Irrigation

Irrigation is the process of applying controlled amounts of water to plants at needed intervals. Irrigation helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall. Irrigation also has other uses in crop production, including frost protection, suppressing weed growth in grain fields and preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed.

Irrigation systems are also used for cooling livestock, dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the removal of surface and sub-surface water from a given area.

Irrigation has been a central feature of agriculture for over 5,000 years and is the product of many cultures. Historically, it was the basis for economies and societies across the globe, from Asia to the Southwestern United States.

Archaeological investigation has found evidence of irrigation in areas lacking sufficient natural rainfall to support crops for rainfed agriculture. The earliest known use of the technology dates to the 6th millennium BCE in Khuzistan in the south-west of present-day Iran.

Irrigation was used as a means of manipulation of water in the alluvial plains of the Indus valley civilization, the application of it is estimated to have begun around 4500 BC and drastically increased the size and prosperity of their agricultural settlements. The Indus Valley Civilization developed sophisticated irrigation and water-storage systems, including artificial reservoirs at Girnar dated to 3000 BCE, and an early canal irrigation system from c. 2600 BCE. Large-scale agriculture was practiced, with an extensive network of canals used for the purpose of irrigation.

Types of irrigation

There are several methods of irrigation. They vary in how the water is supplied to the plants. The goal is to apply the water to the plants as uniformly as possible, so that each plant has the amount of water it needs, neither too much nor too little. Irrigation can also be understood whether it is supplementary to rainfall as happens in many parts of the world, or whether it is 'full irrigation' whereby crops rarely depend on any contribution from rainfall. Full irrigation is less common and only happens in arid landscapes experiencing very low rainfall or when crops are grown in semi-arid areas outside of any rainy seasons.

Surface irrigation, also known as gravity irrigation, is the oldest form of irrigation and has been in use for thousands of years. In surface (furrow, flood, or level basin) irrigation systems, water moves across the surface of an agricultural lands, in order to wet it and infiltrate into the soil. Water moves by following gravity or the slope of the land. Surface irrigation can be subdivided into furrow, border strip or basin irrigation. It is often called flood irrigation when the irrigation results in flooding or near flooding of the cultivated land. Historically, surface irrigation has been the most common method of irrigating agricultural land and is still used in most parts of the world.

Where water levels from the irrigation source permit, the levels are controlled by dikes, usually plugged by soil. This is often seen in terraced rice fields (rice paddies), where the method is used to flood or control the level of water in each distinct field. In some cases, the water is pumped, or lifted by human or animal power to the level of the land. The water application efficiency of surface irrigation is typically lower than other forms of irrigation.

Surface irrigation is even used to water landscapes in certain areas, for example, in and around Phoenix, Arizona. The irrigated area is surrounded by a berm and the water is delivered according to a schedule set by a local irrigation district.

Drip irrigation – a dripper in action

Micro-irrigation, sometimes called localized irrigation, low volume irrigation, or trickle irrigation is a system where water is distributed under low pressure through a piped network, in a pre-determined pattern, and applied as a small discharge to each plant or adjacent to it. Traditional drip irrigation use individual emitters, subsurface drip irrigation (SDI), micro-spray or micro-sprinklers, and mini-bubbler irrigation all belong to this category of irrigation methods.

Drip irrigation

Drip (or micro) irrigation, also known as trickle irrigation, functions as its name suggests. In this system water falls drop by drop just at the position of roots. Water is delivered at or near the root zone of plants, drop by drop. This method can be the most water-efficient method of irrigation,if managed properly, evaporation and runoff are minimized. The field water efficiency of drip irrigation is typically in the range of 80 to 90 percent when managed correctly.

In modern agriculture, drip irrigation is often combined with plastic mulch, further reducing evaporation, and is also the means of delivery of fertilizer. The process is known as fertigation.

Deep percolation, where water moves below the root zone, can occur if a drip system is operated for too long or if the delivery rate is too high. Drip irrigation methods range from very high-tech and computerized to low-tech and labor-intensive. Lower water pressures are usually needed than for most other types of systems, with the exception of low energy center pivot systems and surface irrigation systems, and the system can be designed for uniformity throughout a field or for precise water delivery to individual plants in a landscape containing a mix of plant species. Although it is difficult to regulate pressure on steep slopes, pressure compensating emitters are available, so the field does not have to be level. High-tech solutions involve precisely calibrated emitters located along lines of tubing that extend from a computerized set of valves.

In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns. A system using sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a solid-set irrigation system. Higher pressure sprinklers that rotate are called rotors and are driven by a ball drive, gear drive, or impact mechanism. Rotors can be designed to rotate in a full or partial circle. Guns are similar to rotors, except that they generally operate at very high pressures of 275 to 900 kPa (40 to 130 psi) and flows of 3 to 76 L/s (50 to 1200 US gal/min), usually with nozzle diameters in the range of 10 to 50 mm (0.5 to 1.9 in). Guns are used not only for irrigation, but also for industrial applications such as dust suppression and logging.

Sprinklers can also be mounted on moving platforms connected to the water source by a hose. Automatically moving wheeled systems known as traveling sprinklers may irrigate areas such as small farms, sports fields, parks, pastures, and cemeteries unattended. Most of these use a length of polyethylene tubing wound on a steel drum. As the tubing is wound on the drum powered by the irrigation water or a small gas engine, the sprinkler is pulled across the field. When the sprinkler arrives back at the reel the system shuts off. This type of system is known to most people as a "waterreel" traveling irrigation sprinkler and they are used extensively for dust suppression, irrigation, and land application of waste water.

Lawn sprinkler systems

A lawn sprinkler system is permanently installed, as opposed to a hose-end sprinkler, which is portable. Sprinkler systems are installed in residential lawns, in commercial landscapes, for churches and schools, in public parks and cemeteries, and on golf courses. Most of the components of these irrigation systems are hidden under ground, since aesthetics are important in a landscape. A typical lawn sprinkler system will consist of one or more zones, limited in size by the capacity of the water source. Each zone will cover a designated portion of the landscape. Sections of the landscape will usually be divided by microclimate, type of plant material, and type of irrigation equipment. A landscape irrigation system may also include zones containing drip irrigation, bubblers, or other types of equipment besides sprinklers.

Although manual systems are still used, most lawn sprinkler systems may be operated automatically using an irrigation controller, sometimes called a clock or timer. Most automatic systems employ electric solenoid valves. Each zone has one or more of these valves that are wired to the controller. When the controller sends power to the valve, the valve opens, allowing water to flow to the sprinklers in that zone.

There are two main types of sprinklers used in lawn irrigation, pop-up spray heads and rotors. Spray heads have a fixed spray pattern, while rotors have one or more streams that rotate. Spray heads are used to cover smaller areas, while rotors are used for larger areas. Golf course rotors are sometimes so large that a single sprinkler is combined with a valve and called a 'valve in head'. When used in a turf area, the sprinklers are installed with the top of the head flush with the ground surface. When the system is pressurized, the head will pop up out of the ground and water the desired area until the valve closes and shuts off that zone. Once there is no more pressure in the lateral line, the sprinkler head will retract back into the ground. In flower beds or shrub areas, sprinklers may be mounted on above ground risers or even taller pop-up sprinklers may be used and installed flush as in a lawn area.

Hose-end sprinklers

There are many types of hose-end sprinklers. Many of them are smaller versions of larger agricultural and landscape sprinklers, sized to work with a typical garden hose. Some have a spiked base allowing them to be temporarily stuck in the ground, while others have a sled base designed to be dragged while attached to the hose.

Subirrigation

Subirrigation has been used for many years in field crops in areas with high water tables. It is a method of artificially raising the water table to allow the soil to be moistened from below the plants' root zone. Often those systems are located on permanent grasslands in lowlands or river valleys and combined with drainage infrastructure. A system of pumping stations, canals, weirs and gates allows it to increase or decrease the water level in a network of ditches and thereby control the water table.

Subirrigation is also used in the commercial greenhouse production, usually for potted plants. Water is delivered from below, absorbed by upwards, and the excess collected for recycling. Typically, a solution of water and nutrients floods a container or flows through a trough for a short period of time, 10–20 minutes, and is then pumped back into a holding tank for reuse. Sub-irrigation in greenhouses requires fairly sophisticated, expensive equipment and management. Advantages are water and nutrient conservation, and labor savings through reduced system maintenance and automation. It is similar in principle and action to subsurface basin irrigation.

Another type of subirrigation is the self-watering container, also known as a sub-irrigated planter. This consists of a planter suspended over a reservoir with some type of wicking material such as a polyester rope. The water is drawn up the wick through capillary action. A similar technique is the wicking bed; this too uses capillary action.

Pruning and Training

Some of cultivated fruit trees grow wild and do not give sufficient yield unless pruned or trained to a specific form. All types of fruit tree do not require pruning e.g. mango, chiku, etc and some fruit trees can grow well naturally e.g. pineapple, papaya they do not require pruning. While most deciduous tree like apple, pear, almond etc and grapes, ber, fig citrus, pomegranate, guava etc require pruning to train them for desired shape.

