock, or even a scale of bulb. **Classification of cuttings:** Cuttings are usually classified in to 3 groups according to the particular part of the plant used as cutting.

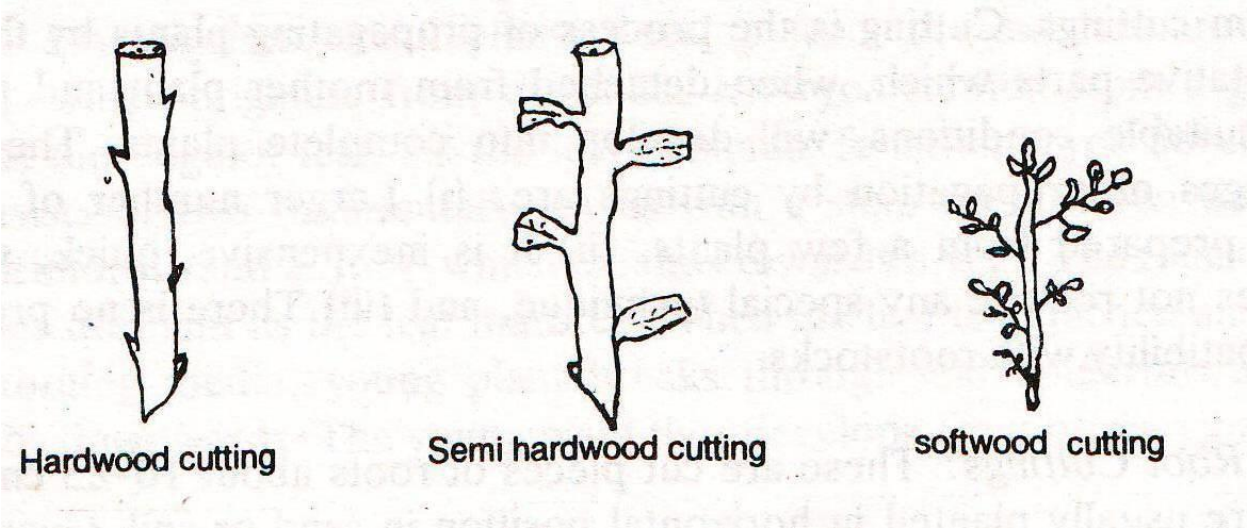
1) Stem cuttings

2) Root cuttings

3) Leaf cuttings

Stem cutting: Stem cuttings can be divided in to 4 types based on the degree of maturity and lignification of wood used in making cuttings.

- Hard wood stem cuttings
- Semi hard wood stems cuttings
- Soft wood stem cuttings
- Herbaceous stem cuttings



Hard wood stem cuttings: These cuttings are made from the past seasons growth or wood that has matured and lignified are known as hardwood cuttings.

Preparation and planting: Select a fully matured shoot with normal internodes from a healthy, vigorous plant growing in full sun light. Remove all the leaves with out damaging the axillary buds. Give a slant cut just below the basal node of the selected shoot. Measure the required length (about 15 to 25cm and containing 3 to 4 buds) from the base of the shoot and give a horizontal cut 1 to 2.5cm above the top node. Repeat the procedure and prepare as many cuttings as possible from the shoot. In case of difficult to root species treat the prepared cuttings with recommended growth regulators to induce rooting. Make holes in the prepared bed or pot with the help of a stick or dibbler. Insert the cuttings in the hole such that at least two nodes are inside the soil. Take care of polarity while planting cuttings. After planting press the medium firmly around the cutting and water immediately. **Eg:** Grape, Fig, Pomegranate, Bougainvillea, Acalypha,Rose etc.

Types of hard wood cutting

Straight or simple cutting: It consists of only the current year‘s wood and doesn‘t bear any older wood.Eg. Hibiscus, nerium.

Heel cutting: *A* small piece of older wood is retained at the base of each cutting Eg. Rose

Mallet cutting: An entire section of the older wood is retained.Eg.Thuja.

Semi-hard wood stem cuttings: Semi hard wood cuttings are prepared from new shoots just after a flush of growth which is partially matured.

Preparation and planting: Select partially matured shoots from a healthy and vigorous growing plant and take out the terminal 7 to 15cm portion by giving a horizontal cut just below a basal node. Remove all the leaves towards the base of the shoot and retain only the terminal leaves. If the retained leaves are very large, reduce their size by cutting the top half portion. This facilitates planting the cuttings closer and also minimizes the loss of water from cutting. Plant the cuttings in the same way as hard wood cuttings are planted. Eg. Camellia, Citrus, Eranthemum, Acalypha, Geranium, Hibiscus, Jasmine, Lemon, olive etc.

Soft wood cuttings: Cuttings are prepared from the soft succulent new spring growth of species which are 4 to 6 months old.

Preparation and planting: Select the soft succulent shoots from a healthy and vigorous growing plant, growing in full sun light and take out the terminal 7 to 15cm portion by giving a horizontal cut just below a basal node. Don‘t remove the leaves except for the part to be buried inside the rooting media. Soft wood cuttings should be kept in green house or in moist chamber where a high humidity can be maintained which keeps the tissues in turgid condition. Plant the cuttings in the same way as hard wood cuttings are planted. Eg. Nerium, crotons, Eranthemum, Graftophyllum etc.

Herbaceous stem cuttings: This type of cuttings is taken from succulent herbaceous green house plants.

Preparation and planting: Select the succulent herbaceous shoots from a healthy and vigorous green house growing plant. Retain all the leaves. Give a basal cut below a basal node. Plant the cuttings in the same way as hard wood cuttings are planted. *Eg.* Chrysanthemum, Coleus, Carnations, Geraniums, Cactus etc.

Leaf Cuttings: Certain plants with thick and fleshy leaves have the capacity to produce plantlets on their leaves. In leaf cuttings, the leaf blade with or without petiole and axillary bud is used for starting new plants**.** Adventious roots and shoots form at the base of the leaf and form in to a new plant. However, the original leaf does not become a part of the new plant.

Frequent watering and high humidity and bottom heating are desirable for better and rapid rooting of leaf cuttings. Sand or sand and peat moss (1:1) are satisfactory rooting media for leaf cuttings.

For leaf cuttings, depending on the species the whole leaf blade, leaf blade sections or the leaf with petiole is used. So, leaf cuttings can be classified in to:

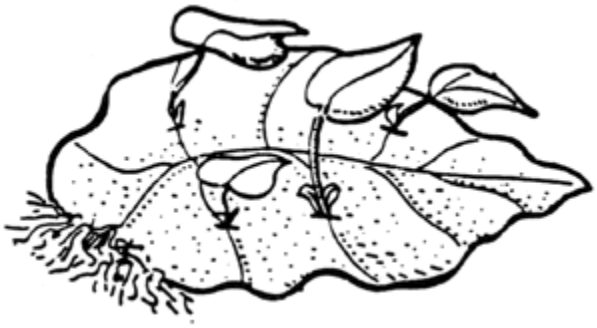
1. Leaf blade cutting
2. Leaf vein cutting / Leaf slashing
3. Leaf margin cutting
4. Leaf bud cutting

Leaf blade/Leaf section cutting:

Preparation and planting: Select a healthy leaf and Give a slanting cut towards the base of the leaf. Measure a length of about 7 to 10-cm and give a horizontal cut towards the terminal end. Prepare as many cuttings as possible from the selected leaf. Insert up to ¾ of the prepared leaf cuttings in to the medium. Take care of polarity while planting the cuttings. Compress the soil around the leaf cuttings and water immediately. Eg. Sansevieria.

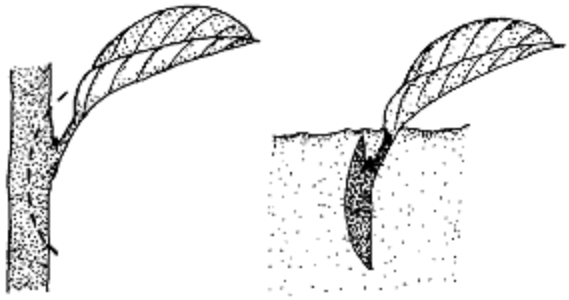
Leaf vein cutting/Leaf slashing:

Preparation and planting: Select a healthy and full mature leaf and detach it from the mother plant. Give cuts to alternate veins closer to the petiole on the lower surface of the leaf. Keep the leaf flat on the medium in such a way that the lower portion comes in contact with the medium. Pin or hold down the leaf in some manner so as to expose the upper surface and to maintain the contact between the cuts on the vein and the rooting medium. Water the cuttings carefully *Eg*. Begonia rex.



