Modifications Of Roots

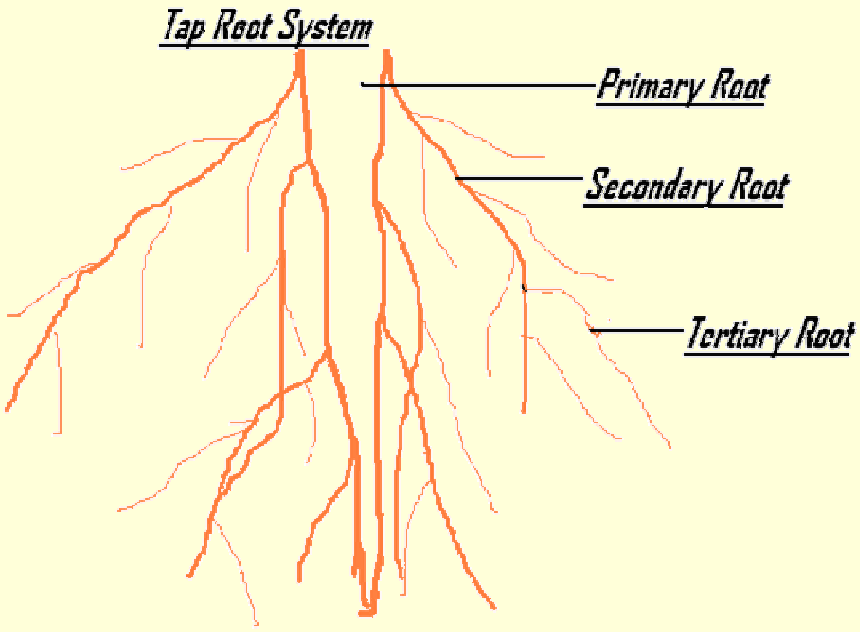
And

Vegetative Propagation

Characteristics of a root

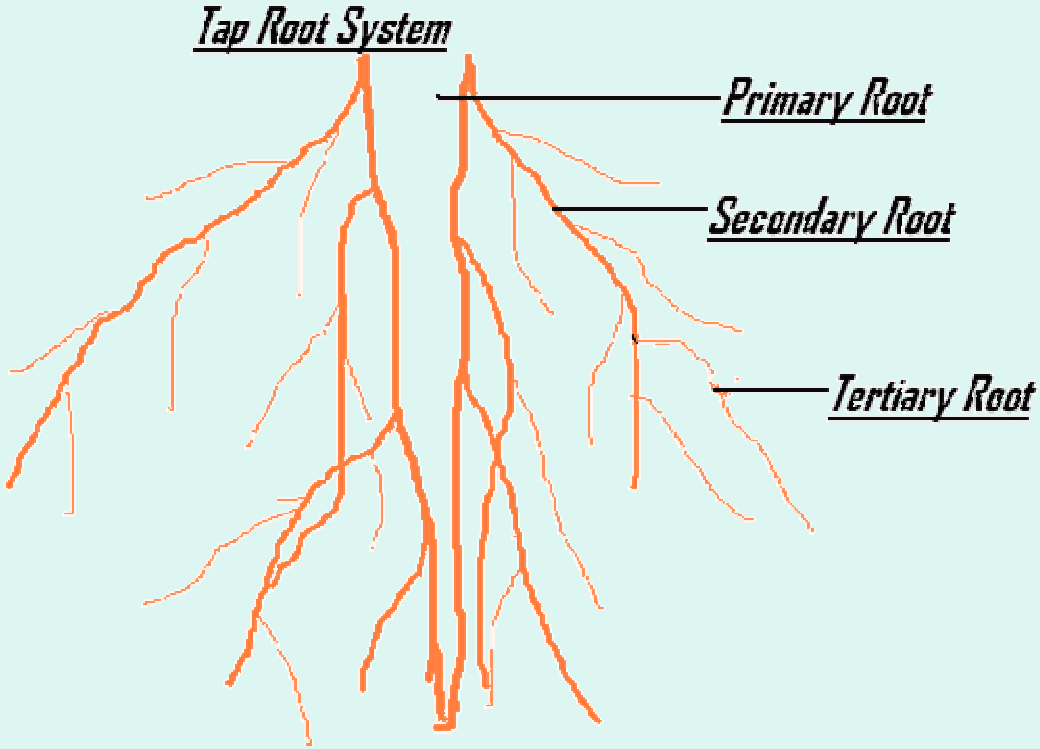
- The root is the underground, non-green part of the plant.
- It grows from the radicle of the embryo of seed.
- It grows into the soil away from sunlight.

Parts of a root

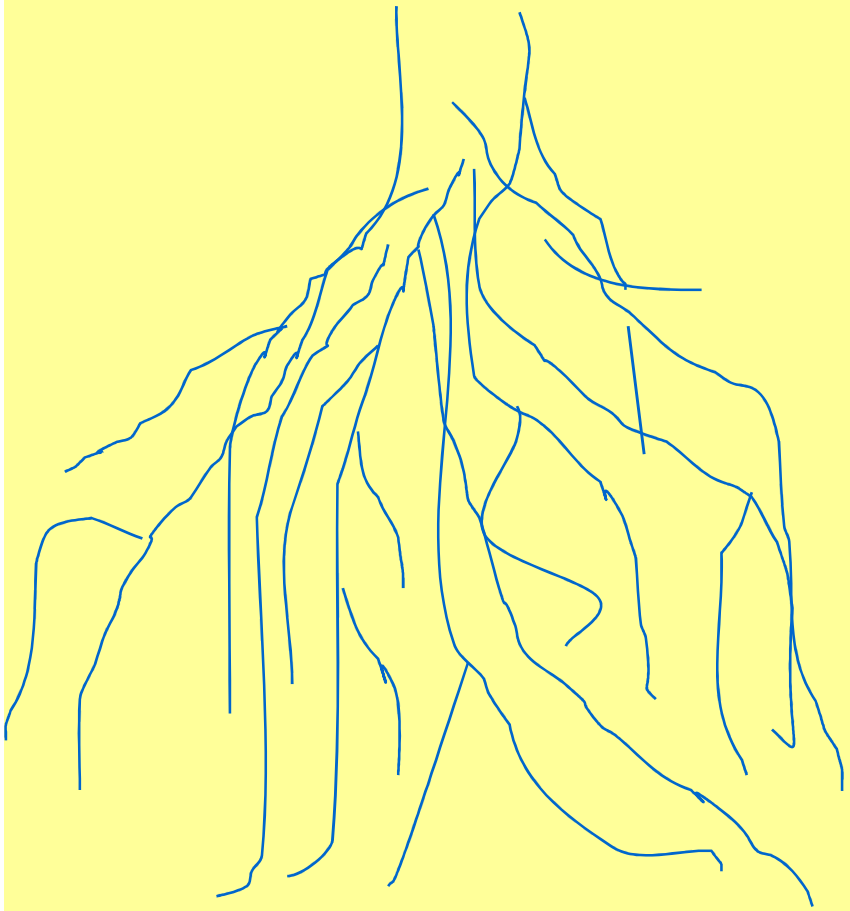


- When a dicot seed germinate, the radicle gives rise to a long deep-seated root. This is called Primary Root
- The primary roots get divided into branches which are known as Secondary Roots

Types of a root



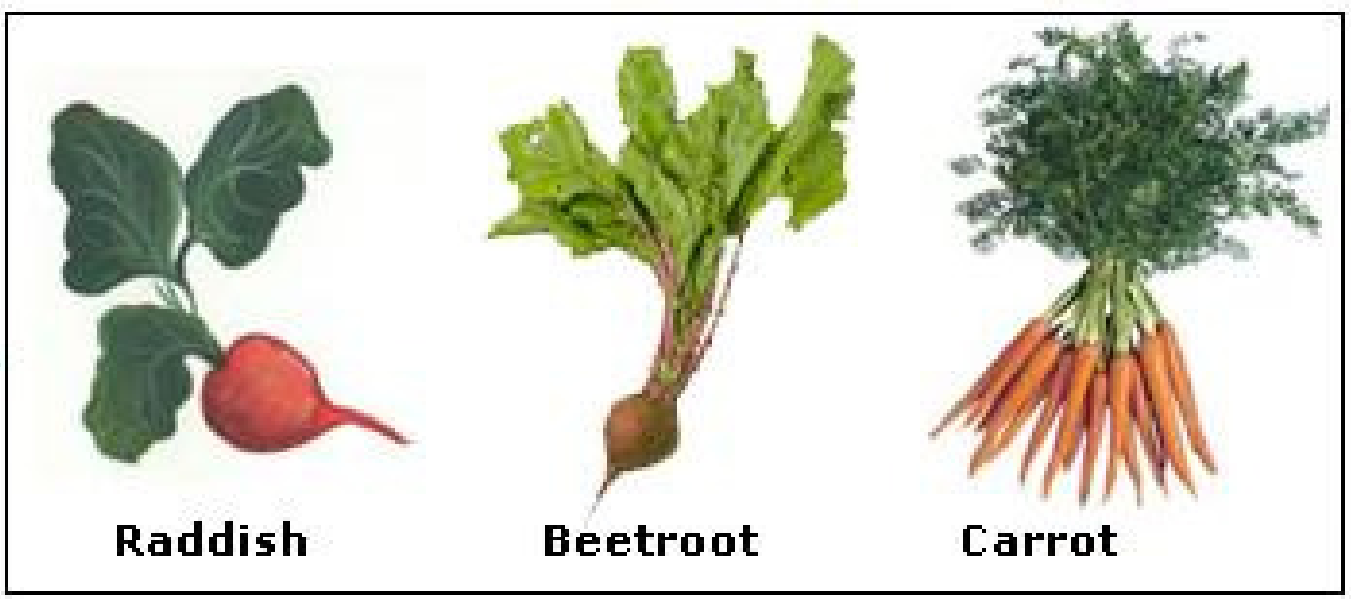
- TAP ROOT SYSTEM.
- IT consists of a single main primary root with lateral branches arising from it.
- Long primary root grows vertically downward into the soil.
- IT is found in dicot plants like castor, pea, mango, gram and beans.