PRUNING

Pruning may be defined as the art and science of cutting away of portion of plant to improve its shape, to influence its growth, flowering and fruitfulness and to improve the quality of the product. It is done to divert a part of plant energy from one part to another part of plant.

Training of young trees, Maintenance of grown up trees i.e. to maintain the health of bearing plant.

It increases new vegetative growth

In young trees flowering will be delayed

In old trees there will be new vigorous vegetative growth which bears fruit

It reduces bearing surface are as a result tree remain dwarf which is compensated by accommodating more number of dwarf trees (because pruning is a dwarfing process)

Improvement in size, colour and quality of fruits

Young trees are pruned to train it to acquire a desired shape.

In old trees light heading back is done to stimulate the flowering

In bearing trees light pruning is done to stimulate fresh growth. it bearing flower buds on fresh growth

In old trees heavy pruning is done to restore vigorous

All the diseased, weak, dead or shading branches must be removed.

Heading back: Only tops of branches are headed back or cut off (light pruning).

Thinning out: Complete removal of a branches or a part

Dehorning: Cutting away the main limbs or thick major branches

Bulk pruning: Heavy pruning all over the tree. For good fruit production only judicious heading back or thinning out should be done.

Start cutting from the lower end first, leave half way or even less and then cut from the top

Keep the cut surface clean and smooth

Protect the wound with Bordeaux paste.

TRAINING

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

To admit more light and air to the centre of the tree to expose maximum leaf surface to the sun

To direct the growth of the tree so that various cultural operations such as spraying, ploughing, harvesting can be performed easily and at lower cost.

To protect the tree from sun burn and wind damage.

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

Central leader system:

In this system the central leader branches are allowed to grow indefinitely so that it will grow more rapidly and vigorously than the side branches and tree became tall. Such a tree bears fruit more near the top. The lower branches are less vigorous and less fruitful.

Open centre or vase system:

The main stem is allowed to grow only up to a certain height about 1.5 to 1.8 m and then it cut for development of lateral branches. It allows full sunshine to reach each branch.

Delayed open centre or modified leader system:

It is intermediate between the above systems. It is developed by first training the tree to the leader type by allowing the central axil to grow un pruned for the first four or five years. Then central stem is headed back and lateral branches are allowed to grow as in the open centre system.

Bush system:An unpruned tree multi stem and dwarf growing habit. Over head trellis or Bower system

Modified bower or Telephone system:

Similar to bower system except that after every two meter as space is kept to walk and carry out cultural operations. Of the many factors influencing floral initiation, carbohydrates-nitrogen ration appears to be the one factor that could be controlled. The accumulation of carbohydrates can be brought about by more rapid manufacture and less immediate utilization. In vegetative weak plants, favorable conditions for carbohydrate accumulation will have to be created by provision of desired temperature, light, water and nutrient change while in vigorous plants this change is to be induced by the reduction of water and nutrient supply. Regulation of fruiting can be effected by influencing fruit bud differentiation or by influencing fruit set and development.

Pruning, root pruning, ringing, girdling, notching, bending, smudging are some of the specialized horticultural practices followed for regulation of fruiting.

Ringing and Girdling

Ringing consists of removing a ring of bark about 1 to 2 cm wide around the trunk or branches, while Girdling is a milder treatment to draw a knife around the branch so as to cut through the bark but not the wood. A wire tied very firmly round the stem also serves the same purpose.

Ringing or girdling will increase the concentration of carbohydrates above the wing. It will also reduce the nitrogen supply because subsequent to the stopping of food to the roots, the root growth will be stopped and hence the supply of nitrogen to the tree will slowly decrease and became limited. No more root growth, no nitrogen supplies. The result will be a wide C: N ratio and then flowering increased. Ringing is a drastic operation done when fruit trees fail set fruit. It is likely to check vegetative growth and to some extent the growth of roots. Ringing is done in vigorous mango tree

Notching

It is similar to ringing except that in notching only soil slip bark about 0.2 to 0.5 cm thick and 1.5 to 2.5 cm in length is removed just above or close to a dormant bud in slantwise so that the latex does not coagulate in the bud itself. The bud selected should be large, plampy and healthy which is produced on a perfect mature wood and has undergone dormancy. Generally 3 to 4 buds in the middle portion of the selected shoot are best to operate on. Fig has responded to notching and it is practiced in fig cultivation. The season for notching the fig is August-September.

Bending

Bending a branch downward, sometimes checks growth and causes accumulation of starch in the branch with greater flowering. This tends to increase carbohydrate concentration. The bending brings pressure on the bark on the translocation of photosynthesis is obstructed due to narrow passage. The bending of branches is usual as a substitute for severe pruning in shaping the young trees and more fruit is borne because more branches are left to bear and more leaves are left to synthesize food material. In case of bending the effect of apical dominance of the growing shoot is removed and auxins during translocation activate the dormant buds.

Smudging

Smudging is a practice of smoking the tree by burning brush wood on the ground and allowing smoke to pass through the centre of the crown of the tree. The smoking is discontinued as soon as the terminal buds begin to swell. Not commonly followed in India. Practice of smoking to the trees like mango, commonly employed in the Philippines to produce off-season crop. Smoking containing ethylene gas, which is responsible for initiation of flowering.

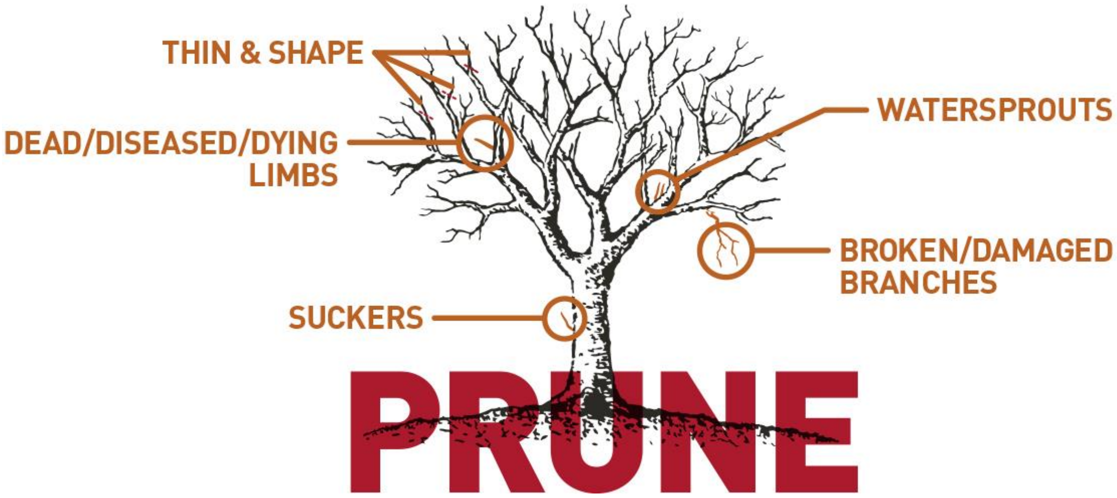
Root pruning

Root pruning results in less carbohydrate utilization of the top growth through there is a little more utilization of carbohydrate for root functions. There is an accumulation of carbohydrates due to check of top growth, which results in fruit bud differentiation. As the effect of root pruning is to check the vegetative growth. The plant became dwarf. Root pruning is a method of inducing fruitfulness or determining the time of flowering. The root pruning is done two months before the bloom required. The main roots are exposed to the sun and the fibrous roots are cut, so water is withheld. The trees are allowed to go dry until their leaves wither and fall down. The time taken for leaf fall is from 3-4 weeks. After that exposed roots are covered with a mixture of soil and manure. The trees are then immediately irrigated. First irrigation may be given with very less water. The trees burst into flowering in about 2-3 weeks. Practice very widely adopted by citrus growers in western and central India (in santra). The trees on which root pruning is practiced quite frequently are short lived and are liable to be week and unhealthy. Hence root pruning is usually restored to when other method such as ringing etc. Root pruning is generally included in bahar treatments given to fruit trees like mosambi, santra, guava, pomegranate, lime etc. It is also practiced while manuring large trees like mango, by trench method where smaller roots coming in the trench are usually cut away.

Bahar treatment

This practice is followed with fruit trees like mosambi, santra, grape fruit, guava, pomegranate ber, lime etc. in the state of Maharashtra, M.P. and Gujarat etc. As there is no distinct winter (very cold winter) these fruit trees are usually continuous vegetative growth resulting in indistinct flowering season. This practice is useful in encouraging flowering as well as regulating the time. About 1 to 1 ½ months prior to the expected flowering irrigation is withholding. There are three flowering season namely Mrig bahar, Hasta bahar and Ambe bahar.