Leaf vein Cutting

Leaf bud cuttings: This cutting consists of a leaf blade, petiole and a short piece of the stem with attached axillary bud. This is practiced in species that are able to initiate roots but not shoots from the detached leaves. In such case the axillary bud at the base of the petiole provides for the essential shoot formation.



Leaf bud cutting

Preparation and planting: Select a healthy and mature shoot with well developed buds and healthy active growing leaves. Separate each leaf along with the axillary bud and a small portion of the stem. Repeat the process until possible number of leaf bud cuttings are made.Treat if necessary the cut surface of the prepared cuttings with the recommended root promoting substance to stimulate rapid root formation. Insert the prepared cutting in the rooting medium so that the bud is1.5 to 2.5 cm below the surface. Compress the medium around the cutting and water immediately. Eg. Black berry, Camellia, Lemon ,Rhododendron and raspberry etc.

Leaf margin cutting:

Preparation and planting: Select a mature and healthy leaf with the foliar embryos intact. Keep the leaf flat on the rooting medium. If the leaf is folded, just cut along the mid rib, so that the leaf can be kept flat on the medium. Keep some weight on the leaf or partially cover it with soil, so that the margin comes in contact with the medium. Water the cuttings carefully Eg. Bryophyllum.

Root cuttings: Plants which give rise root suckers freely are propagated by root cuttings.

Root cuttings

Layering is the developing of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached or become a new plant growing on its own roots. A layered stem is known as a layer.

Layering includes several forms of ground and aerial layering. When rooting is encouraged on the aerial part of a part of a plant after wounding it is known as air layering or gooty or marcottage. When branches running parallel to ground are utilized, it is known as ground layering, The root formation during layering on a stem is stimulated by various stem treatments like ringing, notching etc, which causes an interruption in the downward translocation of carbohydrates and other growth factors from leaves and growing shoot tips.

However, the root formation in layered stems, completely depends upon continuous moisture supply, good aeration and moderate temperature around the rooting zone. Some times synthetic growth regulators like IBA, IAA etc, are also treated to layered stem to induce better rooting, as the auxins in layered stem is an important factor for rooting.

Advantages:

i. It is an easy method and does not require much care and arrangement like cutting.

ii. The mother plant supplies nutrient and other metabolites as it remains attached while rooting.

iii. By using a large branch a much larger plant can be obtained in the first instance.

iv. Some plants that cannot be satisfactorily started from cuttings can be propagated by layering.

Dis advantages:

i. It is a costlier method.

ii. It is a slow process

iii. Limited number of plants can be propagated

iv. Layered plants are generally shallow rooted

v. Interference with cultivation

vi. Require more individual attention

vii. The beneficial effect of root stock cannot be exploited.

Classification of layering:

I. Ground layering

1) Tip layering

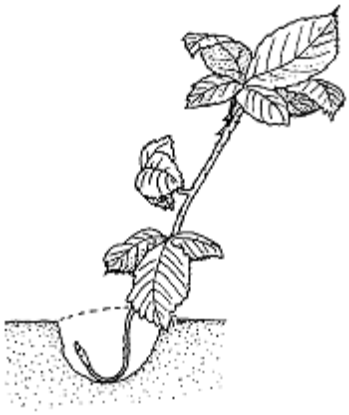
2) Simple layering

3) Trench layering

4) Mound layering or stool layering

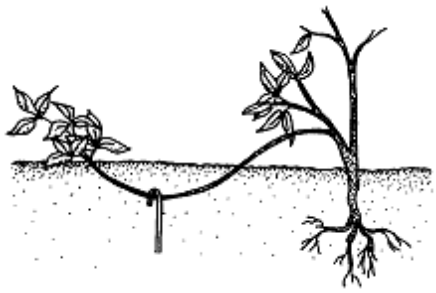
5) Compound or serpentine layering

II. Air layering. (Gootee or Marcottage).



Tip layering

Tip layering: It is generally followed in plants which have trailing type of shoots. It is quite similar to simple layering. ***Procedure:*** Dig a hole 3 to 4 inches deep. Insert the tip of a current season‘s shoot and cover it with soil. The tip grows downward first, then bends sharply and grows upward. Roots form at the bend. The re-curved tip becomes a new plant. Remove the tip layer and plant it in late fall or early spring. Examples of plants propagated by tip layering include purple and black raspberries, and trailing blackberries

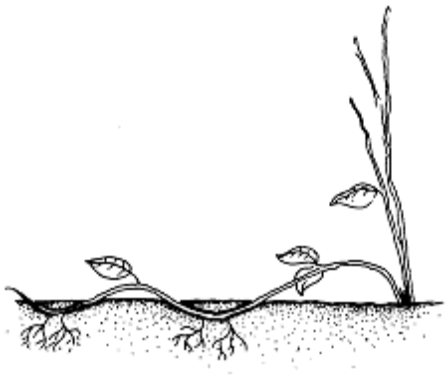


Simple layering

Simple Layering: In this method, a branch is bent to the ground and some portion of it is covered by soil leaving the terminal end of the branch exposed.Root initiation takes place at the bent and buried portion. After allowing sufficient time for root formation, the rooted stem is separated from the mother plant. Eg. Bougainvillea, Jasmine, Rangoon creeper.

Procedure: Select a healthy, flexible and sufficiently long (50 to 60cm) branch towards the base of the plant. The selected branch should be closer to the ground. At a distance of about 15 to 30cm back from the tip give a sharp, slanting inward and upward cut 1.5 to 2.5cm below a node and insert a small wood splinter. Bend the shoot gently to the ground so that the treated part can conveniently be inserted into the soil. Cover the treated region with soil. Peg down the shoot or keep a stone of brick on the covered soil to keep the layered shoot in place. Drive a vertical stake into the soil by the side of the layered branch and tie the terminal

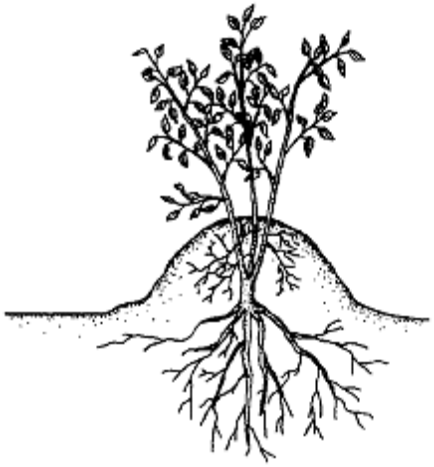
portion of the branch to keep it upright. Water the layered portion regularly so as to keep it moist all through till root initiation take place. After sufficient root formation separate the layer by cutting just below the rooted zone.



Compound or serpentine layering

Compound or serpentine Layering: Compound layering is essentially the same as the simple layering except that the branch is alternatively covered and exposed along its length. The branch for compound layering must be long and flexible so that it can be layered at different places along its length. **Eg.** Bougainvillea, Jasmine, Rangoon creeper.

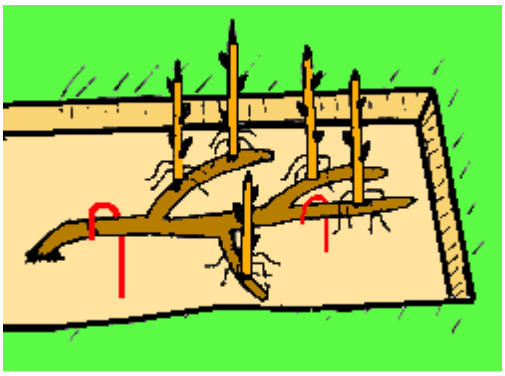
Procedure: Select a healthy, flexible and sufficiently long (100 to 250 cm) basal branch that is close to the ground. Give a sharp slanting, inward and upward cut 1.5 to 2.5 cm below a node at 30cm interval starting from the tip leaving 3 to 3 buds in between two such cuts. Bend the shoot gently to the ground, and insert and cover the cut portions with the soil exposing the uncut portions. The remaining steps are same as in simple layering.



Mound or stool layering

Mound (stool) Layering: In this method, a plant is cut back to the ground level during the dormant season and soil is heaped around the base of the newly developing shoots. After slowing sufficient time for root initiation, individual rooted layers are separated from the mother plant and panted. Eg. Apple roots tocks, Guava, Litchi, Quince,

Procedure: Select the plant to be mound layered or plant a rooted layer in a trench and allow it to grow for a year. Cut back the plant to 2.5 cm from the ground level just before growth begins. Allow the new shoots to develop. When these shoots have grown 7 to 15 cm tall, girdle them at the base and treat the girdle portion with the recommended growth regulator and draw up the loose soil round each shoot to half its height. When these shoots have are 20 to 25 cm tall add soil again to half their height. Add soil again when the shoots grow to a height of about 35 to 45 cm. Water the heaped soil regularly and allow sufficient time for the initiation of roots. A depression can be made in the centre of the heap to hold water. After sufficient root formation, remove the heaped soil and cut the rooted shoots individually to their base. Transplant the rooted shots in pots or suitable containers.