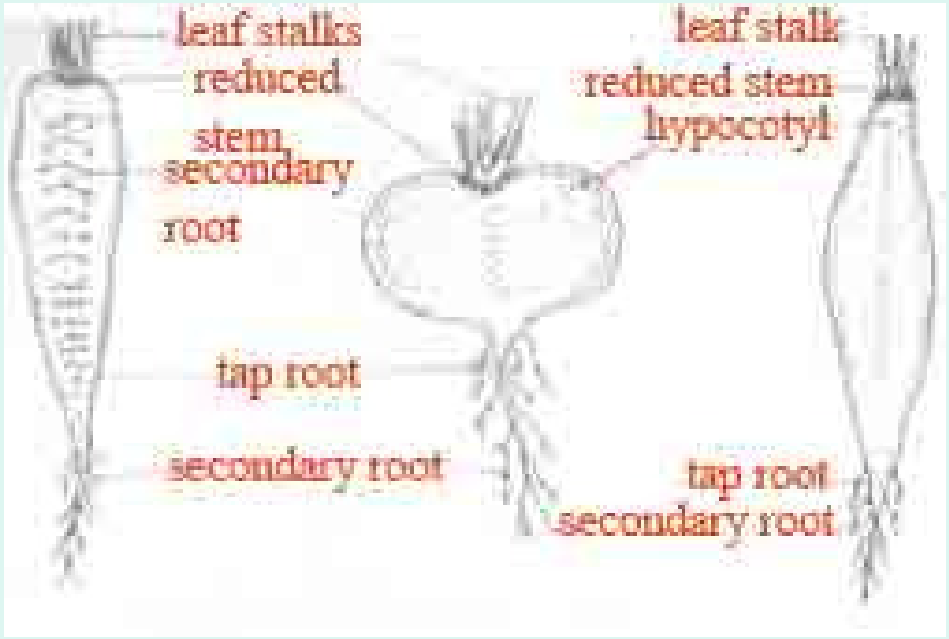
- FIBROUS ROOT SYSTEM

- IN the fibrous root the primary root is short lived and is replaced after some time by a clusters of thin fibre-like roots.
- They spread out in the soil give firm support to the plant
- They are found in monocot plants like wheat, maize, rice, grasses.

Underground roots for storage		Aerial roots for various functions
Tap roots	Adventitious roots	
1. Fusiform root e.g., Raddish 2. Napiform root e.g., Beetroot 3. Conical root e.g., Carrot	1. Tuberous roots e.g., Sweet potato 2. Fasciculated roots e.g., Dahlia 3. Nodulose roots e.g., Mangoginger 4. Moniliform root e.g., Momordica 5. Annulated roots e.g., Ipecacuanha	A. For mechanical support 1. Prot roots e.g., Banyan 2. Stilt roots e.g., Pandanus 3. Climbing roots e.g., Betel B. Sucking roots e.g., Cuscuta C. Respiratory roots - Pneumatophores e.g., Aricennia D. Floating roots e.g., Jussiea E. Epiphytic roots e.g., Vanda



Tap Root Modifications


leaf stalks
reduced
stem
secondary
root
tap root
secondary root
leaf stalk
reduced stem
hypocotyl
tap root
secondary root

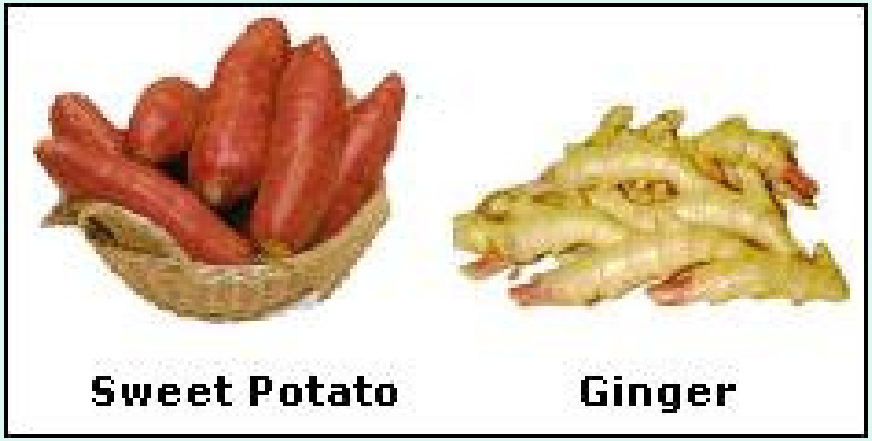
Modification of adventitious root

Tuberous roots are without any definite shape; example:Sweet potato.
Fasciculated root (tuberous root) occur in clusters at the base of the stem; example: asparagus, dahlia.

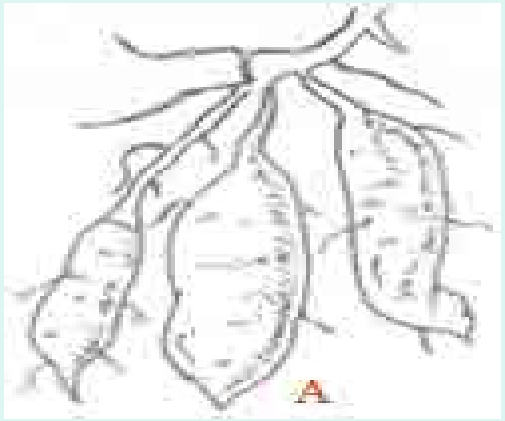
Nodulose roots become swollen near the tips; example: turmeric.

Stilt roots arise from the first few nodes of the stem. These penetrate obliquely down in to the soil and give support to the plant; example: maize, sugarcane.

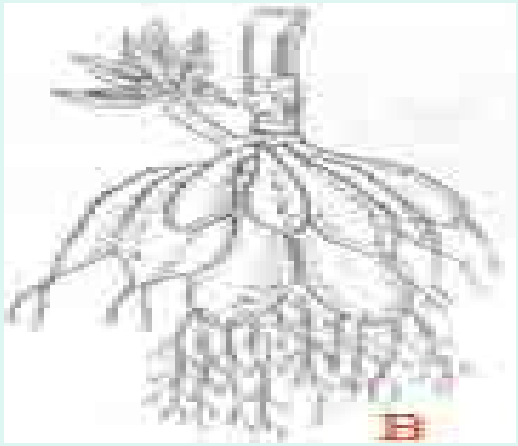
Prop roots give mechanical support to the aerial branches. The lateral branches grow vertically downward into the soil and acts as pillars; example: banyan



Modified Adventitious Roots (for storage of food)