The orchard is ploughed up to 20 cm depth both ways and the roots are exposed by removing the upper 10-15 cm of soil within a radius of 60-90 cm around the trunk. The dead and decayed fibrous roots are removed in the area exposed. The leaves start turning yellow, shrivel and fall. These are the indication to know that the trees have rested long enough and accumulated food reserves. The exposed roots are then recovered with original soil and necessary manures are added. Trees are irrigated lightly. The second watering is given on the 3rd or 5th day and first two watering stimulate blossoming and if heavy irrigations are given at the beginning, this may tend to vegetative growth only. Root exposure is not necessary in case of sandy, sandy loam and other types of light soils. The choice of bahar depends upon availability of water and time of year the fruit is required in the market. Where irrigation water is available, the grower prefers Hasta or Ambe bahar


THIN & SHAPE
DEAD/DISEASED/DYING LIMBS
WATERSPROUTS
BROKEN/DAMAGED BRANCHES
SUCKERS
PRUNE

Cutting

Stem cuttings: A stem cutting is any cutting taken from the main shoot of a plant or any side shoot growing from the same plant or stem. The shoots with high carbohydrate content usually root better. Broadly, there are four types of stem cuttings, namely hardwood, softwood, semi-hardwood and herbaceous cuttings.

Hardwood cuttings: Cutting from mature and lignified stem of shrubs and trees are called as hardwood cuttings. Hardwood cuttings are prepared during dormant season, usually from one-year-old shoots of previous season's growth . The size of cuttings varies from 10 to 45 cm in length and 0.5 to 2.5 cm in diameter, depending upon the species. Usually, the cuttings of 25-30cm length, with pencil thickness are preferred. Each cutting should have at least three or more buds. While preparing the cutting, a straight cut is given at the base of shoot- below the node while a slanting cut, 1 to 2 cm above the bud is given at the top of cutting. However, in case of hollow pith species such as kiwifruit, top cut should also be close to bud to avoid drying up of top portion. For tropical and subtropical crops, straight cut is given at top in order to minimize transpiration loss and slant cut should be given at the base to expose more area for absorption of water and nutrients. This helps in maintaining the polarity of the shoot and if rain occurs, water does not accumulate on the tip of the cutting, which saves the cutting from fungal infection. A number of deciduous fruit plants like grape, kiwifruit, hazel nut, chest nut, fig, quince, pomegranate, mulberry, plum, olive, and gooseberry etc. are commercially propagated by hardwood cuttings.

Semi-hardwood (green wood) cuttings: Semi-hard wood cuttings are those made from woody, broad-leaved evergreen species with partially matured wood. These types of cuttings are mostly used in evergreen fruit plants like mango, guava, lemon, jackfruit some shrubs and shrubby ornamental plants. The length of the cuttings varies from 7 to 20 cm. The cuttings are prepared by trimming the cuttings with a straight cut below the node and removing a few lower leaves. However, it is better to retain two-to-four leaves on the top of the cuttings. While planting 1/4th cutting should be inserted in the soil. The best time for taking such cuttings is summer, when new shoots have emerged and their wood is partially matured. It is necessary that leafy cuttings should be rooted under conditions when water loss from the leaves is minimum. Commercially, such cuttings are rooted under intermittent mist, fog or under polyethylene sheets laid over the cuttings.

Hardwood cutting Semi- Hardwood cutting Softwood cutting

Different types of cuttings

Softwood cuttings: Cuttings prepared from the soft-succulent and non-lignified shoots, which are not hard or woody, are called as softwood cuttings. Such types of cuttings are very prone to desiccation. Therefore, proper arrangement for controlling humidity is required. Usually the size of cutting is 5-5.7 cm but it may vary from species-to-species. In general, some leaves should be retained with this type of cuttings. The best time for preparing softwood cuttings is late summer. Softwood cuttings generally root easier and quicker than other types, but require more attention and sophisticated equipments. Similarly, the temperature should be maintained 23 to 27oC during rooting at the base of cuttings.

Herbaceous cuttings: Herbaceous cuttings are made from succulent non-woody plants like geranium, chrysanthemum, coleus, carnation and many foliage crops. These are usually 7-15 cm long with few leaves retained at the upper end. These are rooted under the same conditions as that of softwood cuttings, requiring high relative humidity. Bottom heat is also useful for initiation of rooting process. Herbaceous cuttings of some plants exclude a sticky sap (as in geranium, pineapple, cactus etc.) that interferes with root initiation process. In such cases, basal ends of cuttings should be allowed to dry for few hours before planting. Generally, fruit plants are not propagated by herbaceous cuttings.

Root cuttings: Propagation by means of root cuttings is also a simple and cheap method of vegetative propagation in species, which are difficult-to-propagate by other methods. In general, the plants, which produce suckers freely, are easily propagated by root cuttings. For preparation of root-cuttings, roots which are of 1cm thickness and 10-15cm long are cut into pieces (Fig.5.3). The best time for taking root cutting is late winter or early spring, when roots are well supplied with stored food material. However, in temperate fruits, root cuttings are prepared in the month of December and are kept in warm place in moss grass or wet sand for callusing and are then transplanted in the nursery during February-March in the open beds. Blackberry and raspberry are commercially propagated by this method. However, kiwifruit, breadfruit, fig, rose, mulberry, apple, pear, peach, cherry and persimmon are also propagated by root cutting

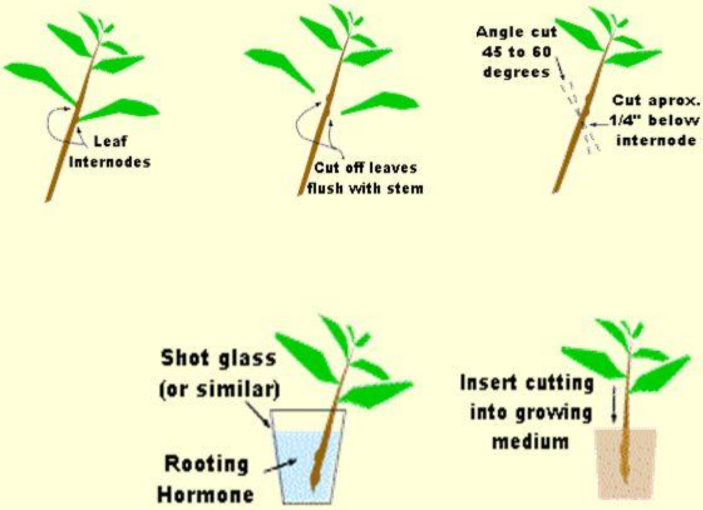
Leaf cuttings: Propagation through leaf bud cuttings is partially useful in species where leaves develop root system but die because of non-development of shoot system. Leaf bud cuttings are particularly useful when planting material is scarce because each node in leaf can be used as cutting. Leaf bud cutting should preferably be prepared during growing season because buds if enter into dormancy may be difficult to force to active stage, thereby inhibit the rooting in such cuttings.

Leaf bud cuttings: A leaf bud cutting consists of a leaf blade, petiole and short piece of stem with attached axiliary bud of actively growing leaves . In leaf bud cutting, 10-15 cm stem portion is used when propagating material is small. It is an useful method of propagation in blackberry, raspberry, lemon, camellia etc.

Stem Cuttings- Use the stem and leaves or just the stem.

Cuttings should be 6-10" long & between nodes

Dibble, then place cutting in soil



Layering

Layering has evolved as a common means of vegetative propagation of numerous species in natural environments. Layering is also utilized by horticulturists to propagate desirable plants.

Natural layering typically occurs when a branch touches the ground, whereupon it produces adventitious roots. At a later stage the connection with the parent plant is severed and a new plant is produced as a result.

The horticultural layering process typically involves wounding the target region to expose the inner stem and optionally applying rooting compounds. In ground layering or simple layering, the stem is bent down and the target region is buried in the soil. This is done in plant nurseries in imitation of natural layering by many plants such as brambles which bow over and touch the tip on the ground, at which point it grows roots and, when separated, can continue as a separate plant. In either case, the rooting process may take from several weeks to a year.

Layering is more complicated than taking cuttings, but has the advantage that the propagated portion continues to receive water and nutrients from the parent plant while it is forming roots. This is important for plants that form roots slowly, or for propagating large pieces. Layering is used quite frequently in the propagation of bonsai; it is also used as a technique for both creating new roots and improving existing roots.

Method and process

A low-growing stem is bent down to touch a hole dug in the ground, then pinned in place using something shaped like a clothes hanger hook and covered over with soil. However, a few inches of leafy growth must remain above the ground for the bent stem to grow into a new plant. Removing a section of skin from the lower-facing stem part before burying may help the rooting process. If using rooting hormone, the stem should be cut just beneath a node. The resultant notch should be wedged open with a toothpick or similar piece of wood and the hormone applied before burying.

The buried stem part then grows new roots which take hold in the soil while the above parts grow as individual new plants. Once the end of the stem has grown long enough the process can be repeated, creating the appearance of a row of plants linked by humped, intermittently buried stems. Better results can be achieved when the top of the plant is closer to the vertical.

Once the process is completed, the buried section should be kept well-watered until roots begin to form. The new individual plant may require one to two years before it is strong enough to survive on its own. When it is, the original stem should be cut where it enters the ground, thereby separating the two plants.