Trench Layering

Trench Layering: Trench layering consists of growing a plant or a branch of a plant in a horizontal position in the base of a trench and filling in soil a round the new shoots as they develop, so that the shoot bases are etiolated. Roots develop from the base of these new shoots. Etiolated roots develop from the base of these new shoots. Trench layering is used primarily for woody species difficult to propagate by mound layering. Trench layering is used primarily for woody species difficult to propagate by mound layering. Eg. Apple rootstocks, Litchi, Quince.

Procedure: Dig small trenches of about 25-30cm deep and in about 1 m wide rows. Plant rooted layers or one year old nursery – budded or grafted plants in the trenches in rows at an angle of 30O to 45 Oand 50 to 10cm apart within the row.The rows should be1.2 to 1.5 m apart. Just before growth begins, lay the plant or a branch flat on the bottom of the trench. Plants must be kept completely flat with wooden pegs or wire fasteners**.** Cut back the shoots slightly and remove the weak branches. Add roots medium (sand or sawdust or peat moss) or their mixture at intervals to produce etiolating on 5 to 10 cm of the base of the developing shoots. Apply first 2.5 to 5cm layer before buds swell and repeat as shoots emerge and expand. At the end of the season, remove the medium and cut off the rooted shoots close to the parent plant. Transplant the rooted shoots in pots or suitable containers.

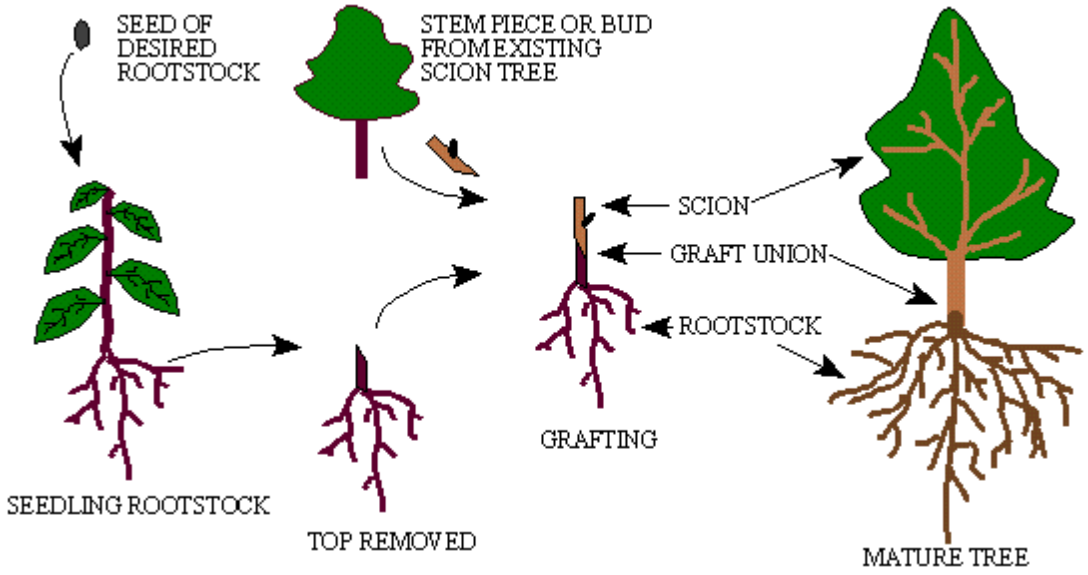
Air Layering

II. Air Layering: In air layering roots form on an aerial shoot. The rooting medium is tied to the shoot for getting root initiation. Sphagnum moss is the best rooting medium for air layering as it holds large quantities of water till root initiation and through the root initiation and through the root development. Eg. Crotons, ficus, fig, Guava, Phalsa, Pomegranate.

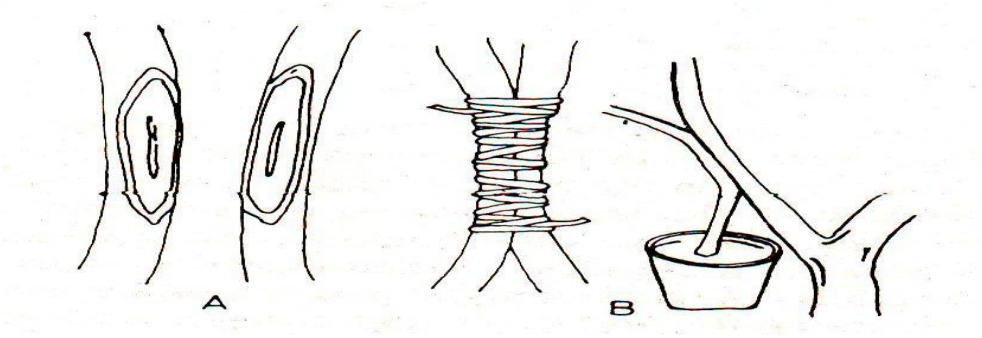
Procedure: Select a healthy branch of previous season‘s growth. At a point 15 to 30 cm back from the tip of the shoot make a girdle just below a node by completely removing a strip of bark 2 to 3.5 cm wide all around the shot. Scrape the exposed surface lightly to remove traces a phloem or cambium to retard healing. In difficult-to-root species treat the girdled portion with the recommended growth regulator to induce better rooting. Cover the girdled portion with moist propagating medium. Sphagnum mass, saw dust, vermiculite. Tie the medium around the girdled portion using a polyethylene sheet. Tying should be perfect so that no water can enter the treated part. After observing the fully developed roots through the transparent polyethylene sheet, separate the root zone and transplant the layer appropriately.

Plant propagation by budding and grafting

Plant propagation by grafting--Grafting is an art of joining parts of two independent plants in such a manner that they unite and grow together into single independent plant.The part of graft combination which is to become the upper portion or the shoot system or top of the new plant is termed the **scion** or **cion** and the part which is to become the lower portion or the root system is the **rootstock** or **under stock** or some time **stock**. The single plant obtained as a result of union between the stock and scion is termed as **Stion**.



Methods of grafting: Mainly in grafting there are two types. ***Attached scion methods of grafting*** *and* ***detached scion methods of grafting.***
In attached scion methods of grafting the scion is still attached to the mother plant (Scion Plant) till the graft union takes place where as in detached scion methods of grafting the scion is separated from the scion plant or mother plant just before grafting. Under attached scion methods of grafting simple inarching or approach grafting is most important.



Simple inarching

Simple inarching/Approach grafting: The distinguishing feature of this method of grafting is that two independent plants on their own roots (self sustaining) are grafted together. This method provides a means of establishing a successful union between certain plants which are difficult to graft by any other method as the two plants will be on their own roots till the formation of successful graft. Eg. Guava, mango, Sapota.

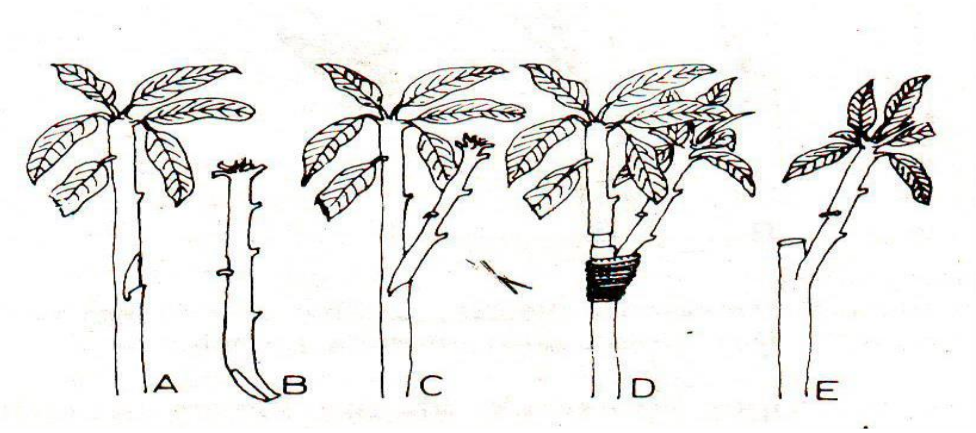
Procedure: Select a healthy shoot of having a 3.5cm girth on the selected mother plant which is to be used as a scion source. Select a root stock (raised in pot) having approximately the same size as that of the selected shoot on the mother plant. On the internodal region, where the union is to occur, a slice of bark and wood 2.5 to5 cm long is cut from both the selected stock and scion shoots. The cut should be given on the stock and scion should be of the same size. The cuts should be perfectly smooth so that a close contact of the cambial layers of stock and scion is brought about when they are pressed together. Tie the two cut surfaces together tightly with string or cloth.