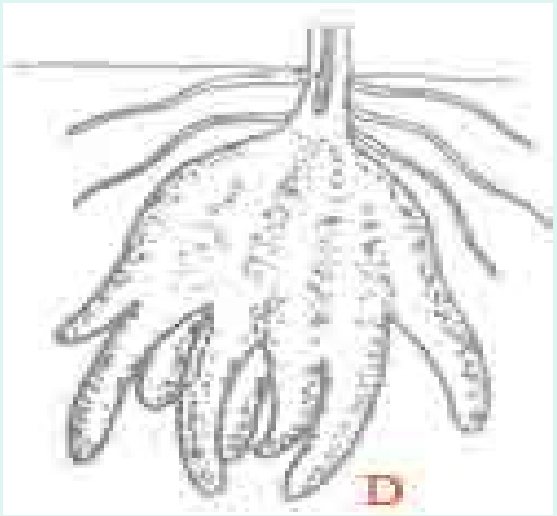


Tuberous Roots of Sweet Potato



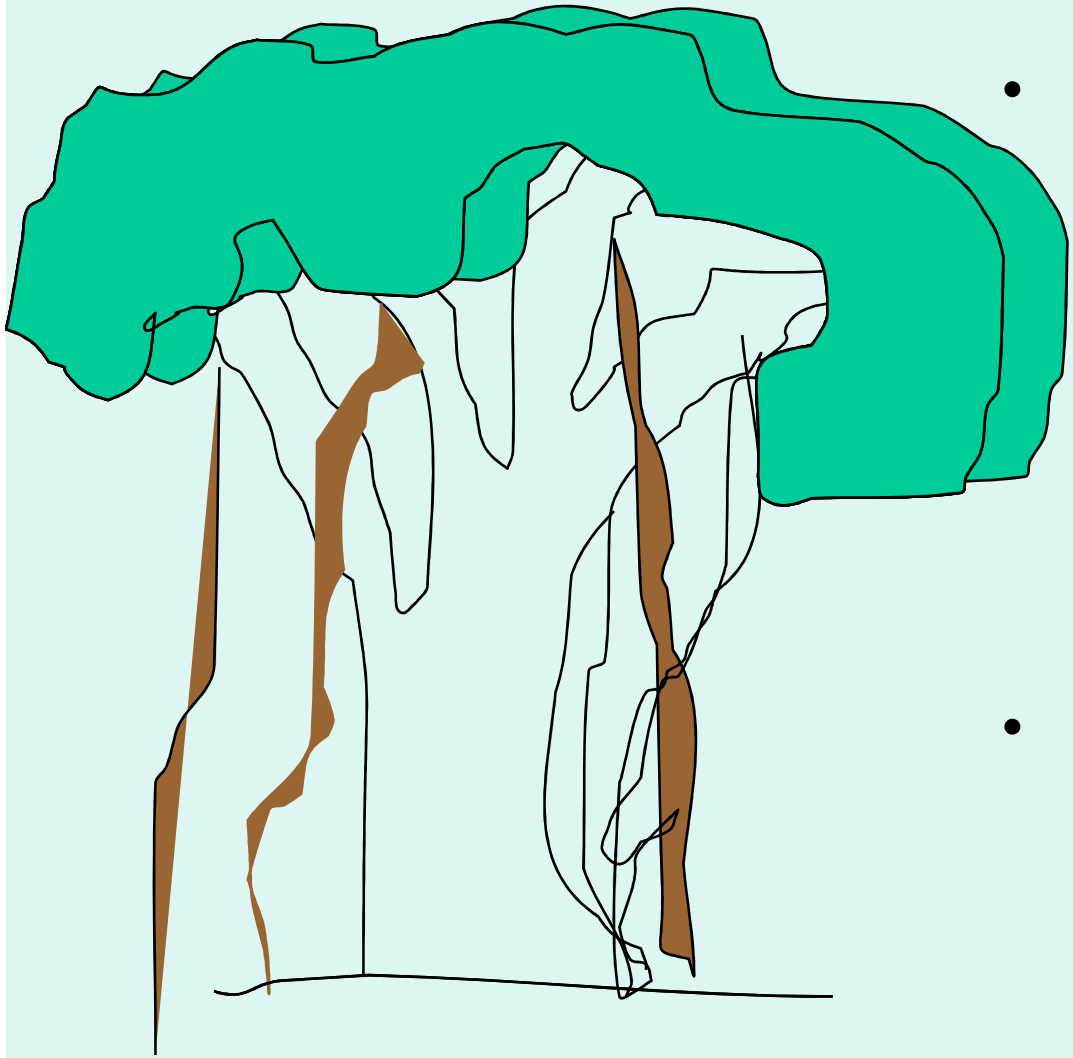
Fasciculated Roots of Dahlia

Annulated Root

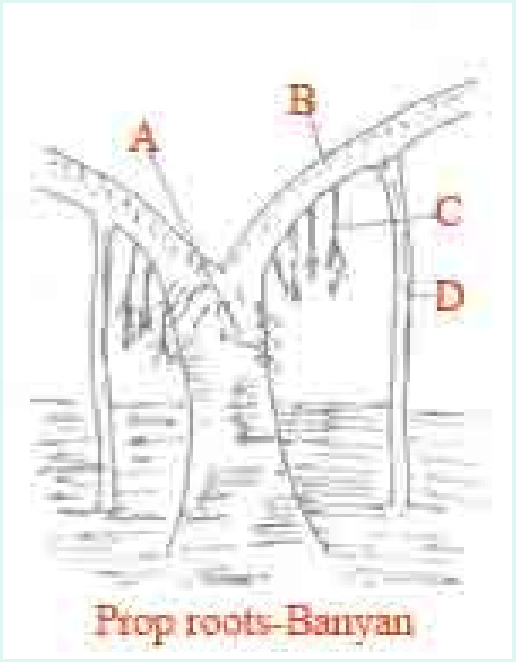


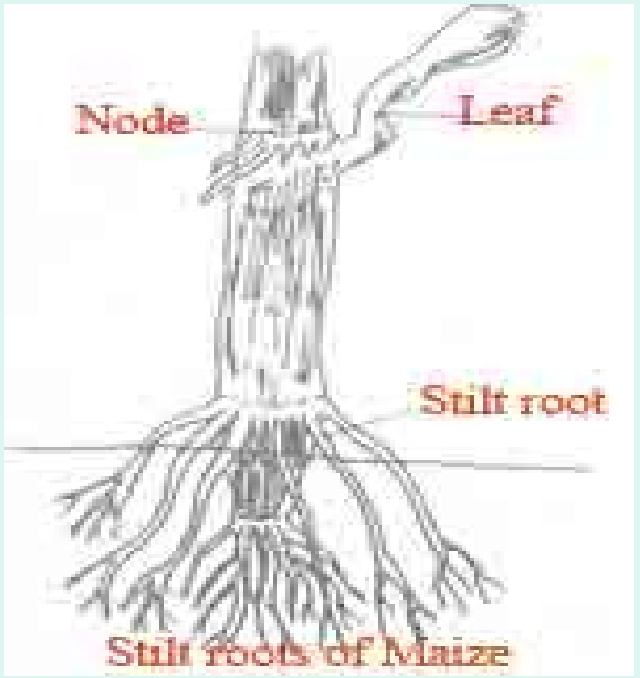
Palmate Tuberous Roots of an Orchid

SUPPORTING ROOTS

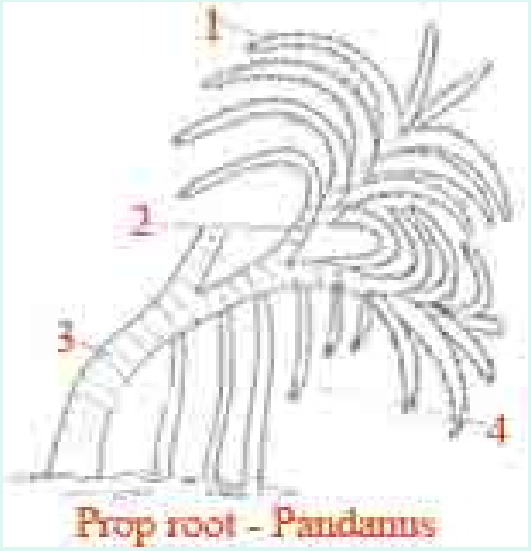


- In some plants such as the banyan tree the Indian rubber plant, roots arise from the horizontal branches of the stem and grow towards the soil. On touching the soil they penetrate into it and act as pillars. These pillar like
- Roots are called prop roots. They support the heavy branches of the tree.

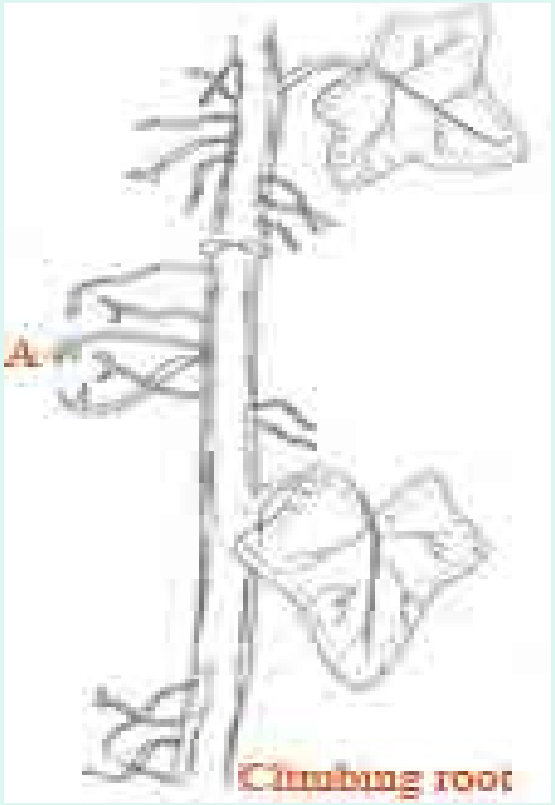




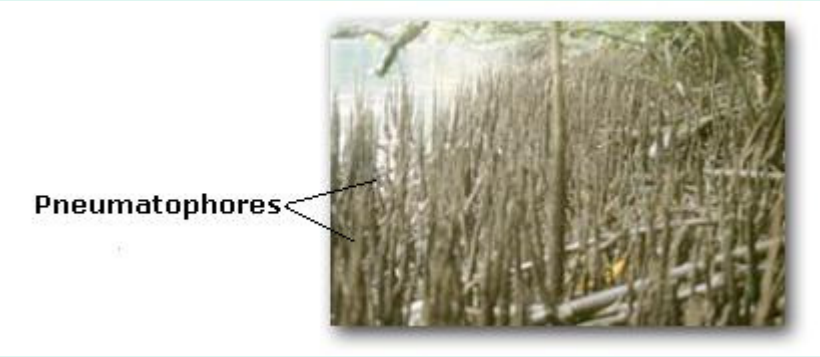
A. Main Tree Trunk
B. Branch of Tree Trunk
C. Aerial Root
D. Prop Root



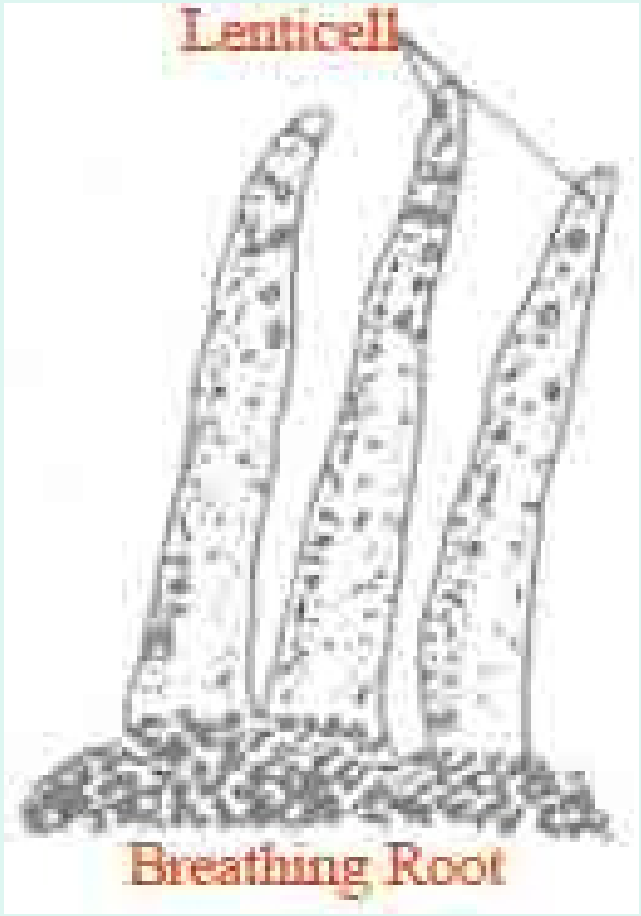
1. Leaf
2. Main Trunk Branch
3. Main Trunk Tilted
4. Multiple Root Cap