Simple layering can be more attractive when managing a cascading or spreading plant.These plants tend to propagate in this manner anyway, and potting a new limb will give extra plants without having to sow new seed.

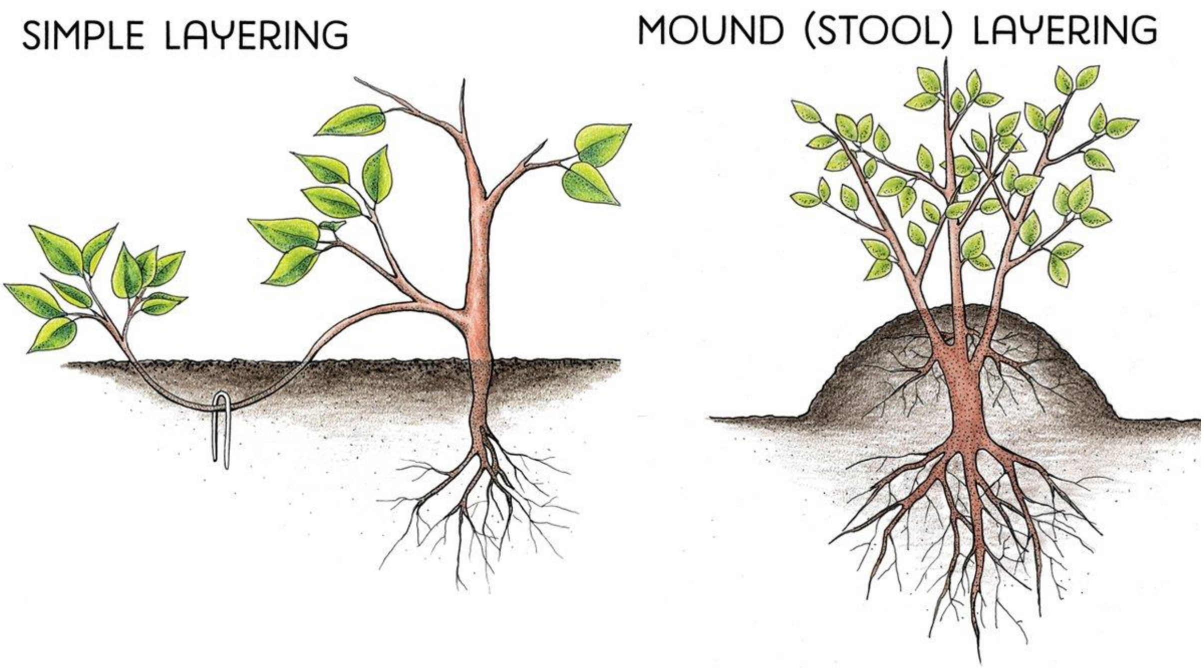
Simple layering can also help when a plant has overgrown its pot and is drooping over the side. The long stem is layered into another pot until it roots, thus bringing it back to soil level.

Ground layering

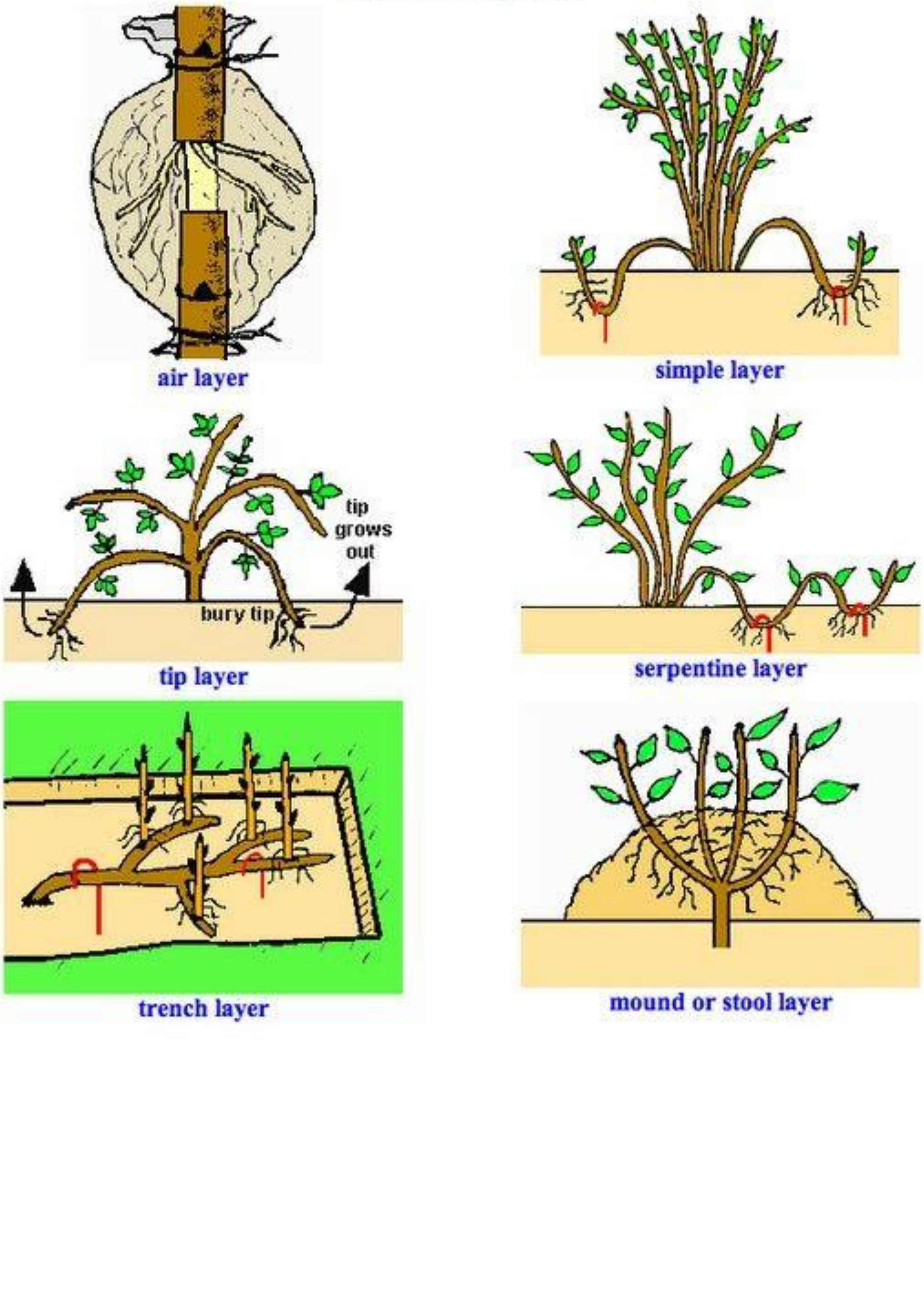
Ground layering or mound layering is the typical propagation technique for the popular Malling-Merton series of clonal apple root stocks, in which the original plants are set in the ground with the stem nearly horizontal, which forces side buds to grow upward[citation needed]. After these are started, the original stem is buried up to some distance from the tip. At the end of the growing season, the side branches will have rooted, and can be separated while the plant is dormant. Some of these will be used for grafting rootstocks, and some can be reused in the nursery for the next growing season's crop. Ground layering is used in the formation of visible surface roots, known as "nebari", on bonsai trees.

Air layering

In air layering (or marcotting), the target region is wounded by an upward 4 cm long cut and held open with a toothpick or similar, or a strip of bark is removed. The wound is then surrounded with a lump of moisture-retaining medium such as sphagnum moss or cloth, and then further surrounded by a moisture barrier such as plastic film tied or taped to the branch to prevent moisture loss or ingress of too much water as from rain. Rooting hormone is often applied to the wound to encourage root growth. When sufficient roots have grown from the wound, the stem is removed from the parent plant and planted, taking care to shield it from too much sun and to protect it from drying out until the new roots take hold. It can take the layer from a few weeks to one or more growing seasons to produce sufficient roots; this is largely dependent on the plant species and the vigor of the parent plant.



Types of Layering



air layer

simple layer

tip layer

serpentine layer

trench layer

mound or stool layer

Budding

Grafting and budding are horticultural techniques used to join parts from two or more plants so that they appear to grow as a single plant. ... In the budding process, a bud is taken from one plant and grown on another.

Budding refers to technique where two different varieties of plants grow as single plant. The Scion and rootstock are joined together, which develop into a single tree. The technique holds importance as it can provide variety of flowers and hence fruits on single tree.Jun 13, 2020

Chip budding and T-budding are the two most important types of budding for woody ornamentals and fruit trees (see Table 13–1, page 522). Chip and T-budding are much simpler and, therefore, much faster than manual grafting techniques.

Basically, the procedure in budding consists of the following steps:

Preparation of the rootstock. ...

Preparation of the bud-scion. ...

Insertion of the prepared bud-scion. ...

Tying or wrapping. ...

Cut back of the rootstock. ...

Care of clones.