Pre-curing of scion: In detached scion methods of grafting, the scion is to be procured before grafting. For precuring, a partially matured scion shoot about the thickness of a little finger is selected.The maturity is indicated by the presence of dark green leaves and grey dark colour on the shoots. The selected shoot is defoliated retaining only the petioles up to a length of about 4‖ from the apical bud. The defoliated shoot is left on the tree for a period of 7-10 days. During this time, the bud on the shoot begins to swell. This shoot is then called as **—Pre-cured scion**‖, which is separated from the tree.

In detached scion methods of grafting there are two types-they are ***side grafting*** and ***apical grafting*** methods**.**

Among the detached scion methods of grafting the important ones are described below.

Under side grafting method Veneer grafting is important and is described below.

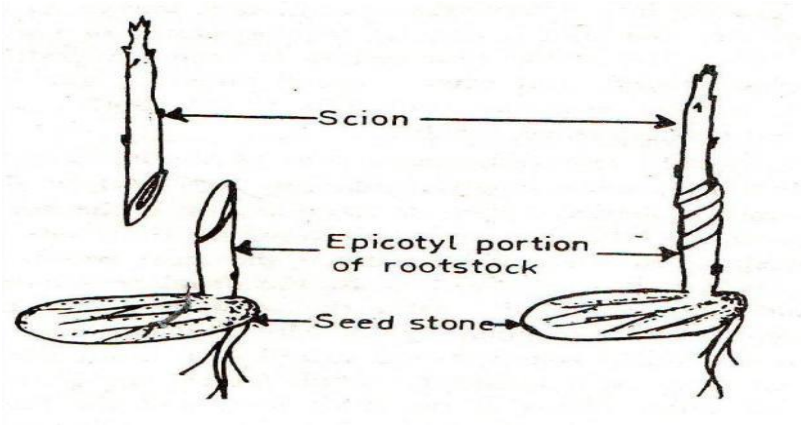


A-Prepared root stock, **B-**prepared Scion, C-Scion inserted,**D**-Girdled stock and tied graft joint,**E**-Sucessful graft,the stock being removed

Veneer grafting: This is also a kind of side grafting with slight modification .It is used widely for grafting small potted plants and *insitu* grafting .Eg. .Avocado, Mango etc.

Procedure: On the stock plant, at the desired height, in the internodal region, give a shallow inward cut running to a length of about 2.5 to 5cm. At the base of the first cut make another short and inward cut intersecting the first cut and remove a piece of wood and bark. On the scion , towards the base, give a long (2.5-5.0cm), slanting cut towards one side and another short, inward and downward cut on the opposite side. The cuts given on stock and scion should be of same dimensions, so that, the cambium layers can be matched as closely as possible. Insert the scion on to the rootstock such that a contact of cambium is established at least on one side, and tie them firmly. After the union has healed, cut back the stock above the graft union either on gradual steps or all at once.

Among apical detached scion methods of grafting the important ones are described below.

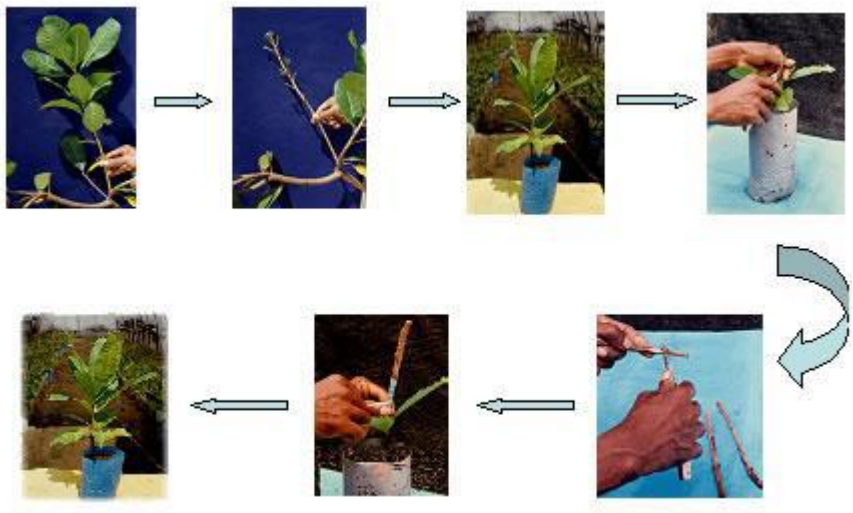


Epicotyl grafting

Epicotyl (Stone) Grafting: This method of grafting is done on the epicotyl region of the young seedlings; hence the name epicotyl grafting. Eg. Cashew, mango etc.
Procedure: Select very young seedling about 10 days old raised in polythene bags of size (15cmX22cm). Cut off the top portion of the chosen seedling leaving 5-6cm long shoot

(epicotyl). With a sharp knife make a vertical, downward slit (2-3cm long) at the centre of the remaining portion of the epicotyl. Select a dormant 3-4 months old terminal shoot of about 5-8cm long from a proven mother plant as the scion stick. Cut the lower end of the selected scion to a wedge shape by giving slanting and inward cuts of 2-3cm on opposite sides. Insert the wedge shaped scion in the slit made on the seedling and secure firmly with polythene strips or tape. Water the graft regularly without wetting the graft region. In about three weeks the scion starts sprouting. If the seedlings are raised in sand beds they are uprooted (with stones) 15 to 20 days after sowing (when seedlings attain10-15cm height) and grafting is done as described above. The grafted seedling is then planted in polythene bags or pots keeping the graft union above the soil level and without damaging the stone. June to September is the best period for epicotyl grafting.

Soft wood grafting: It has been developed to graft small and young rootstocks which are grown *in situ* or in pots. Eg. Cashew, Mango.



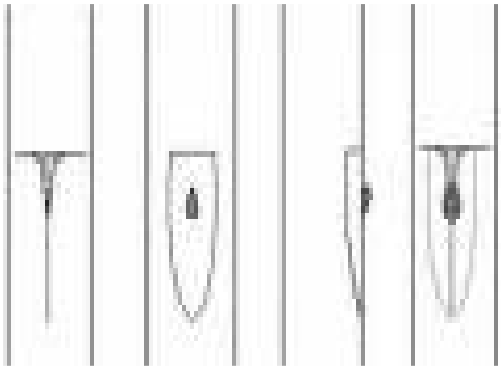
Softwood grafting

Procedure: Raise the rootstock seedlings in suitable containers or preferably in the main field itself where the grafts are desired to be grown and allow them to grow for a year or more. When the seedling attain a height of 30-45cm and the new shoot and leaves usually have bronze colour. Decapitate the top portion of the fresh growth on the stock plant with a knife, retaining bout 8 cm of the fresh stem. Make a longitudinal cut of 3 cm in the retained fresh stem. Select a scion stick of about 10cm long and about the same thickness as of the prepared stem on the stock. Cut the basal end of the scion to a wedge shape of about 3cm long by chopping the bark and a little wood on two opposite sides. Insert the prepared wedge part of the scion stick into the slit made on the stock and secure firmly with polythene strips. Water the grafted plant regularly. The scion sprouts in about three weeks.

Plant Propagation by Budding

Budding is also a method of grafting wherein only one bud with a piece of bark and with or without wood is used as the scion material. It is also called as bud grafting. The plant that grows after union of the stock and bud is known as budding.

Methods of budding:



Shield budding / T- budding

T-Budding (Shield budding): This method is known as T-budding as the cuts given on the stock are of the shape of the letter **T**, and shield budding as the bud piece like a shield. This method is widely used for propagating fruit trees and many ornamental plants. This method is generally limited to the stock that is about 0.75 to 2.50cm in diameter and actively growing so that the bark separate readily from the wood. Eg.Citrus, Rose etc.