Modified Adventitious Roots (for mechanical support)

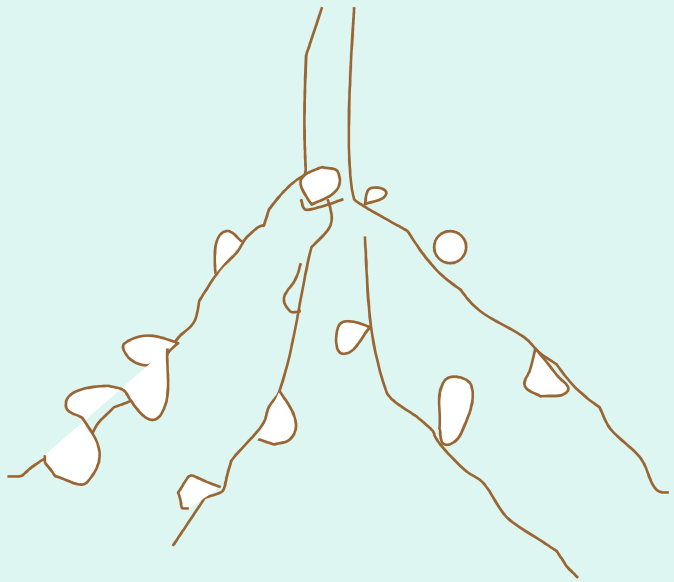


Pneumatophores


Lenticell
Breathing Root

NODULATED ROOTS

- Peas, beans, groundnuts, moong, urad and gram are a few examples of plants that possess nodulated roots. These plants are called leguminous plants.



Roots Modified for Vital Functions

1. Epiphytic roots or Hygroscopic roots

These adventitious roots are found in some orchids that grow as epiphytes on tree trunks. These specialised roots are whitish and thickened having a sponge like tissue called velamen. It helps in absorbing and storing water e.g. Vanda.

2. Assimilatory roots

These are chlorophyll containing green roots performing photosynthesis. e.g. Trapa, Tinospora etc.

3. Parasitic roots/Haustoria

These roots are seen in non-green parasitic plants unable to manufacture food of their own. These roots penetrate the host tissue and enter its conducting system to absorb the food required e.g. Cuscuta, Orobanche, Viscum etc.

4. Reproductive roots

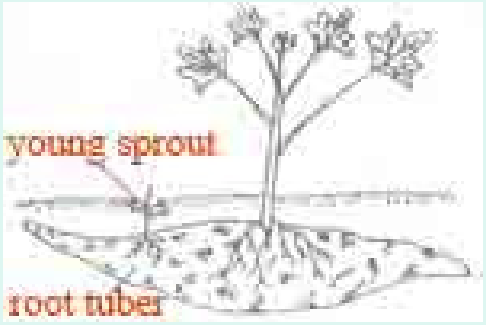
Many roots e.g. in sweet potato, develop buds to form leafy shoots that later serve as a means of propagation

5. Mycorrhizal roots

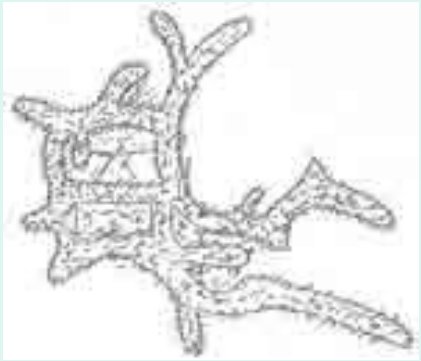
In plants like Pinus and Monotrapa, roots become associated with fungal hyphae helps to absorb water and minerals from soil and gets the supply of organic food from the roots.

Aerial Epiphytic Roots of an Orchid

Parasitic Roots of Cuscuta



Reproductive Roots of Sweet Potato



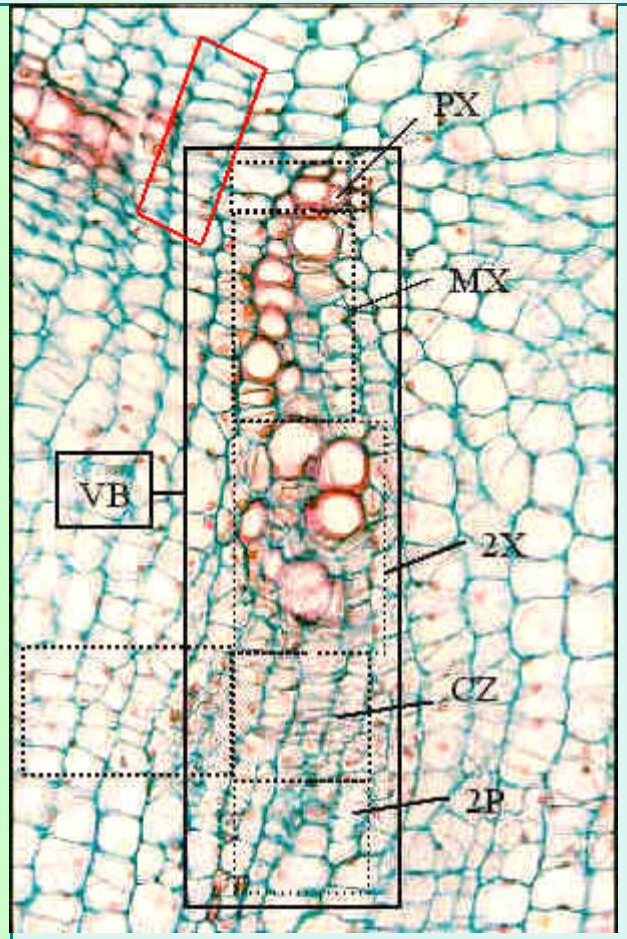
Pinus Rootlets invested with Mycorrhizal Fungus

Beta TS mature root

The root of *Beta* shows anomalous secondary growth patterns. This is evidenced by the formation of successive supernumerary cambia each of which gives rise to a ring of vascular bundles and wide zones of parenchymatous tissue between these bundles. Note that the successive bundles are arranged more-or-less along the same radius as preceding ones.

Beta vulgaris - the beetroot

This cross-section shows a portion of one vascular bundle in the beetroot. The centre of the root is uppermost. The vascular bundle contains protoxylem (PX), which is associated with the metaxylem (MX). Some secondary xylem (2X) is visible next to the fascicular and interfascicular cambia (CZ). secondary phloem (2P) occurs near the bottom of this micrograph. Looks normal so far correct? Well, now look at the cells outlined in the red box at top left. Look familiar? They should - this is cambial tissue as well. Now what? Obviously, the beetroot produces multiple supernumerary cambia. As a result, the vascular system it forms shows anomalous secondary growth patterns.



Methods Of Vegetative Propagation

Vegetative reproduction (vegetative propagation, vegetative multiplication, vegetative cloning) is a form of asexual reproduction in plants. It is a process by which new individuals arise without production of seeds or spores. It can occur naturally or be induced by horticulturists.

Success rates and difficulty of propagation vary greatly. For example willow and coleus can be propagated merely by inserting a stem in water or moist soil. On the other hand, monocotyledons, unlike dicotyledons, typically lack a vascular cambium and therefore are harder to propagate

Although most plants normally reproduce sexually, many have the ability for vegetative propagation, or can be vegetatively propagated if small pieces are subjected to chemical (hormonal) treatments. This is because meristematic cells that are capable of differentiating are present in many plant tissues

There are mainly two types of vegetative propagation :

1. **Natural Vegetative Propagation**
2. **Artificial Vegetative Propagation**

Natural Methods

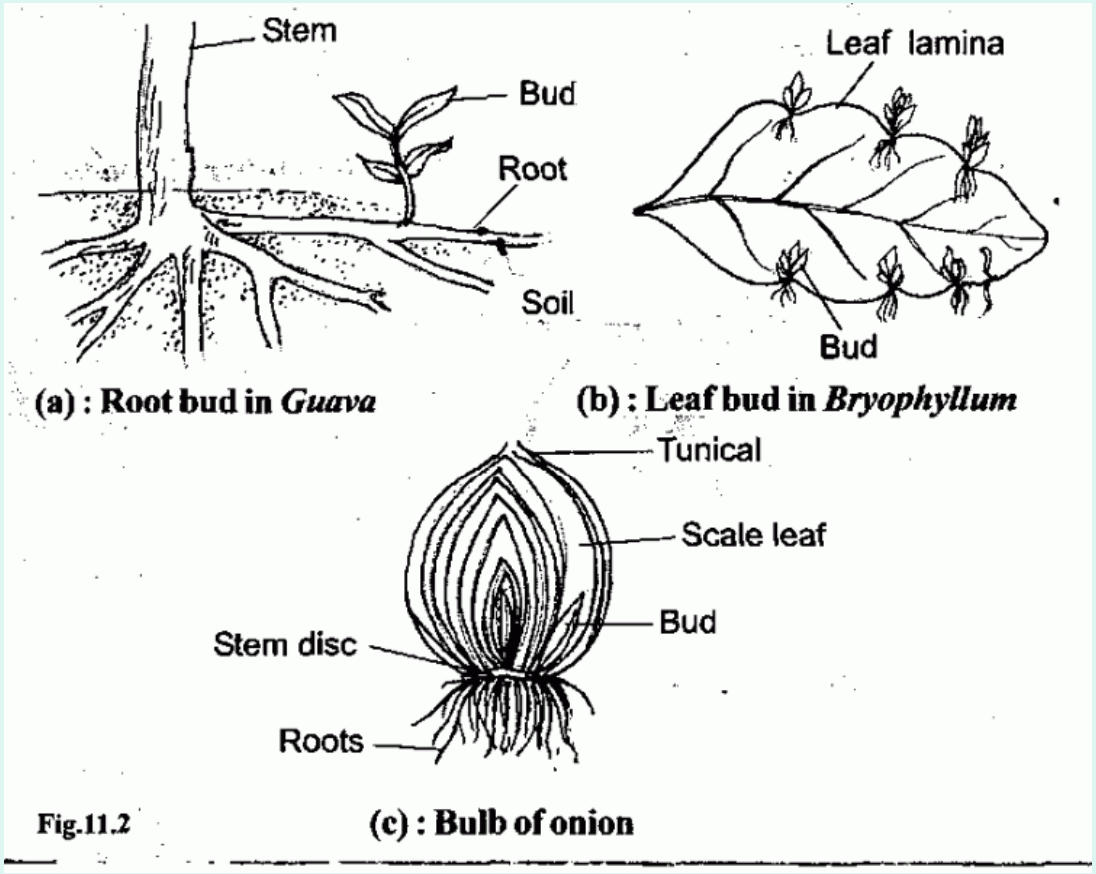
Natural vegetative reproduction is mostly a process found in herbaceous and woody perennial plants, and typically involves structural modifications of the stem, although any horizontal, underground part of a plant (whether stem or a root) can contribute to vegetative reproduction of a plant. And, in a few species (such as *Kalanchoë*), leaves are involved in vegetative reproduction.