Vegetative buds are used as a scion. The time of budding depends upon the availability of buds and cell sap flow in the rootstock seedlings so that bark separates easily to take scion bud.

methods of budding

T-Budding:

The scion is removed from the shoot in the shape of the bud. The bud may or may not have small portion of xylem wood. A T-shaped cut is given in the rootstock just as deep as the bark. Then the bud is inserted under the bark in this T-shaped exposed xylem and tied with a polythene strip. The portion of the active bud is left uncovered for sprouting. This is the most important method of budding in citrus, peaches and roses.

Inverted-T-Budding:

The only difference is that inverted T-cut is given on the rootstock seedling and scion bud is inserted from below upward.

Patch Budding:

A rectangular patch of bark is removed completely from rootstock seedling of sufficient thickness at a height of 20 cm. A similar-sized patch bud is taken from the scion and placed over to the stock and tied. It is a little time consuming to perform. However patch budding is very successful to bud guava and aonla.

Ring Budding:

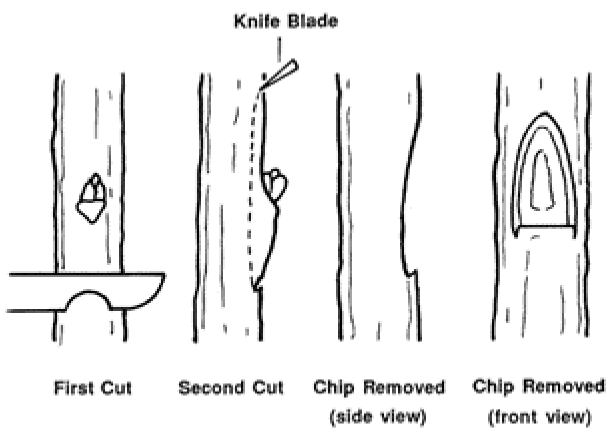
The rootstock is headed back just as in grafting at a height of 15-20 cm. A ring of bark is removed from the top of the beheaded rootstock seedling. A similar ring along with a bud is taken from the scion and inserted on to the rootstock. This is commonly done in peach and mulberry.

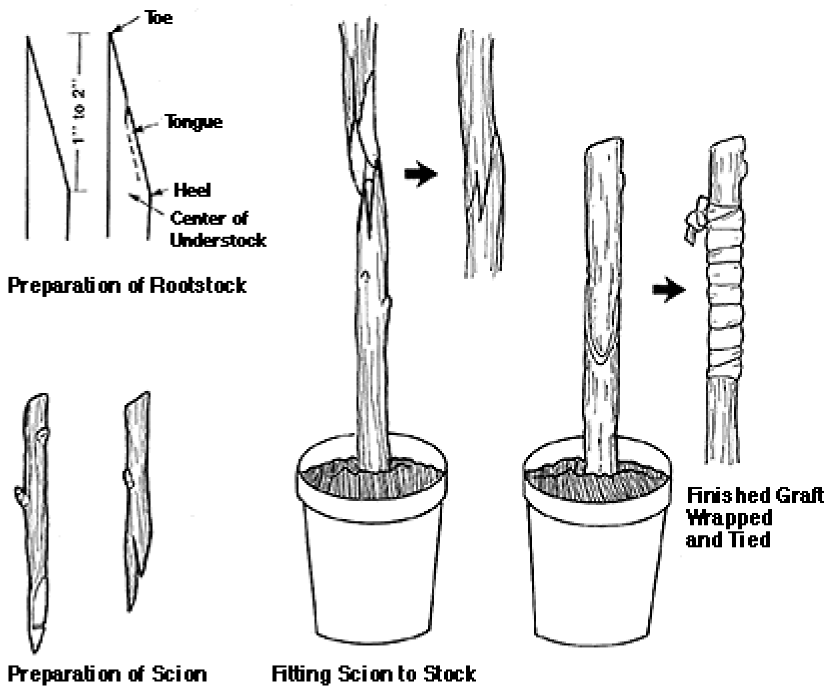
Chip-budding:

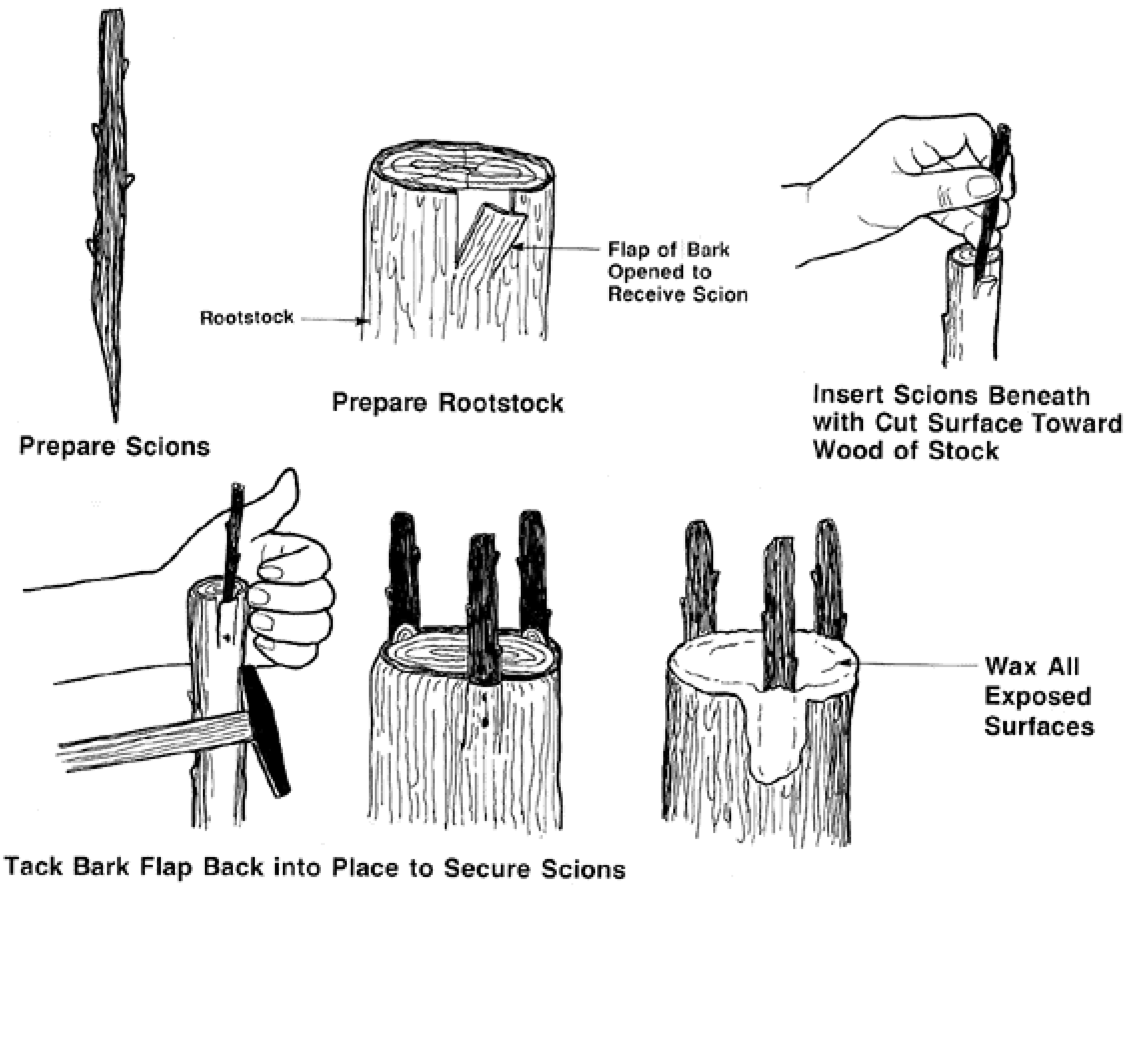
It is carried out when cell sap flow is too low and budding is not possible with other methods.