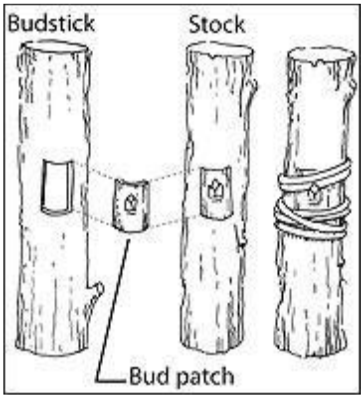
Procedure: After selecting the stock plant, select an internodal region with smooth bark preferably at a height of 15-25 cm from ground level. Give a vertical cut through the bark to a length of about 2.5-3.75cm. At the top of this vertical cut, give another horizontal cut (1cm or 1/3rd of the circumference of the stem) in such a way that the two cuts given resemble the letter **T.** Lift the bark piece on either side of the vertical cut for the insertion of the bud. Select a required bud stick and start a slicing cut about 1.5cm below the bud and continue it upward and under the bud to about 2.5cm above the bud. Give another horizontal cut about 1cm above the bud. Remove the shield of bark containing bud. The traces of wood, if attached may be removed. Insert the bud between the flaps of bark on the stock with the help of budding knife in such a way that the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud stick tightly with polythene strip exposing only the bud.

Successful T budding requires that the scion material have fully-formed, mature, dormant buds and that the rootstock be in a condition of active growth such that the "*bark is slipping*". This means that the vascular cambium is actively growing, and the bark can be peeled easily from the stock piece with little damage.

Inverted T- Budding: In heavy rainfall areas, water running down the stem of the stock may enter the T cut, soak under the bark and prevent healing of the bud piece. Under such conditions an inverted T ( ) budding may give better results as it is more likely to shed excess water. Inverted T budding procedure is same as that of T- budding except the horizontal cut on the stock is made at the bottom of the vertical cut rather than at the top.

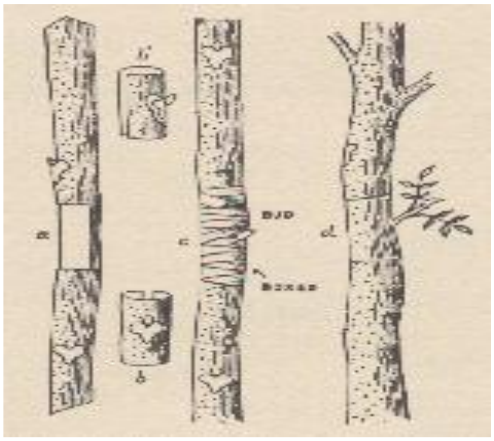
Procedure: On the selected stock plant, give a horizontal cut at the bottom of the given vertical cut representing inverted **T.** Select the required bud stick. Start a slicing cut 1.5 cm above the bud and continue it downward and under the bud to about 2.5 cm below the bud. Give another horizontal cut about 1cm below the bud and remove the bud piece. Insert the bud between the flaps of bark on the stock and push upwards till the horizontal cut of the shield matches the horizontal cut on the stock. Wrap the bud piece and stock completely and tightly exposing only the bud properly.

Patch Budding: In this method a regular patch of bark is completely removed from the stock plant and is replaced with a patch of bark of the same size containing a bud from the desired mother plant. For this method to be successful, the bark of the stock and bud stick should be easily slipping .The diameter of the stock and bud stick should be preferably by about the same (1.5 to 2.75cm) E.g., Ber, Citrus, Cocoa and rubber.



Patch Budding

Procedure: On the selected stock plant at the desired place (10-15cm above the ground level) give two transverse parallel cuts through the bark and about 1-1.5 cm long or 1/3rd the distance around the stock. The distance between the cuts may be 2-3 cm. Join the two transverse cuts at their ends by two vertical cuts. Remove the patch of bark and keep it in place again until the bark patch with the bud from the selected mother plant is ready. On the bud stick give two transverse cuts-one above and one below the bud-and two vertical cuts on each side of the bud. The dimensions of the transverse and vertical should correspond to those given on the stock. Remove the bark patch with bud by sliding side ways. Cuts with bud by sliding side ways. Insert the bud patch immediately on the stock in such a way that the horizontal cuts of the bark patch and those on the stock plant match together perfectly. Wrap the inserted bud patch with polythene strip covering all the cut surfaces but exposing the bud properly.



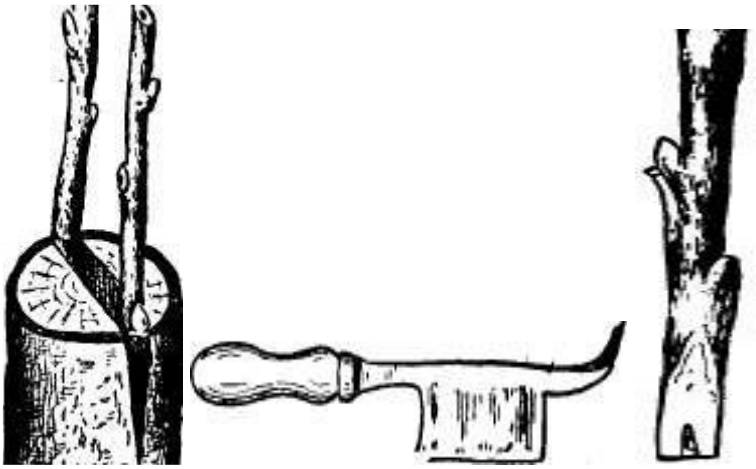
Ring budding

Ring budding: The bud is prepared by taking a ring of a bark, 3cm long with the bud in the centre. In the root stock, two transverse cut 1.5cm apart are made and these are connected with a vertical cut and a ring of bark is removed. The prepared scion bud with the ring of bark is fitted in the exposed portion of the rootstock and tied. E.g, Cinchona.

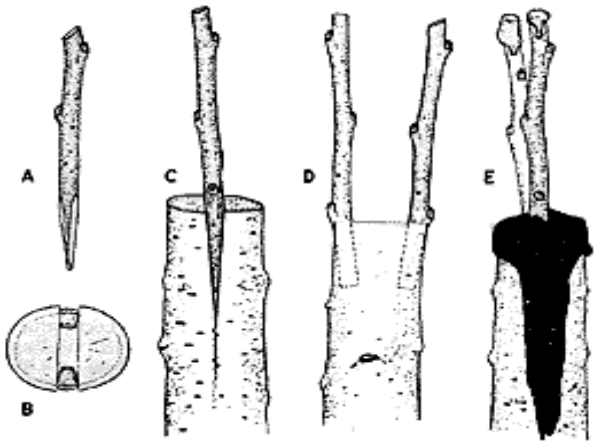
Double working: It is practiced for several purposes (1) to overcome incompatibility between the stock and scion.Iincompatible stock and scion may be united by means of a piece of interstock that is compatible to both (2) to secure resistance to drought or cold by providing a disease or cold resistant trunk by means of double working.(3) To obtain resistance to pest and dwarfing effect by using a pest resistant stock and a dwarfing stock and (4) top working of grafted orchard trees is essentially a double working; here the tree trunk as an intermediate stock may exert certain influences on the new top.

The inserted intermediate stem piece is called as **sinking scion / foster mother /interstock / inter stem.**

Top working: Top-working for changing a variety is generally done on long lived species, growing in a healthy condition. Short lived species, old trees or diseased trees are not suitable for top working; in such cases new planting is considered more economical and useful than top working.



Top working by cleft grafting



Top working by cleft grafting on main branches

This practice is resorted to (1) when the existing tree is of inferior type, (2) when the tree is unproductive and (3) to provide pollenizers (4) to change the variety.

For top working different methods of grafting like cleft grafting, bark grafting, splice grafting or side grafting can be used. However, cleft is the most popular and commonly used method for top working especially when thick branches are selected .When younger and thin branches are used, whip and tongue grafting are best.

Top working of older trees is generally done over a period of two years. In the first year, half of the scaffold branches are top worked retaining the other branches as nurse branches which in turn are grafted in the second year. In the smaller and comparatively younger trees the entire tree is top worked in the first year. Here also one or more nurse branches are retained till the union is successful. Nurse branches protect the top worked scions from winter injury, sun burn and also from desiccating winds and water sprouts develop less frequently when nurse branches are retained. Top working is most successful when relatively young trees are used. If older trees are selected for top working, it is better to select vigorous lateral branches that arise from the main limbs.

The branches to be top worked should be cut in such a way that the cut surface is smooth and is at a point of the branch where there are no knots or smaller branches. Immediately after top working the limbs should be thoroughly covered with grafting wax, sealing all the exposed cut surfaces.

CLONAL PROPAGATION

The reproduction of a group of plants from a single plant by vegetative propagation is called clonal propagation. All these plants have the same heredity / genetic constitution and are quite uniform when grown under the same conditions.

May be defined as genetically uniform material derived from a single individual parent exclusively by vegetative methods such as cuttings, divisions etc.All the plants of a clone are true to the parent in their growth and performance.