There are many angiosperms and some gymnosperms in which the vegetative parts like roots, stems and leaves get modified to store food and act as organs of perennation, as these organs can remain viable even if the entire plant appears to have died in unfavourable conditions.

Roots : Some plants (guava, mint) produce adventitious buds. These buds develop into new plantlets under favourable conditions.

Root Tuber is nothing but the tuberous root e.g., carrot, radish (tap root modified), sweet potato (adventitious roots modified, Dahlia, Asparagus (adventitious roots modified, mostly singles);

Leaves : Some plants, especially mature fleshy leaves, develop adventitious buds at the margins e.g. Bryophyllum.



(a) : **Root bud in *Guava***

(b) : **Leaf bud in *Bryophyllum***

Fig.11.2

(c) : **Bulb of onion**

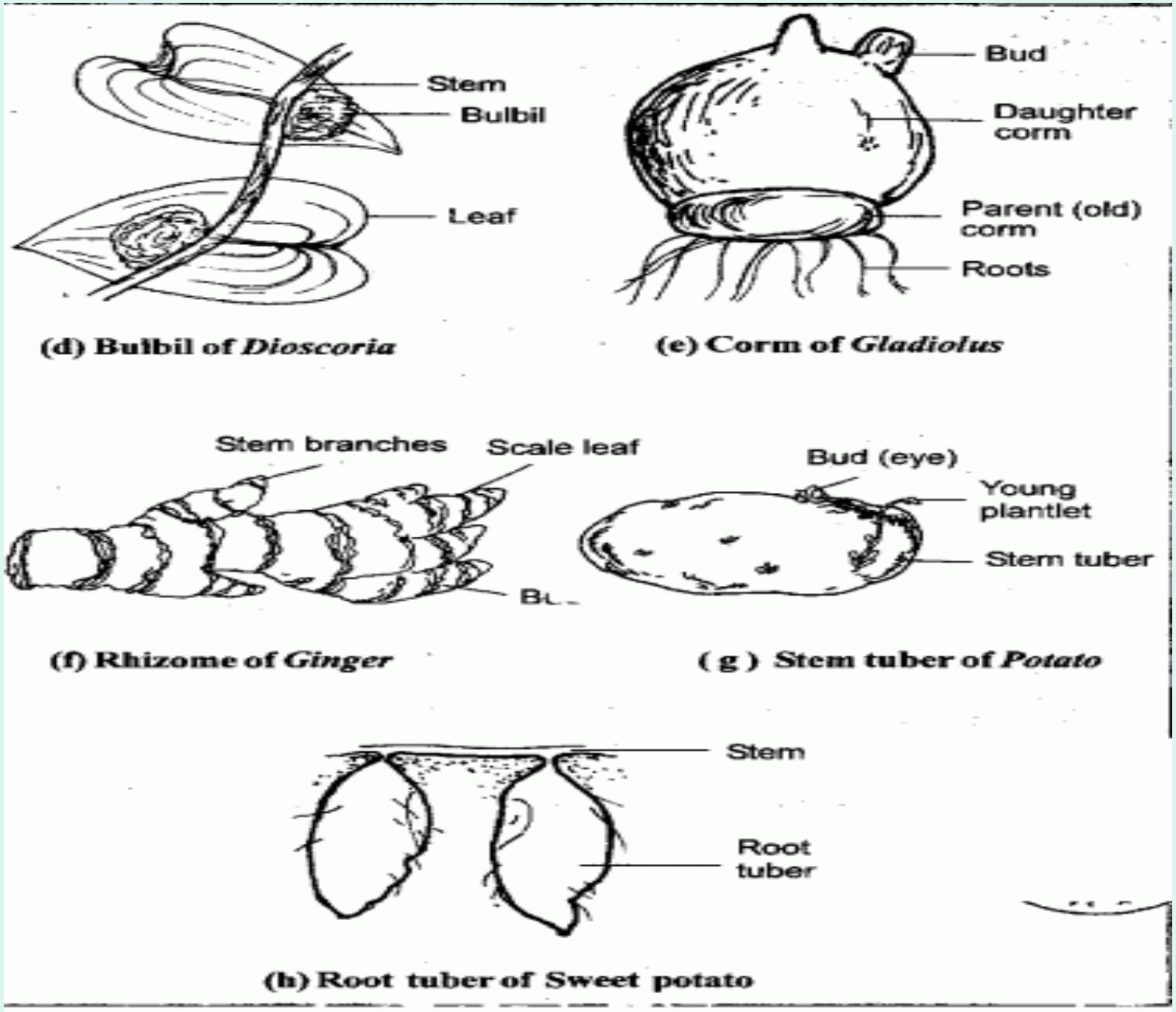


Fig. 11.2 : Methods of asexual reproduction in higher plants [Natural methods including organs of propagation and perennation]

Stems : Stems in many plaints, are modified into (i) different perennating organs capable of vegetative propagation or (ii) simply organs of vegetative propagation

These are all modified forms of stem. Plants remain alive during unfavourable conditions in these forms, although their aerial parts may die.

(a) Underground Modifications

Bulb g; onion, garlic; there is a small, flattened and condensed stem with roots, and fleshy, scale leaves; dried outer scale leaves form a /amcfl(covering); green, cylindrical, elongated leaves are produced later from the buds in the axils of scale leaves.

Corm e.g., Gladiolus it has a short, stout, vertical modified underground stem with some scaly leaves and adventitious roots.

Rhizome e.g., Ginger, Turmeric these plants have a modified underground stem that grows almost horizontally / obliquely, with scale leaves and adventitious roots produced from the nodes. Ferns produce obliquely growing rhizomes (called caudex or root-stock)-, these are mostly dark in colour and often hard.

Tuber e g., Potato; it has a swollen stem produced at the tip of some underground branch or branch near the ground, each with 'eyes' produced at the nodes (seen as small depressions), eyes have scale leaves; new plants can develop from each 'eye.'

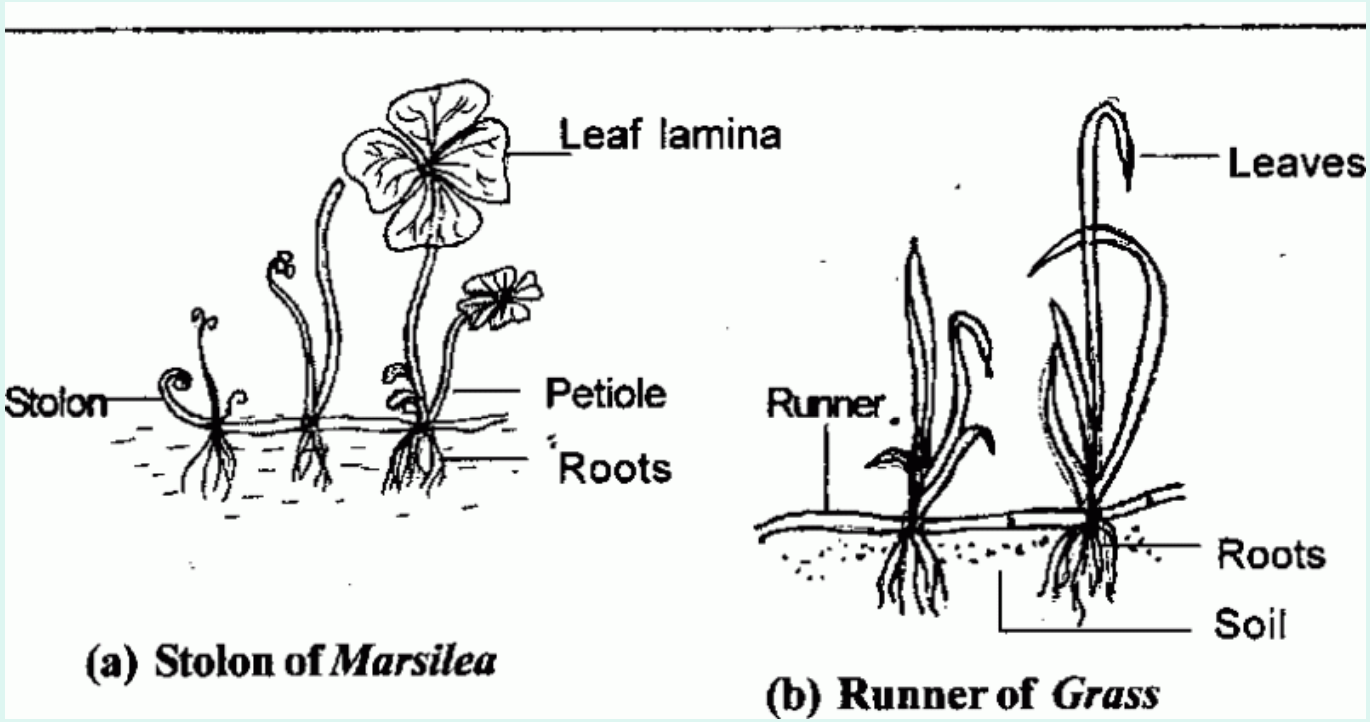
Other examples of modified stems include aerial modifications

Bulbils **e.g., Dioscoria (mataaloo, an angiosperm), Cycas (a gymnosperm); small swollen shoots at the nodes of the aerial parts of stem, capable of producing new plants.**

Tillers **e.g., grasses; a collection of aerial shoots produced by grasses before they produce flowers. A tiller arises at the node, almost at the soil level and consists of a number of leaves.**
These are the organs of perennation and vegetative propagation.