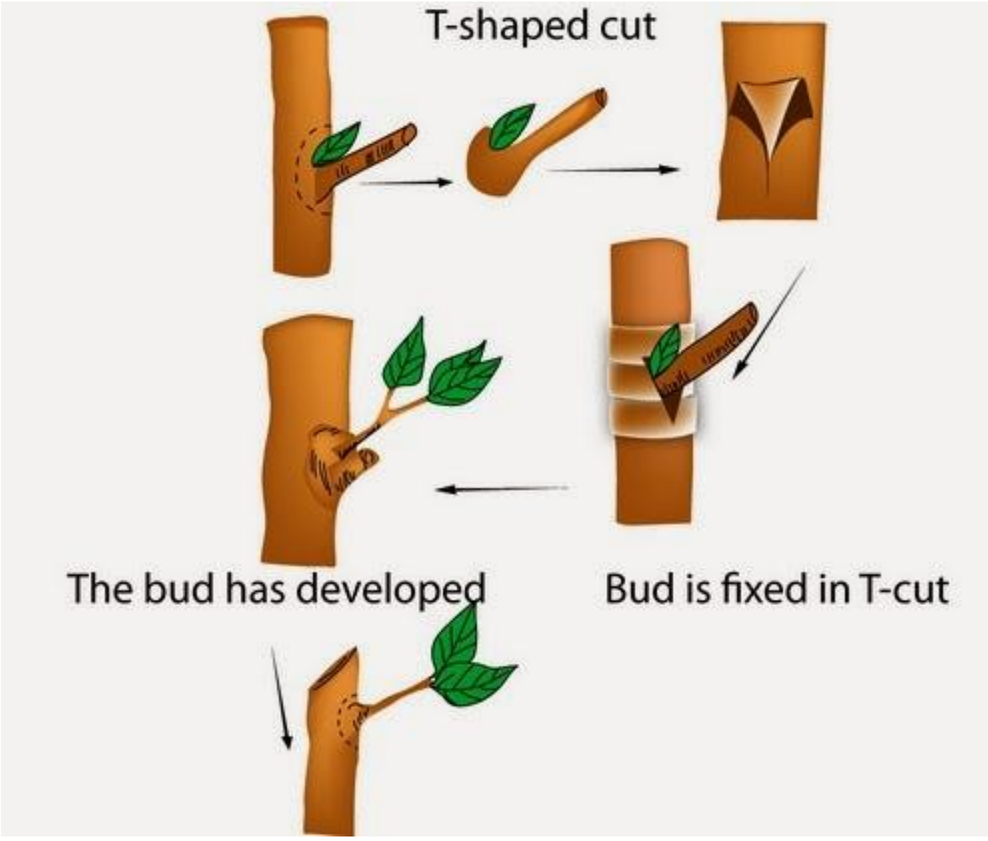
Forkert Budding:

It is just like patch budding, but patch is not totally removed from the stock. It is left attached from one side. While placing a bud on the patch, the bark patch is again placed on the bud by removing a little portion in flop to sprouting of bud.

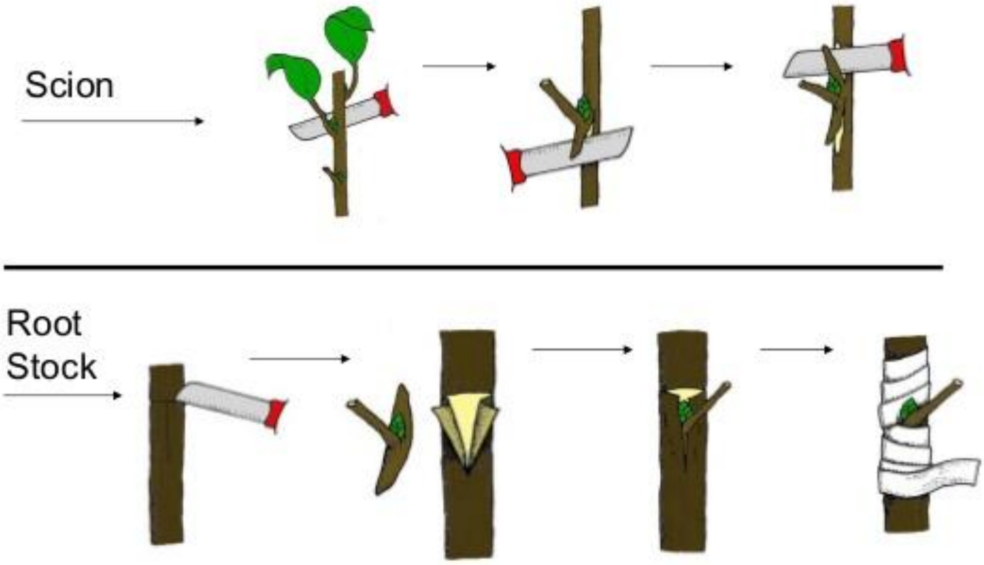



Toe
1" to 2"
Tongue
Heel
Center of Understock
Preparation of Rootstock
Preparation of Scion
Fitting Scion to Stock
Finished Graft Wrapped and Tied


Prepare Scions
Rootstock
Flap of Bark Opened to Receive Scion
Prepare Rootstock
Insert Scions Beneath with Cut Surface Toward Wood of Stock
Wax All Exposed Surfaces
Tack Bark Flap Back into Place to Secure Scions


T-shaped cut
The bud has developed
Bud is fixed in T-cut

T-budding is the most common method for propagating fruit trees.



Grafting or graftage is a horticultural technique whereby tissues of plants are joined so as to continue their growth together. The upper part of the combined plant is called the scion (/ˈsaɪən/) while the lower part is called the rootstock. The success of this joining requires that the vascular tissues grow together and such joining is called inosculation. The technique is most commonly used in asexual propagation of commercially grown plants for the horticultural and agricultural trades.

In most cases, one plant is selected for its roots and this is called the stock or rootstock. The other plant is selected for its stems, leaves, flowers, or fruits and is called the scion or cion. The scion contains the desired genes to be duplicated in future production by the stock/scion plant.

In stem grafting, a common grafting method, a shoot of a selected, desired plant cultivar is grafted onto the stock of another type. In another common form called bud grafting, a dormant side bud is grafted onto the stem of another stock plant, and when it has inosculated successfully, it is encouraged to grow by pruning off the stem of the stock plant just above the newly grafted bud.

For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other. Both tissues must be kept alive until the graft has "taken", usually a period of a few weeks. Successful grafting only requires that a vascular connection take place between the grafted tissues. Research conducted in Arabidopsis thaliana hypocotyls have shown that the connection of phloem takes place after 3 days of initial grafting, whereas the connection of xylem can take up to 7 days.[2] Joints formed by grafting are not as strong as naturally formed joints, so a physical weak point often still occurs at the graft because only the newly formed tissues inosculate with each other. The existing structural tissue (or wood) of the stock plant does not fuse.

Graft particular to plum cherry. The scion is the largest in the plant, due to the imperfect union of the two. It can be seen on the enlarged trunk: this accumulation of starch is an indication of imperfection.

Precocity: The ability to induce fruitfulness without the need for completing the juvenile phase. Juvenility is the natural state through which a seedling plant must pass before it can become reproductive. In most fruiting trees, juvenility may last between 5 and 9 years, but in some tropical fruits, e.g., mangosteen, juvenility may be prolonged for up to 15 years. Grafting of mature scions onto rootstocks can result in fruiting in as little as two years.

Dwarfing: To induce dwarfing or cold tolerance or other characteristics to the scion. Most apple trees in modern orchards are grafted on to dwarf or semi-dwarf trees planted at high density. They provide more fruit per unit of land, of higher quality, and reduce the danger of accidents by harvest crews working on ladders. Care must be taken when planting dwarf or semi-dwarf trees. If such a tree is planted with the graft below the soil, then the scion portion can also grow roots and the tree will still grow to its standard size.

Ease of propagation: Because the scion is difficult to propagate vegetatively by other means, such as by cuttings. In this case, cuttings of an easily rooted plant are used to provide a rootstock. In some cases, the scion may be easily propagated, but grafting may still be used because it is commercially the most cost-effective way of raising a particular type of plant.

Hybrid breeding: To speed maturity of hybrids in fruit tree breeding programs. Hybrid seedlings may take ten or more years to flower and fruit on their own roots. Grafting can reduce the time to flowering and shorten the breeding program.

Hardiness: Because the scion has weak roots or the roots of the stock plants are tolerant of difficult conditions. e.g. many Western Australian plants are sensitive to dieback on heavy soils, common in urban gardens, and are grafted onto hardier eastern Australian relatives. Grevilleas and eucalypts are examples.

Sturdiness: To provide a strong, tall trunk for certain ornamental shrubs and trees. In these cases, a graft is made at a desired height on a stock plant with a strong stem. This is used to raise 'standard' roses, which are rose bushes on a high stem, and it is also used for some ornamental trees, such as certain weeping cherries.

Disease/pest resistance: In areas where soil-borne pests or pathogens would prevent the successful planting of the desired cultivar, the use of pest/disease tolerant rootstocks allow the production from the cultivar that would be otherwise unsuccessful. A major example is the use of rootstocks in combating Phylloxera.

Pollen source: To provide pollenizers. For example, in tightly planted or badly planned apple orchards of a single variety, limbs of crab apple may be grafted at regularly spaced intervals onto trees down rows, say every fourth tree. This takes care of pollen needs at blossom time.

Repair: To repair damage to the trunk of a tree that would prohibit nutrient flow, such as stripping of the bark by rodents that completely girdles the trunk. In this case a bridge graft may be used to connect tissues receiving flow from the roots to tissues above the damage that have been severed from the flow. Where a water sprout, basal shoot or sapling of the same species is growing nearby, any of these can be grafted to the area above the damage by a method called inarch grafting. These alternatives to scions must be of the correct length to span the gap of the wound.

Changing cultivars: To change the cultivar in a fruit orchard to a more profitable cultivar, called top working. It may be faster to graft a new cultivar onto existing limbs of established trees than to replant an entire orchard.

Genetic consistency: Apples are notorious for their genetic variability, even differing in multiple characteristics, such as, size, color, and flavor, of fruits located on the same tree. In the commercial farming industry, consistency is maintained by grafting a scion with desired fruit traits onto a hardy stock.