The reproduction of a group of plants from a single plant by vegetative propagation is called clonal propagation. The group of plants or horticultural variety derived from one original plant by means of vegetative propagation (e.g. rooting of cuttings, or slips, budding, grafting, bulb lets etc) have the same heredity and are quite uniform when grown under the same conditions. Also the vegetative progeny from a single seedling.

Clone of many commercial crops like potato, tea, banana, onion, turnip and many horticultural crops have been established by clonal propagation. In many plants which are heterozygous and sterile, clonal propagation is the only means of perpetuation. Clonal selection and propagation can also be used to evolve new varieties in vegetatively propagated plants.

The steps involved in the production and maintenance of a clone: There are essentially three steps in the production and maintenance of clone .(1) Selection of pedigree and pathogen free, true to type, stock plants,(2) maintenance of stocks in a disease free condition and rouging of off types and (3) propagation and distribution of such stocks.

MICRO PROPAGATION

Micro propagation (tissue culture or invitro culture) refers to the multiplication of plants, in aseptic condition and in artificial growth medium from plant parts like meristem tip, callus, embryos anthers, axillary buds etc.

It is a method by which a true to type and disease free entire plant can be regenerated from a miniature piece of plant in aseptic condition in artificial growing medium rapidly throughout the year.

Tissue culture plants

Merits of micro propagation:

a) Tissue culture helps in rapid multiplication of true to type plants throughout the year.

b) A new plant can be regenerated from a miniature plant part, whereas, in conventional methods a shoot of considerable length is required.

c) Large number of plants can be produced in culture tubes in small space with uniform growth and productivity instead of growing them in large areas in nursery.

d) Plants raised by tissue culture are free from diseases.

e) Tissue culture coupled with somatic hybridization (production of hybrid cells by fusion of two protoplasts with different genetic makeup.)helps in evolving new cultivars in a short time.

f) Micro propagation facilitates long distance transport of propagation materials and long term storage of clonal materials.

g) Tissue culture methods are particularly effective in plants that don‘t breed true from seeds, seeds are not viable (male sterile) or not available (banana) and in plant where propagation by conventional methods are expensive (Orchids)

Demerits of Micro propagation:

a) The cost involved in setting up and maintenance of a laboratory is very high and may not justify their use in all the horticultural plants ordinarily.

b) Tissue culture techniques require skilled manpower.

c) Slight infection may damage the entire lot of plants.

d) Some genetic modification (mutation) of the plant may develop with some varieties and culture systems, which may alter the quality of the produce.

e) The seedlings grown under artificial condition may not survive when placed under normal environmental condition.

Methods of Micro propagation: Different methods of micro-propagation are Meristem culture, Callus culture, Cell culture, Embryo culture, Protoplast culture, Shoot apex grafting, and Pollen grain culture.

Invitro: Latin for ‘‘in glass‖. Reactions, responses or experiments in an artificial environment in isolation from the whole organism.

In vivo: Latin for ―in living‖. Biological processes that occur with in the whole living organism.

Propagating structures

Plant Propagation Structures in Nursery

Plant propagation structures plays vital role in propagation of various seedlings and grafts in nurseries. These structures helps to maintain congenial climatic conditions for better germination, easy rooting and hardening of seedling. Plant propagation structures helps the successful and healthy production of seedlings.

1. Poly-houses
2. Net houses
3. Plastic tunnels
4. Mist Chambers

Poly-house

- Poly-house is widely used for prorogating off season seedlings which fetch better price in the market.
- Modern poly-house are automated for temperature and humidity control to assist propagation
- In poly-houses, plant are propagated using pro-trays or poly-bags on ground or benches.
- In Poly-houses, thermostat, hygrometer, automatic ventilation system is maintained to facilitate micro-climate.

Irrigation and fertigation systems in poly-houses is automated to provide measured quantity of water and nutrients to plants.

Poly-house Structure for Nursery **Net house Structure for Nursery**

Net House

- Net houses are widely used as propagation structure in tropical areas, where artificial heating is not required and artificial cooling is expensive.
- The roof of net house may be covered with gunny cloth or even with live plant creeper to cut off the solar radiation and to keep the house cool. Different type of shade nets are available in the market for shade purpose.
- Net houses can be constructed as per need of propagation and therefore its size of net houses varies.

Plastic Tunnels

- Plastic tunnel is a simple but effective method of protective cultivation, used by many nurserymen throughout the world.
- The three feet wide loops which support the polyethylene are made from 0.2 inch diameter wire and are erected at 30 inches intervals.
- A white translucent polyethylene sheet of 6 feet wide is then stretched over the loops and is fastened to the frame of the tunnel.
- Plastic tunnels prove effective for seed germination as well as vegetative propagation of nursery plants in winter season.

Plastic Tunnels Used in Nursery

Mist Chamber

- Nursery plants propagated by cuttings are grown in mist chambers.
- In Mist Chamber, Relative humidity is maintained artificially at high level (95 %) with the help of mist installations, which spray water under pressure.
- High relative humidity facilitates better root initiation and cooling effect prevents the cutting from drying out.

Mist Chamber Used in Nursery

Advantages

- This method results in faster rooting of the cuttings.
- Create optimum Microclimate for better root initiation and development.

- Higher success rate found in propagation of hard wood cuttings.

Disadvantages

- Hardening of rooted cuttings is more difficult and requires careful attention. Selection of right medium is very important.
- Under mist conditions oxygen deficiency can create problem.

Principles of orchard establishment

❖ **Location and site:**

The following points are considered before selection of the site.

- The fruit orchard should plant in favourable climate and soil conditions. Topography and elevation also influence the growth of fruit plant.
- The majority of fruit are perishable in nature and they should transport without delay, therefore, the site should be near the market, it also help in reducing the cost of transport. About 30-50 per cent of the total cost is expended on the packing, handling and transportation.
- Orchard should be connected either by road or by rail.
- The site should be free from frost, cyclones, hail storms and strong hot and cold winds.
- Proper irrigation facilities should be available near the orchard. The good quality water free from impurities is more beneficial to the fruit plants.
- Soil of the orchard should be fertile well drained by given the slightly slope to drained the excess water.
- Owner of the orchard should have his home on or near the orchard.
- To get the good return from the orchard, it should plant near the processing industry.
- Labour availability should be ensured for cultural practices in the orchard.

❖ **Planning of orchard:**

Planting of an orchard is perennial investment; therefore, appropriate planning is necessary to avoid making it a liability. Grower should be making a sketch of the proposed orchard on a paper before the actual planting is taken in hand.

❖ **Planting distance:**

The planting distance varies according to the vigour of species or type of fruit, soil status, climate, type of root stock used in bidding of grafting, nature of pruning etc. The fruit crops are planted at the distance given below:

S. No.	Fruit crop	Planting distance
1.	Mango	10 X 10 m
2.	Citrus	6 X 6 m
3.	Banana	1.8 X 1.8 m
4.	Guava	6 X 6 m
5.	Papaya	2.5 X 2.5 m
6.	Sapota	10 X 10 m
7.	Ber	6 X 6 m

8.	Aonla	8 X 8 m
9.	Date palm	8 X 8 m
10.	Pomegranate	5 X 5 m
11.	Litchi	10 X 10m

After marking the places for the plants, pits should dig out during the May and June months. The trees are planted 8 X 8 meter or more distance, pits of one cubic meter size suitable. However, fruit crop planted between 4-6 meter and below 4 meter distances pit size should be 50 cm^3 and 45 cm^3, respectively. Digging during the summer months helps in eradicating harmful organism including weeds by exposing the soil.

❖ **Pit filling:**

All stones, rubbles, bricks are removed from the excavated soil. The pits are filled with equal quantity of both FYM and soil along with super phosphate (2.5 kg), murate of potash (1 kg), methyl parathion dust 2 % or carbaryl dust (30 gm) is also mixed in soil. Lime and gypsum can also used in acidic and sodic soils, respectively. After completely filling the pit, it is left to rains for setting down.

❖ **Planting:**

A small hole is dug in the centre of a pit which can accommodate root system of the graft/sapling. After that placed the sapling in small pit and pressed the soil from all sides to hold the plant erect. Just after the planting sapling should be irrigate.

❖ **Planting season or time:**

The planting season of the different fruit crop varies. Most of the tropical and subtropical plants are planted beginning of monsoon to take the advantage of high humidity in rainy season it will help in reducing the stress effect. Tropical and subtropical fruit plants can also plant in September or in the beginning October and February-March. During this period amble quantity of irrigation water should be available for survival of the plants.

Deciduous fruit plants like apple, pear, peach, plum etc. are planted during the winter when they are dormant. Planting should be completed before the start of new growth of plants. Peach and plum are planted up to mid of January and pear and apple up to middle of February.