(B) Organs of Vegetative Propagation (Fig.11.3)

There are some plants in which shoot is modified into different structures to carry on only vegetative propagation, like, stolons, suckers, runners and offsets etc., that do not store food (so no perennation) as such, but carry out vegetative propagation under normal conditions. The shoot is differentiated into nodes and internodes. They produce leaves (from upper surface) and adventitious roots (from lower surface) in tufts at the nodes.


Leaf lamina
Stolon
Petiole
Roots
(a) Stolon of *Marsilea*
Leaves
Runner
Roots
Soil
(b) Runner of *Grass*

Stolon :It is a creeping, thin, somewhat fleshy, green branch produced from the lower nodes of the stem at the soil level. In those plants that develop stolons, there is no erect stem. Many such stolons can develop from a single plant and spread in different directions e.g., Mentha, blackberry, Marsilea.

Runner: It is like a stolon but comparatively thin and wiry, produced similarly, runners can bring about a very successful and rapid method of vegetative propagation e.g., most grasses, strawberry.

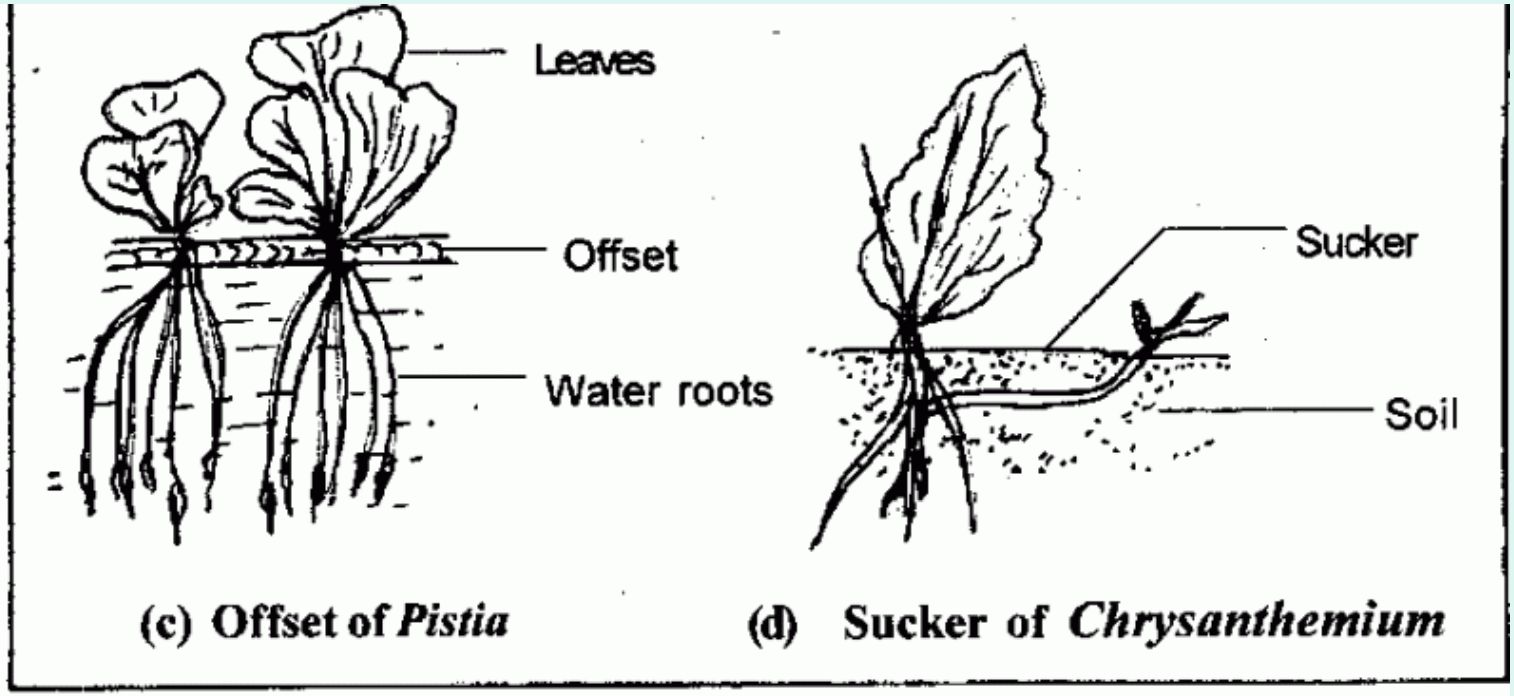


Fig. 11.3 : Methods of asexual reproduction in plants [Modification of shoot]

Offset: It is a specialized fleshy branch similar to stolon in aquatic, free floating plants with similar morphology. They grow on the surface of water e.g., Pistia, Eichhornia.

Suckers : There are the branches produced at the nodes from the rhizomatous part of the underground stem. These branches usually grow under the soil for some distance before they come out of the soil near or away from the plant e.g., banana, Canna, Chrysanthemum.

Artificial vegetative propagation

It is very common practice to vegetatively propagate cultivars that have desirable characteristics. Man-made methods of vegetative reproduction are usually enhancements of natural processes, but range from rooting cuttings to grafting and artificial propagation by laboratory tissue culture.

Several methods of vegetative propagation are man-made and developed by plant growers and Horticulturists for commercial production of crops. They are called artificial methods. They also include several natural methods of propagation such as use of potato tubers for growing potato crops commercially. Similarly, rhizomes of ginger, corms of banana, bulbs of onion, runners of mint, etc. are artificially used for commercial production of these crops. Some of the artificial methods are given below -

(a)Cuttings. **The small piece of any plant organ (stem, root or leaf) used for propagation is called cutting. Leaf cuttings are used to propagate *Sansevieria, Begonia, Bryophyllum, Glocinia* and *Kalanchoe.* Root cuttings are used to propagate *Citron* and *Tamarind.* Stem cuttings are most commonly used for artificial vegetative propagation. About 20-30 cm long pieces of stem are planted in the natural position in the soil for proper sprouting. Factors such as age of the parent plant, length and diameter of the cutting, season and the type of plans are taken into consideration for the propagation of a particular species. Sometimes the stem cuttings are treated with rooting hormone (IBA) for proper development of roots. Examples are plants propagated by cuttings are - Grapes, Sugarcane (Fig. 1.14), Rose,*Bougainville***

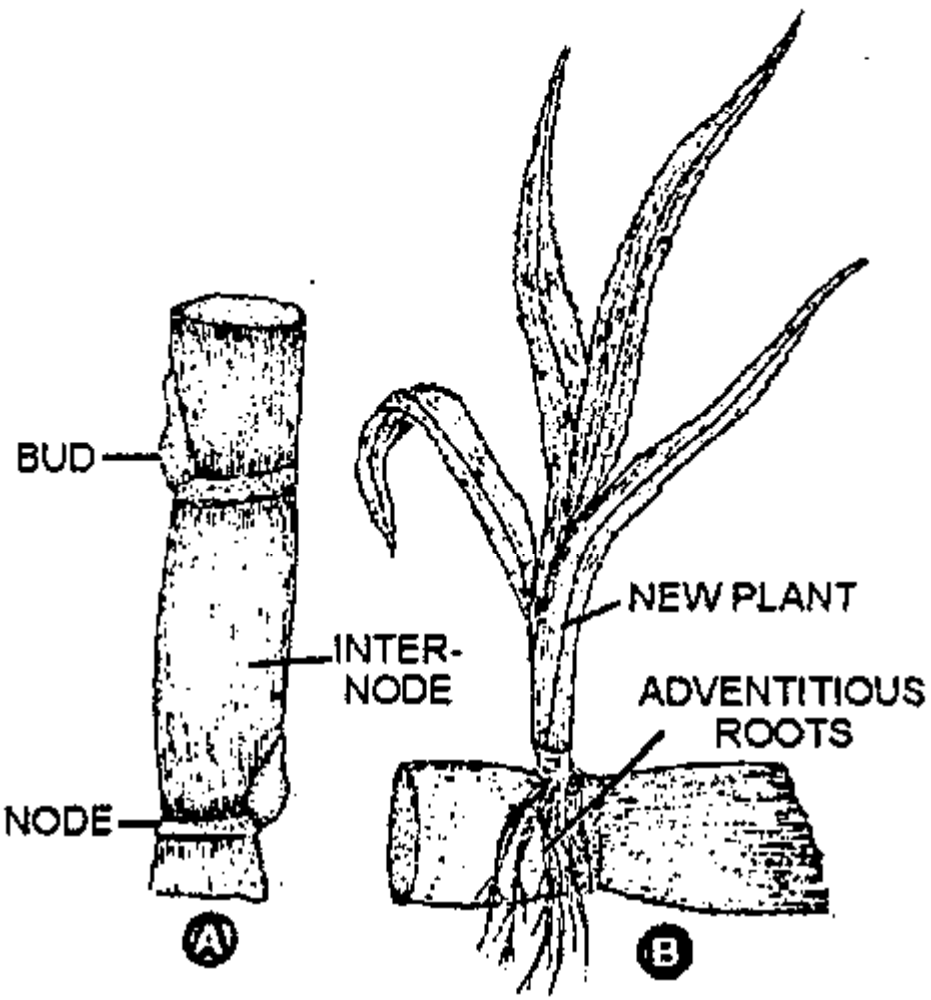


FIGURE 1.14. A. a portion of sugarcane stem having buds; B. a bud growing into new plant.

b) Layering. In this method, roots are artificially induced on the stem branches before they are detached from the parent plant for propagation.