Factors for successful graft

Compatibility of scion and stock: Because grafting involves the joining of vascular tissues between the scion and rootstock, plants lacking vascular cambium, such as monocots, cannot normally be grafted. As a general rule, the closer two plants are genetically, the more likely the graft union will form. Genetically identical clones and intra-species plants have a high success rate for grafting. Grafting between species of the same genus is sometimes successful. Grafting has a low success rate when performed with plants in the same family but in different genera. And grafting between different families is rare

Cambium alignment and pressure: The vascular cambium of the scion and stock should be tightly pressed together and oriented in the direction of normal growth. Proper alignment and pressure encourages the tissues to join quickly, allowing nutrients and water to transfer from the stockroot to the scion.

Completed during appropriate stage of plant: The grafting is completed at a time when the scion and stock are capable of producing callus and other wound-response tissues. Generally, grafting is performed when the scion is dormant, as premature budding can drain the grafting site of moisture before the grafting union is properly established. Temperature greatly affects the physiological stage of plants. If the temperature is too warm, premature budding may result. Elsewise, high temperatures can slow or halt callus formation.

Proper care of graft site: After grafting, it is important to nurse the grafted plant back to health for a period of time. Various grafting tapes and waxes are used to protect the scion and stock from excessive water loss. Furthermore, depending on the type of graft, twine or string is used to add structural support to the grafting site. Sometimes it is necessary to prune the site, as the rootstock may produce shoots that inhibit the growth of the scion.

Depiction of general purpose grafting knives

Cutting tools: It is good procedure to keep the cutting tool sharp to minimize tissue damage and clean from dirt and other substances to avoid the spread of disease. A good knife for general grafting should have a blade and handle length of about 3 inches and 4 inches respectively. Specialized knives for grafting include bud-grafting knives, surgical knives, and pruning knives. Cleavers, chisels, and saws are utilized when the stock is too large to be cut otherwise.

Disinfecting tools: Treating the cutting tools with disinfectants ensures the grafting site is clear of pathogens. A common sterilizing agent is absolute alcohol.

Graft seals: Keeps the grafting site hydrated. Good seals should be tight enough to retain moisture while, at the same time, loose enough to accommodate plant growth. Includes specialized types of clay, wax, petroleum jelly, and adhesive tape.

Tying and support materials: Adds support and pressure to the grafting site to hold the stock and scion together before the tissues join, which is especially important in herbaceous grafting. The employed material is often dampened before use to help protect the site from desiccation. Support equipment includes strips made from various substances, twine, nails, and splints.

Grafting machines: Because grafting can take a lot of time and skill, grafting machines have been created. Automation is particularly popular for seedling grafting in countries such as Japan and Korea where farming land is both limited and used intensively. Certain machines can graft 800 seedlings per hour.

Techniques

T budding

Approach grafting or inarching is used to join together plants that are otherwise difficult to join. The plants are grown close together, and then joined so that each plant has roots below and growth above the point of union.[6] Both scion and stock retain their respective parents that may or may not be removed after joining. Also used in pleaching. The graft can be successfully accomplished any time of year.

Bud

Bud grafting (also called chip budding) uses a bud instead of a twig. Grafting roses is the most common example of bud grafting. In this method a bud is removed from the parent plant, and the base of the bud is inserted beneath the bark of the stem of the stock plant from which the rest of the shoot has been cut. Any extra bud that starts growing from the stem of the stock plant is removed. Examples: roses and fruit trees like peaches. Budwood is a stick with several buds on it that can be cut out and used for bud grafting. It is a common method of propagation for citrus treeS

Cleft

In cleft grafting a small cut is made in the stock and then the pointed end of the scion is inserted in the stock. This is best done in the early spring and is useful for joining a thin scion about 1 cm (3⁄8 in) diameter to a thicker branch or stock. It is best if the former has 3–5 buds and the latter is 2–7 cm (3⁄4–2 3⁄4 in) in diameter. The branch or stock should be split carefully down the middle to form a cleft about 3 cm (1 1⁄8 in) deep. If it is a branch that is not vertical then the cleft should be cut horizontally. The end of the scion should be cut cleanly to a long shallow wedge, preferably with a single cut for each wedge surface, and not whittled. A third cut may be made across the end of the wedge to make it straight across.

Slide the wedge into the cleft so that it is at the edge of the stock and the centre of the wedge faces are against the cambium layer between the bark and the wood. It is preferable if a second scion is inserted in a similar way into the other side of the cleft. This helps to seal off the cleft. Tape around the top of the stock to hold the scion in place and cover with grafting wax or sealing compound. This stops the cambium layers from drying out and also prevents the ingress of water into the cleft.

Whip

In whip grafting the scion and the stock are cut slanting and then joined. The grafted point is then bound with tape and covered with a soft sealant to prevent dehydration and infection by germs. The common variation is a whip and tongue graft, which is considered the most difficult to master but has the highest rate of success as it offers the most cambium contact between the scion and the stock. It is the most common graft used in preparing commercial fruit trees. It is generally used with stock less than 1.25 cm (1⁄2 in) diameter, with the ideal diameter closer to 1 cm (3⁄8 in) and the scion should be of roughly the same diameter as the stock.

The stock is cut through on one side only at a shallow angle with a sharp knife. (If the stock is a branch and not the main trunk of the rootstock then the cut surface should face outward from the centre of the tree.) The scion is similarly sliced through at an equal angle starting just below a bud, so that the bud is at the top of the cut and on the other side than the cut face.

In the whip and tongue variation, a notch is cut downwards into the sliced face of the stock and a similar cut upwards into the face of the scion cut. These act as the tongues and it requires some skill to make the cuts so that the scion and the stock marry up neatly. The elongated "Z" shape adds strength, removing the need for a companion rod in the first season

The joint is then taped around and treated with tree-sealing compound or grafting wax. A whip graft without a tongue is less stable and may need added support

Stub

Stub grafting is a technique that requires less stock than cleft grafting, and retains the shape of a tree. Also scions are generally of 6–8 buds in this process. An incision is made into the branch 1 cm (3⁄8 in) long, then the scion is wedged and forced into the branch. The scion should be at an angle of at most 35° to the parent tree so that the crotch remains strong. The graft is covered with grafting compound. After the graft has taken, the branch is removed and treated a few centimeters above the graft, to be fully removed when the graft is strong.

Four-flap

The four-flap graft (also called banana graft) is commonly used for pecans, and first became popular with this species in Oklahoma in 1975. It is heralded for maximum cambium overlap, but is a complex graft. It requires similarly sized diameters for the rootstock and scion. The bark of the rootstock is sliced and peeled back in four flaps, and the hardwood is removed, looking somewhat like a peeled banana. It is a difficult graft to learn.

Awl

Awl grafting takes the least resources and the least time. It is best done by an experienced grafter, as it is possible to accidentally drive the tool too far into the stock, reducing the scion's chance of survival. Awl grafting can be done by using a screwdriver to make a slit in the bark, not penetrating the cambium layer completely. Then inset the wedged scion into the incision.

Veneer

Veneer grafting, or inlay grafting, is a method used for stock larger than 3 cm (1 1⁄8 in) in diameter. The scion is recommended to be about as thick as a pencil. Clefts are made of the same size as the scion on the side of the branch, not on top. The scion end is shaped as a wedge, inserted, and wrapped with tape to the scaffolding branches to give it more strength.

Rind

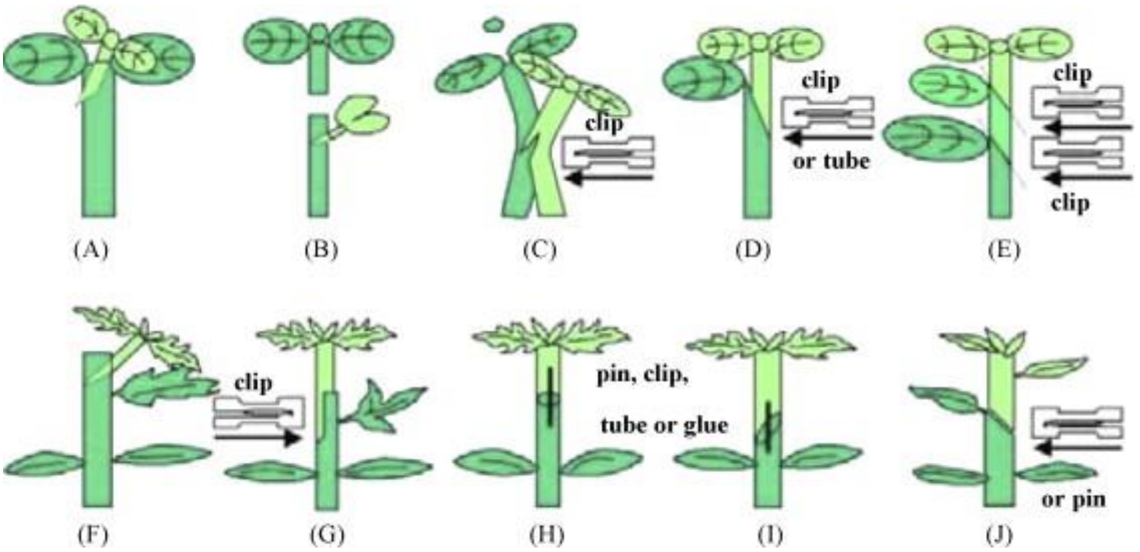
Rind grafting involves grafting a small scion onto the end of a thick stock. The thick stock is sawn off, and a ~4 cm long bark-deep cut is made parallel to the stock, from the sawn-off end down, and the bark is separated from the wood on one or both sides. The scion is shaped as a wedge, exposing cambium on both sides, and is pushed in under the back of the stock, with a flat side against the wood.