Principles of orchard establishment

♦ Orchard is a long-term investment and needs lot of planning and expertise.

 While planning and planting a new orchard, one should give utmost attention and care to various aspects like,

- Selection of location and site,
- Nature of soil and subsoil,
- Planning of suitable kinds and varieties of fruits,
- Proper planting distance and
- Purchasing of plants from reliable nurseries.

Preparation of land

 The land should be cleaned properly for free movement of men and machinery.

 All the trees, bushes and creepers should be removed.
 The soil of the area designed for growing fruit plants needs thorough preparation.
 A virgin land requires a deep ploughing and harrowing.
 The land should be repeatedly ploughed and bring the soil to a fine tilth.

Layout plan
 The marking of position of the plant in the field is referred as layout.
 The layout plan of the orchard should be prepared carefully, preferably in consultation with horticultural experts.
 The orchard layout plan includes the system of planning provision for orchard paths, roads, water channels and farm building.
 A sketch of the proposed orchard should be prepared before the actual planting is taken up.

Method of layout
- For layingout an orchard, according to square system, a base line is first established and position of the trees is marked along this line by laying wooden stakes in the ground.
- Another base line at right angle to the first base line, is then marked along with the other edge of the field with the help of a carpenter square or a cross staff.
- The right angle can also be drawn with the help of measuring tape.
- One end of this tape is fixed at **three metre** distance from the corner along the first line and the tape is then stretched along the second base line for a distance of **four metre**. The diagonal distance between these two points should be **five metre.**
- **The** wooden stakes are put in the ground at the desired distance along the second line.
- All the four rows are thus established and staked. Three men, one putting the peg in the field and others correcting alignment while moving along the base line, can easily stake the whole field.
- The marking of position of the plant in the field is called **—layout"**.

Aims:
1) To provide adequate space to plants.
2) To accommodate more number of plants.
3) Easy intercultural operations.
4) System of planting
The following are the important systems of planting generally followed on the basis of Agro-climatic conditions to improve aesthetic view of the land.
1. SQUARE SYSTEM

It is the most commonly used method and easy to layout in the field. In this system, plant to plant and row to row distance is the same. The plants are at the right angle to each other, every unit of four plants forming a square. This system facilitates the interculture in two directions after the orchard is planted.
Advantage:
1) Most easy and popular one.
2) In this row to row and plant to plant distance is kept similar.
3) Plants are exactly at right angle to each other.
4) Interculture operations can be done in both the directions.
5) Adequate space for inter-cultivation of remunerative crops like vegetables.

2. **RECTANGULAR SYSTEM**

In this system, the plot is divided into rectangles instead of squares and trees are planted at the four corners of the rectangle in straight rows running at right angles. Like square system, this system also

facilitates the interculture in two directions. The only difference is that in this system more plants can be accommodated in the row keeping more space between the rows.

Advantages:

1) Lay out in rectangular shape.
2) More space between row to row.
3) Inter-cultural operations can be done in both the ways.
4) Plants get proper space and sunlight.

3. HEXAGONAL SYSTEM

In hexagonal system, the trees are planted in the corners of equilateral triangles. Six trees thus form a hexagon with another tree at its centre. This system, though a little difficult for execution but accommodates 15 percent more plants. Cultivation of land between the tree rows is possible in three directions with this system. This system is generally followed where the land is costly and very fertile with ample provision of irrigation water. **Advantages:**

1) Accommodates 15 % more plants than the square system.
2) Plants are planted at the corner of equilateral triangle.
3) Six trees are planted making a hexagon.
4) The seventh tree is planted in the centre and called septule.
5) This requires fertile land.

Disadvantage: Lay out is difficult and cumbersome.

4. QUINCUNX SYSTEM

This system is exactly like the square system but one additional tree is planted in the centre of each square. The number of plants per acre by this system is almost doubled than the square system. Fruit trees like papaya, kinnow, phalsa, guava, peach, plum etc. can be planted as fillers in the permanent trees provides an additional income to the grower in the early life of the orchard. The filler trees are uprooted when the main orchard trees start commercial fruiting.

5. **CONTOUR SYSTEM**

This system is usually followed in the hilly areas with high slopes but it is very much similar to the square/rectangular system. Under such circumstances, the trees may be well planted in lines following the contour of the soil with only a slight slope. Irrigation and cultivation are then practiced only across the slope of the land as this practice reduces the chances of soil erosion. In this system layout is done as in square/rectangular system, first by establishing the base line at the lowest level and then marking for the trees should be done from the base to the top. Bench terraces are used where the slope is greater than 10 per cent.

TRIANGULAR SYSTEM

1) In this system, trees are planted as in the square system but the plants in the 2nd, 4th, 6th and such other alternate rows are planted midway between the 1st, 3rd, 5th and such other alternative rows. This system provides

2) Plants in alternate rows are off set half the space between plants in a row.

3) Result in 9 % fewer plants than square and rectangular system.

Eg : Amrapali – 1600 plants / ha. 4. More open space for trees and for intercrop.

Principles and Methods of training and pruning

Training and pruning arc important orchard operations. Both the processes form an indispensable process having direct bearing on growth and vigour of plants and yield and quality of fruits. A properly trained and pruned plant sustain heavy crop load and produce bounteous harvest of quality.

Training refers to judicious removal of part to develop a proper shape of plant capable of bearing heavy crop load. *Priuning* is defined as the judicious removal of pans like root, leaf, flower, fruit etc. to obtain good and qualitative yield. thus, it can be conceived that the training is related to shape and size of plants whereas pruning is related with harvesting better yield and more so harvesting fruits of quality. both the processes of training and pruning work together in maintaining shape and size of tree and harvesting desirable yield.

OBJECTIVES OFTRA1NING

- To control and regulate shape of trees so that orchard cultural operations, harvesting etc. can be done easily.
- To develop strong framework of tree.
- To have a better crotch angle between scaffold branches of the trees.
- To facilitate interception of sunrays to each and every part of trees.
- To remove water sprout.
- To develop balance between vegetative and reproductive growth of tree.

PRINCIPLES OF TRAINING

- Training should be started from very beginning age of the plant.
- Most of the fruit trees are trained through single stem system. However, fruits like pomegranate, fig and custard_apple are trained through multi-stemmed training system.
- The selected shoot should be well-distributed all over the main stem.
- In plants having prominent apical dominance the terminal bud should be removed to facilitate emergence of side shoot. From side shoots selection is made for better shoots to be retained on the tree after training.
- The shoots having narrower crotch angle are discarded
- Wafer sprout should be removed.

METHODS OFTRAINING

1. CENTRAL LEADER SYSTEM

In this system the main stem of the tree is allowed to growuninterrupted. The first stem is kept at 45 to 50 cm, height from ground level and otherr branches are allowed to grow on main stem at a distance of 15 to 20 cm. As the main stem grows continuously in this system the tree attains robusl shape. Due to less interception of light by lower branches. mostly they remain unproductive. The bearing is confined in top portion of the trees. Furthermore, the robust shape of trees pose a problem in harvesting of fruits and practicing spray operation etc. The very high shape of plants make them prone to wind damage also. This method of training is not suitable for high altitude and hot arid place where velocity velocity is high.

2. OPEN CENTRE SYSTEM

In this system, when the plant attain a height of 40 to 50 cm it is is beheaded. From the subsequent vegetative growth, 4-5 branches well scattered, arranged and distributed all around the main stem are selected. The tree, thus, trained attain less height. There is belter interception of light by all the shoots of the tree and all branches are capable of bearing flowers and fruits. This system facilitates easy carrying out of operations like harvesting and spraying on the tree. In this system the plants take a bowl shape which provides a good base for setting for frost. Hence open centre system of training is not suitable for high altitude where frost observance is common.

3. MODIFIED LEADER SYSTEM

This is intermediate form of central leader system and open centre system and draws the benefits of both system. In this system the main stem is allowed to grow for 4 to 5 years. After that the main stem is allowed to 150 cm from ground level. On the main stem the first shoot is selected at a height of 40 cm from the

ground and 4 to 5 branches located at a distance of 15 to 20 cm and placed all around the main stem are selected. The plant trained through this system attain moderate height. All retained branches receive ample light and there is better production on the tree. This is very suitable method and practiced in almost all region. This system facilitates easy carrying out of orchard operations like harvesting and spray of plant protection chemicals, nutrients etc.

SOME SPECIAL METHODS OF TRAINING

1. BUSH SYSTEM

In this system the height of the plant is kept to 2.0 m. during first year the plant is cut a height of 700 cm. no shoot is allowed to row upto a height of 25-30 cm. above this height 3 to 4 branches are allowed to grow over which number of branches emerge out. The plants acquire the shape of bush. The centre of the plant is kepi open. This system is suitable for apple.