There are two common types of layering

(/) Mound layering (Fig. 1.15). It is the most common' method of propagating herbaceous plants. In this method, the lower branch of stem is bent down and partially defoliated. An injury is made in the defoliated portion. The injured and defoliated portion is covered with a light layer of moist soil in such a way that the growing tip of the branch remains above the soil surface. After a few days the pegged portion develops adventitious roots. The rooted branch is then cut, separated from parent plant and grown into a new plant. Examples - Jasmine, Grape vine, Strawberry, Raspberry, Cherry, etc.

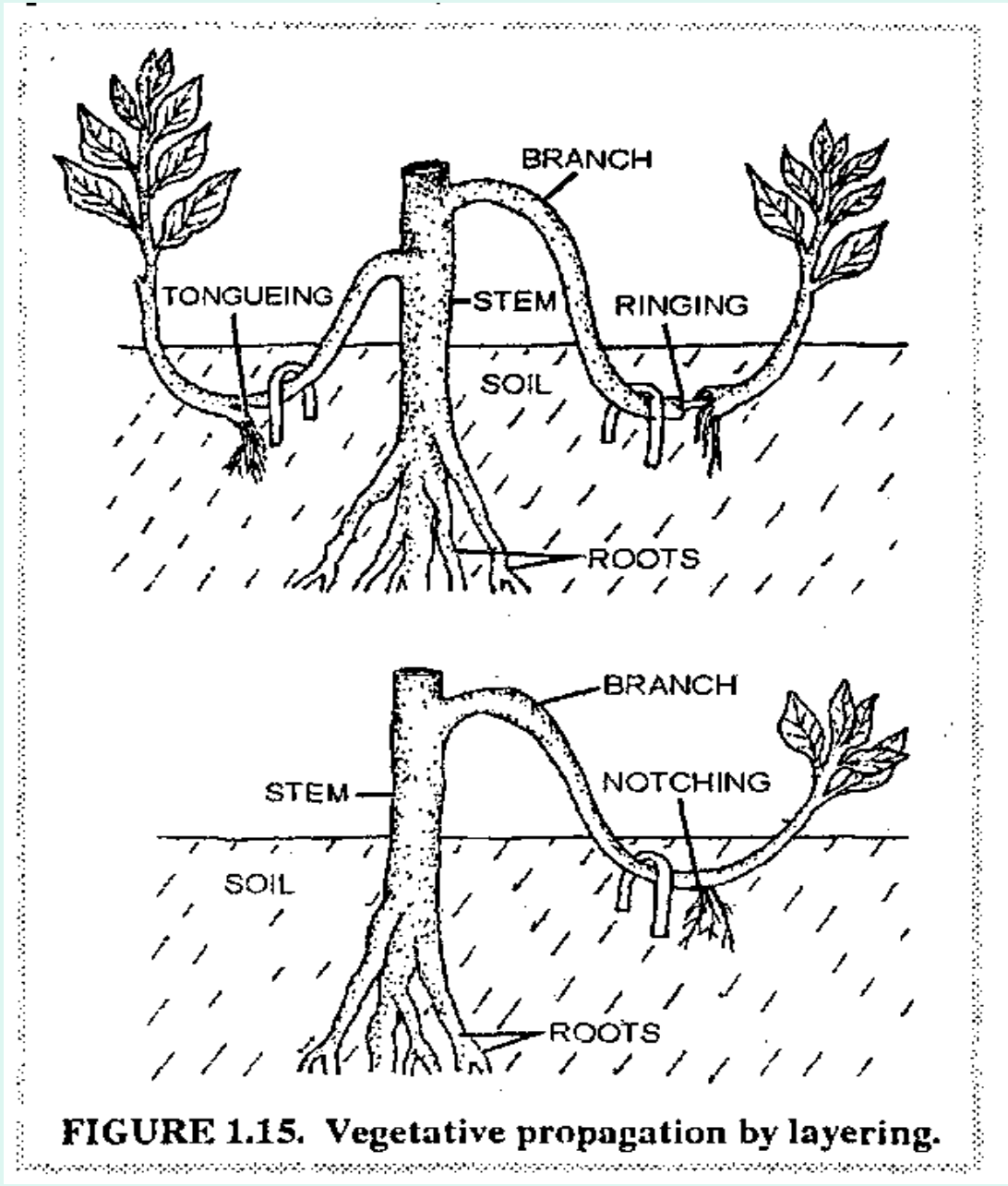


FIGURE 1.15. Vegetative propagation by layering.

***(ii)* Air layering (or Gootee)** **(Fig. 1.16).**

This method is commonly employed in case of shrubs and trees which do not possess branches near the ground. In this method, a ring of bark is removed (girdled) or a slit at an upward angle is made at the base of an aerial branch. The girdled portion is then covered with moist moss or grafting clay (2 parts clay, 1 part cow dung, some pieces of hay, cotton and water) and wrapped with a polythene sheet. The wrapped portion is called gootee. The girdled portion of the branch inside the gootee develops roots within a period of a month or two. Now the branch is cut and planted in the soil after removing the polythene. This method is used in vegetative propagation of Litchi, Pomegranate, Orange, Lemon, Lokat, *Bougainvillia,* etc.

***(c)* Grafting**

. It is the most common method of vegetative propagation described by ancient gardeners long before the science of horticulture became established. In this method, parts of two plants are joined in such a way that they grow as one plant. Grafting is done between the two closely related dicotyledonous plants having vascular cambia.

The rooted supporting portion of one plant, called Stock is joined with a twig of another plant called Scion. Generally, the root stock belongs to a wild variety which is resistant to diseases and pests and possess an efficient root system for absorption of water and minerals. The scion is derived from the plant possessing better characters. For example, a scion of Dussehri Mango is grafted on the stock of Desi Mango. Similarly, scion of high quality roses are grafted on wild rose root stocks.

During grafting, about 4-12 inches long scion with all the buds intact is placed on the cut end of the stock and the joint is covered with a layer of wax or clay to prevent the evaporation of water or entry of pathogen. All the buds of rooted stock must be removed. Within a few days, the scion and the stock become the composite plant.

Grafting is of four types –

(i) Tongue or Whip grafting,
***(ii)* Wedge grafting,**
***(iii)* Crown grafting and**
***(iv)* Side grafting.**

In case of tongue and wedge graftings, the scion and stock have almost the same diameter whereas in case of crown and side graftings, the stock has more diameter than the scion.

(i) Tongue or Whip grafting (Fig. 1.17). Both the stock and scion are cut obliquely at about the same angle.

***(ii)* Wedge grafting (Fig. 1.18). A V-shaped notch is made on stock and a wedge-shaped cut is made on scion.**

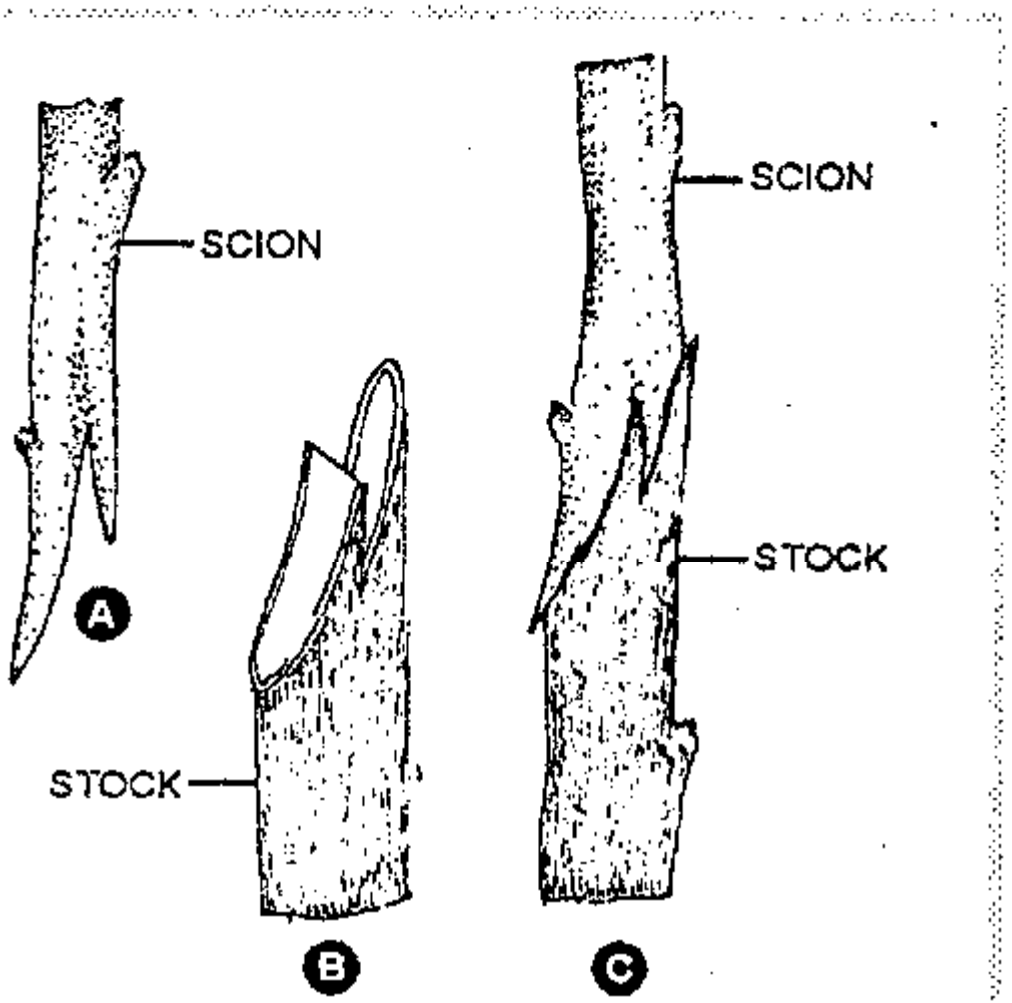


FIGURE 1.17. Tongue or whip grafting.