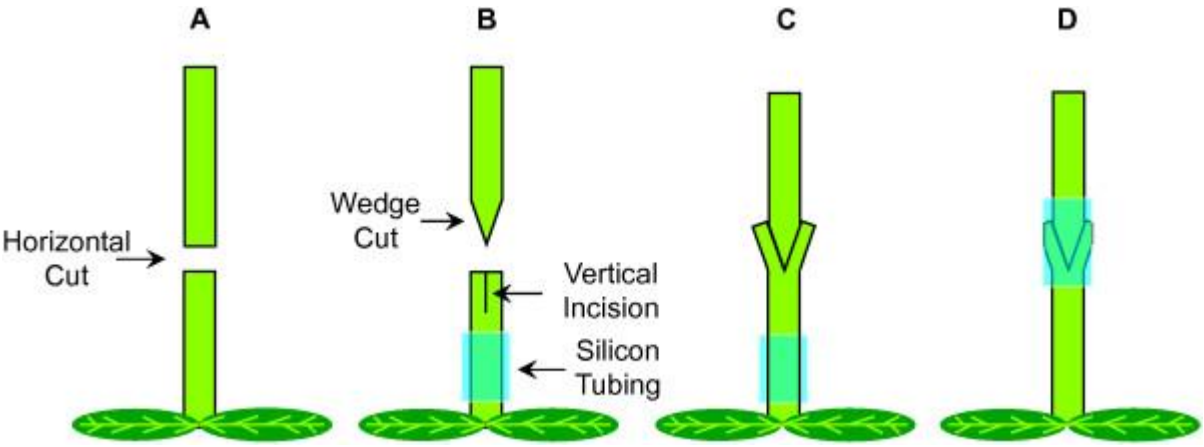
Graft chimera

Occasionally, a so-called "graft hybrid" or more accurately graft chimera can occur where the tissues of the stock continue to grow within the scion. Such a plant can produce flowers and foliage typical of both plants as well as shoots intermediate between the two. The best-known example this is probably +Laburnocytisus 'Adamii', a graft hybrid between Laburnum and Cytisus, which originated in a nursery near Paris, France, in 1825. This small tree bears yellow flowers typical of Laburnum anagyroides, purple flowers typical of Cytisus purpureus and curious coppery-pink flowers that show characteristics of both "parents". Many species of cactus can also produce graft chimeras under the right conditions although they are often created unintentionally and such results are often hard to replicate.

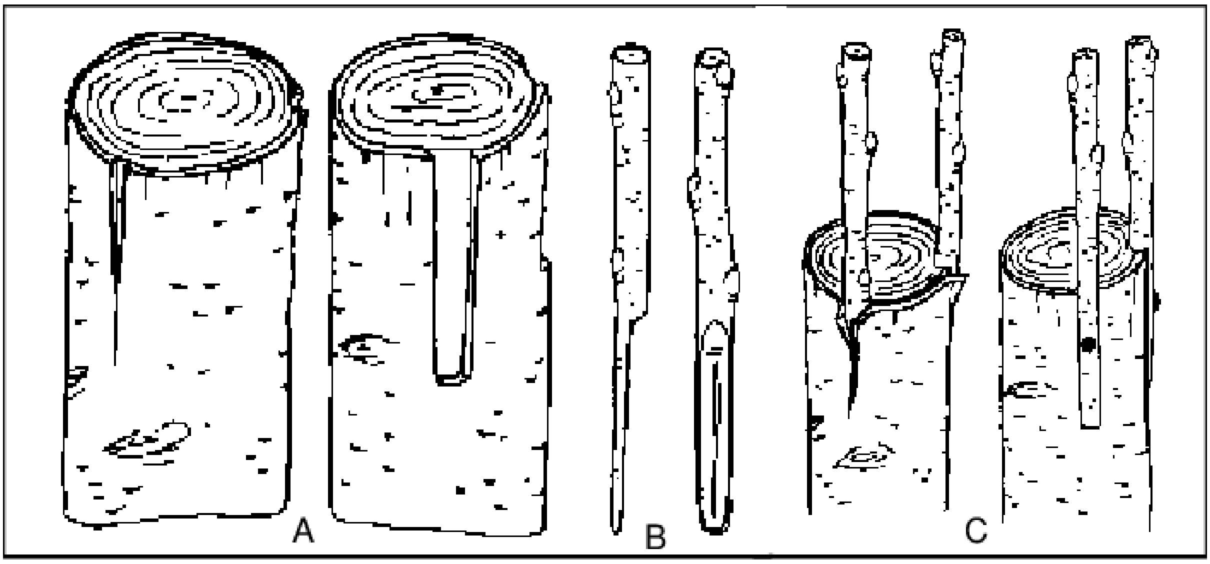
Scientific uses

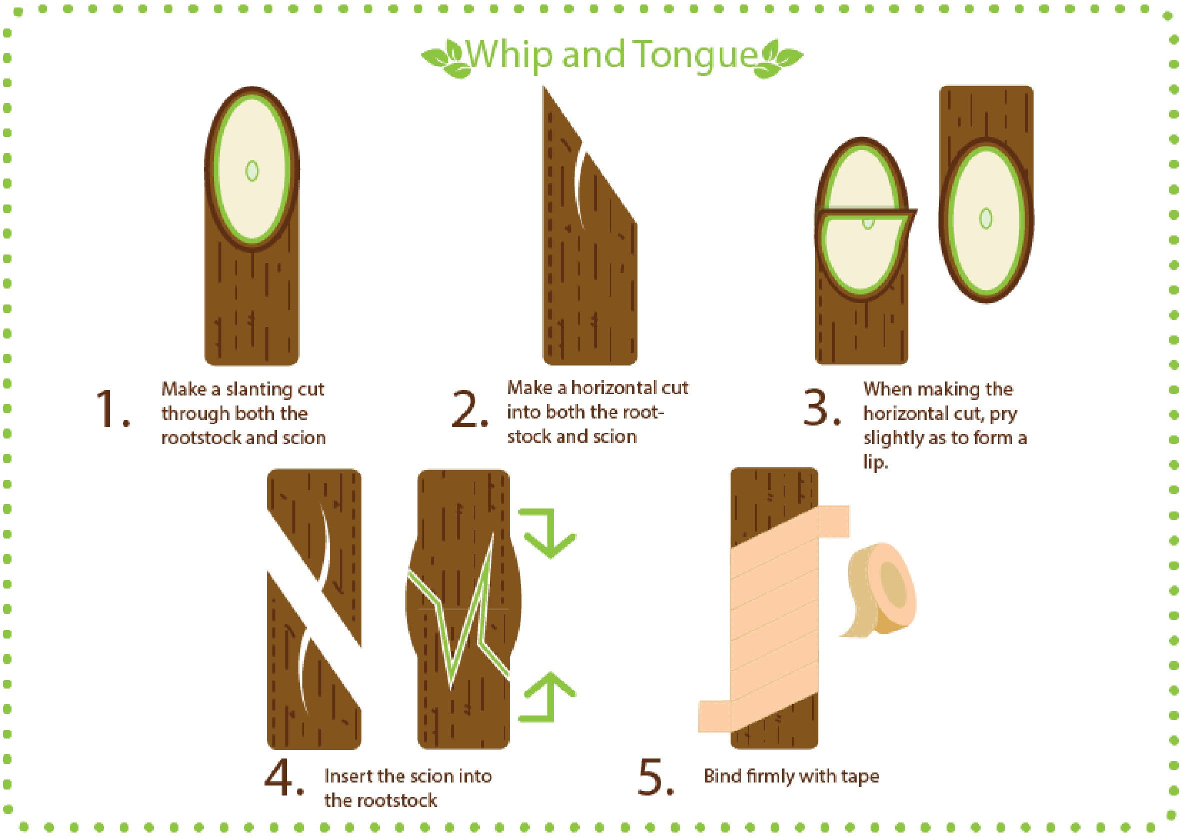
Grafting has been important in flowering research. Leaves or shoots from plants induced to flower can be grafted onto uninduced plants and transmit a floral stimulus that induces them to flower.





Veneer grafting




Whip and Tongue
1. Make a slanting cut through both the rootstock and scion
2. Make a horizontal cut into both the root-stock and scion
3. When making the horizontal cut, pry slightly as to form a lip.
4. Insert the scion into the rootstock
5. Bind firmly with tape