2. PYRAMID SYSTEM

In this system the plants are trained in fashion so that the lower branches may remain longer and higher branches gradually smaller. The alternative tiers of horizontal branches radiating from main stem scattered all around gives the plant an appearance of pyramid. The branches are allowed to grow on main stem al 20 cm height from ground level. The plants are pruned from the tip of main stem and branches to maintain pyramid shape.

3. ESPALIER SYSTEM

The word *espalier* is French in origin meaning 'a fence, a fruit wall or paling'. It refers to the support used for training trees especially apples and pears. The tree trained through this system consists of three to six tiers of horizontal branches trained to grow one foot apart from one another at right angles to the main stem. Thus, the branches grow parallel to the ground. In this system, using poles, three to six rows of wires are stretched one above the other. The first row of wire is stretched at a height of 60 to 70 cm, the second row at 130 to 140 cm height and the third row is stretched at a height of 200 cm from ground level. Over these wires the branches of the trees are trained in both the directions parallel to the ground. In this system the line to line distance of the plant is kept less as the plants are grown only in two direction along with wire.

4. CORDON SYSTEM

Cordon refers to closely spurred single stemmed tree tied to a support *e.g.* wires or bamboo canes either in vertical, oblique or horizontal position. This system usually finds favour in apples and pears. The trained plants bear early crop as compared to dwarf pyramid and bush system. The plants are planted at a distance of 1 to 1.5 m. The stem of the plant is tied with wire, The wires of 12 to 13 gauge are fixed to the ground using cement and concrete at 4.5 to 6.0 metre interval. The plants are maintained single stemmed by practicing severe pruning of emerged branches during winter and summer. Depending upon the number of main stem trained along with wire, the system is known as single cordon, double cordon and triple cordon.

TRAINING METHODS FOR GRAPE VINES

1. HEAD SYSTEM

The plants trained through this system develop in a bush shape. During early years the vines require support. Afte 4 to 5 years, the stem becomes sturdy_enough to stand at its own strength. The plants are allowed to grow a height of 75 to 90 crn. At the terminal portion of shoot 5 to 6 side branches are allowed to grow. The growth of side shoots which are one year old is pruned during winter (October in south India. January in north India). On pruned shoot flowers and fruits appear. This system is suitable for legs_ vigorous ciiltivar and very simple and inexpensive. This is practiced in beauty Seedless, Perelette. Delight and Gold etc. cultivar

2. KNIFFIN SYSTEM

This is also known as 4-cane system. In this system two rows of wires are stretched at_a height of 1.05 and 1.65 metre from ground level with help of iron or concrete poles. The vines are cut at a height of 1.65 metre from ground level. Along with both the lines of wire 2 branches of the vines are trained parallel to the ground. Thus, the vines develop 4 arms. This system is suitable for medium_vigorous cultivar. This is practiced in Beauty Seedless, Early Muscat, Banqui-Abyad, Bhokriand Delight etc

3 TELEPHONE SYSTEM/OVERHEAD TRELLIS SYSTEM

This system is also known as 6-cane system. In this system poles are erected at a distance of 3.6 to 4.8 meter. At the terminal end of pole, there is 1.2 m long arm. The arm is drilled with 6 holes. Through these 6 wires

are stretched from one pole to another and the vines are trained over these wires. The vines are allowed to grow'to a height of 1.5 to 1.6 m and then trained Along with the wires.
This system is superior over kniffin system in which lower arm of the cane remain unproductive, in telephone system as all the arms of vines are trained at the same height, hence there is no question of unproductivity of lower vines, further, in telephone system "there is belter penetration of light and good ventilation is there in each and every part of the vine. This system is suitable for moderately vigorous cultivar having more apical dominance.

4. BOWER SYSTEM

This system is well-suited for vigorous cultivar like Anab-e-Shahi. The vines are trained on criss-cross network of wires. To create network of wires, poles are fixed at a distance of 4.5 to 6,0 metre. The poles are 2.1, to 2.4 metre high. Angle irons are fixed through poles to develop a roof like structure. At a distance of 60 cm holes are drilled in angle iron. Through these holes wires are stretched length and width wise to have a criss-cross network of wires. The vines are allowed to grow single stem till it reaches the network of wires. Then it is pinched off to facilitate production of side shoots, Two vigorous shoots in opposite direction are selected at the wire level for training as primary arms. On each primary arm three laterals on either side are selected at 60 cm distance to develop as secondary arms. Each secondary arm is allowed to have 8 to 10 tertiary branches. The tertiary branches form the fruiting cane and covers the entire network of wire. It ismost expensive of all the systems but still practiced at a commercial scale. In tropical climate where the vine grows vigorously and have prominent apical dominance bower system is best suited for training grape vines. This system has many advantages. As.the grape berries remain hidden under canopy of leaves the bird-scaring is prevented. The berries are not desiccated by wind. Due to shade, of vines the weed growth" in' vineyard is smothered. The vine yield more. But this system is costly. Pruning and spraying operation on the trellis becomes difficult.

PRUNING

Judicious removal of pjant part to obtain better and qualitative yield is termed as pruning. pruning is started in later part of plant life when it. becomes capable to produce f!owers anf fruits.

OBJECTIVES OF PRUNING

- To control flowering and frui.ling.
- To augment production in plants which bear on new shoot.
- To obtain regular bearing.
- To remove diseased, damaged insect infested and weak shoots.
- For thinning flowers and fruits.
- *To* ensure access to sunlight to bearing shoots. '
- To invigorate the plants.
- To have a balance between vegetative and reproductive growth.

PRINCIPLES OF PRUNING

- Remove water sprout,
- To remove a shoot completely, it should be removed from the base,
- Avoid bark injury while pruning. To do so the branches of bigger diameter should be cut from downward surface.
- Pruning should be completed well in advance of flowering season.
- In deciduous plant pruning should be done in advance of winter so that low temperature injury may be minimized.
- Apply Bordeaux paste after pruning to avoid incidence of diseases.
- Crowded, interlaccrating, diseased, damaged and insect infested shoot should be removed.

METHODS OF PRUNING

Basically there are **two techniques** which could be utilized individually or in combination depending on the need of the crop

1. HEADING BACK

Removal of terminal portion of shoot leaving basal portion intact is termed as Heading Back.

2. **THINNING OUT**

A few shoots /branches that are considered undesirable are removed entirely without leaving any stub, this operation is called thinning.

3. RINGING OR GRIDLING

In this process a circular ring of bark measuring about 3 cm in length is removed. It hastens bearing by allowing greater accumulation of photosynthesis in upward in upward portion of plant.

4. **NOTCHING**

Making a notch above a bud by removing a wedge shaped piece of bark is termed as notching. It checks the influence of hormone and encourages growth.

5. NICKING

Making a notch below a bud by removing a wedge shaped piece of bark is termed as nicking. This ensures a accumulation of carbohydrates from the leaves to the bud and may result in the formulation of fruit bud.

6. THINING

Selective and complete removal of part of the plant is termed as thinning.

SOWING OF SEED:

The seeds of fruit plants are sown in the prepared nursery beds directly 01 in polybag. The sowing should be done in Hue with maintain the proper spacing {15 x 10 cm) and 2-3 cm deep. The depth of the seed should not keep more. In shallow planting, it will not able to draw the moisture. Seed should cover with thick layer of sand .and leaf mould mixture to prevent crust formation. After sowing the seeds regular water is applied to nursery beds by watering cans both time in morning and evening. In winter, the frequency of water can be reduced but in summer, watering is applied frequently.

For better germination of seeds chemical treatment by GA 1000 ppm or thiourea 0.5% for 12-24 hours before solving is given. The hard seed coat seeds are **also** treated with concentrated H_2SO_4 and NaOH for duration of 5-8 minutes.

Seeds are sown in raised seedbeds 15-20 cm above the ground, leve). It should 1,25 to 1.5 m wide "and 2-2.5 m in length. When the germinated seedlings reached the height of 10-15 cm they are transplanted in well prepared nursery beds at the distance 30x30 cm or 45 x 45 cm spacing. The seedlings of deciduous fruit plants are transplanted in December and January; however, seedlings of evergreen plants are in February-March and August-September.

Raising the- seedlings in poly bags:

The seedling raised in polythene (22.ii x 15 cm of 100 gauge) bags are more economic and convenient 'than the traditional method. These polythene bags are filled with equal proportion of FYM, soil and sand. In polythene bag 4-5 holes are make for drainage the excess water from it. After germination, only one seed is retained and other should remove from the bag.