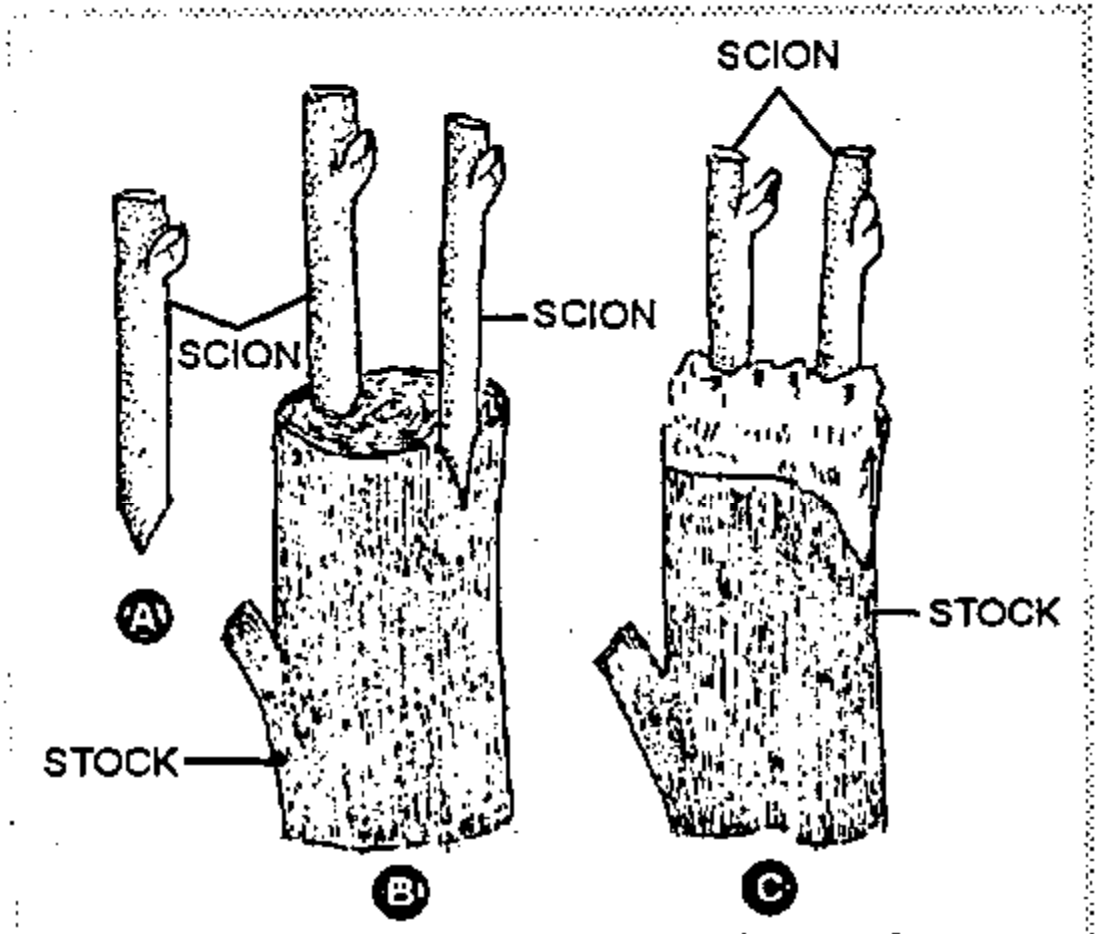


FIGURE 1.18. Crown or wedge-grafting.

iii) **Crown grafting. Several scions having wedge-shaped cut are grafted on the slits at the top of stock.**

(iv) Side grafting. Single scion having wedge-shaped cut is inserted in a lateral slit of the stock.

Examples of the plants propagated by grafting are - Mango, Roses, Apple, Rubber, *Citrus,* Pear, Plum, Peach, etc.

(d) Bud Grafting (Fig. 1.19).

This method is similar to grafting except that scion in this case consists of a bud along with a small portion of bark having intact cambium. The living tissue of scion bud is inserted into an incision made in the stock so that it reaches upto the cambium of stock. The bud portion should remain exposed outside in the air. The'joint is thoroughly sealed using bandage. The complete operation of bud grafting should be performed during the rainy season to ensure survival of the bud. After 3-5 weeks, the bud begins to grow. As soon as the bud sprouts, the stock is cut above the level of graft, *e.g.,* Rose, Apple, Peach, etc.

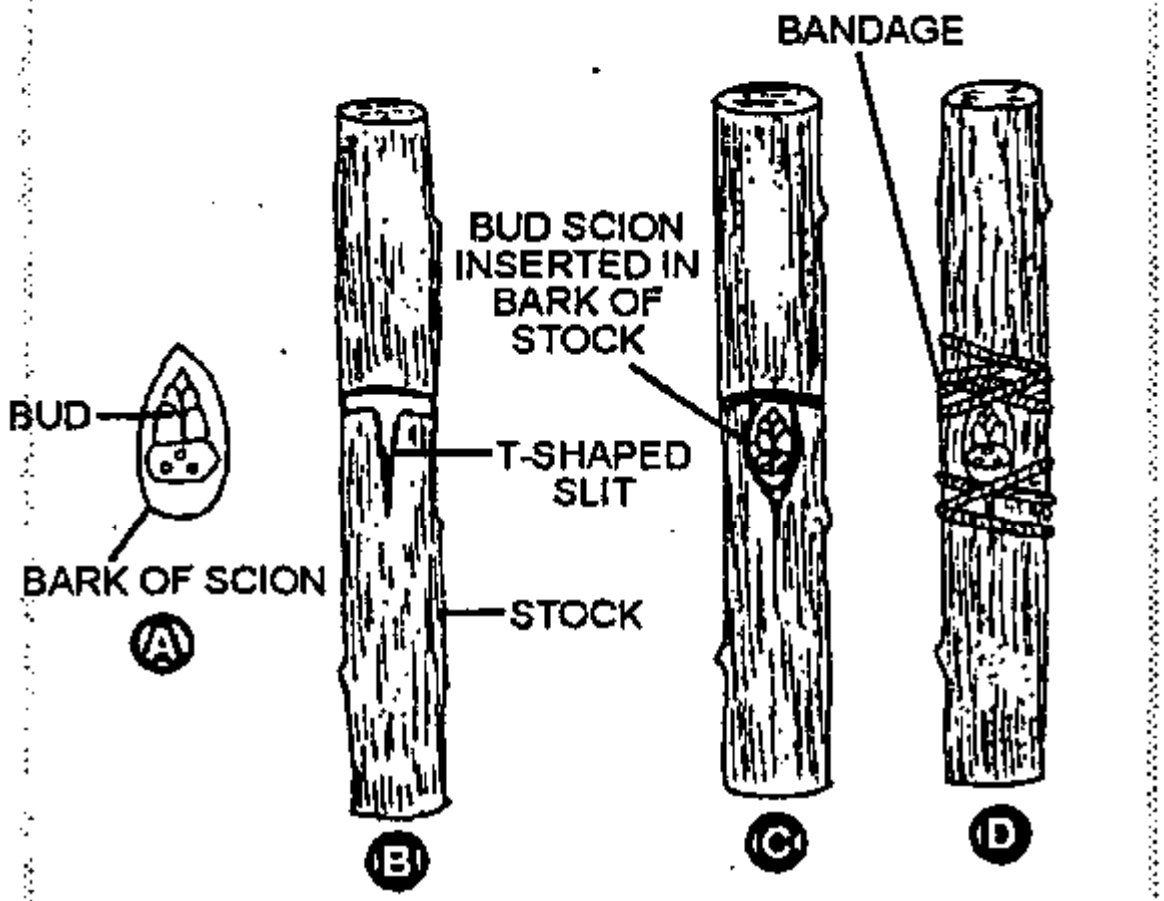


FIGURE 1.19. Bud grafting (see text for explanation).

(e) Propagation by Plant Tissue Culture (Micropropagation)

This method includes propagation of plants by culturing the cells, tissues and organs, called tissue culture (This has been discussed in detail in a separate chapter). Initially, the culturing of cells or tissues results in the formation of an undifferentiated mass of cells, called callus, which later differentiates to produce a large number of plantlets. These plantlets are then transferred to separate pots or nursery beds to obtain a large number of plants. Tissue culture technique is useful in obtaining virus free plants, disease free plants, homozygous diploids and in commercial micropropagation of Orchids, Carnation, Gladiolus, Chrysanthemum and other ornamental plants. This method is also employed for quick multiplication of plants.