Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.8034

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2020) *8*(2), 154-163

Review Article

Indian Journal of Pure & Applied Biosciences

Propagation by Seed (Sexual Method) and Grafting (Asexual Method) in Horticulture Crops

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Received: 9.03.2020 | Revised: 12.04.2020 | Accepted: 16.04.2020

ABSTRACT

Horticulture crops are propagated mainly by two methods viz. sexual (seed) and asexual (vegetative). The plants produced through former method do not produce seedlings true-to-type wherein, identical characters (true-to-type) are inherited from mother plant through asexual method of propagation. Grafting is one of the important methods of asexual propagation methods. The plants produced through grafting yields at same time (uniformly) along with quality fruit. Seedling plants having long juvenile period and gigantic growth habit are considered uneconomical concerns w.r.t. plant protection measures, crop management, harvesting etc. Seed propagation and grafting method of asexual propagation with its type is reviewed and presented.

Keywords: *Propagation, Grafting, Types of grafting, Seed propagation.*

INTRODUCTION

The types of propagation are grouped as (i) sexual or seed propagation and (ii) asexual (vegetative) propagation. Sexual reproduction (propagation) is known as amphimixis. Multiplication takes place through seed that develop after normal meiosis fallowed by syngamy. Sexual reproduction refers to multiplication of plants by seed. In sexual process, fusion of male and female gametes takes place to produce seed. Meiosis division take place in course of fusion and chromosome numbers as in parents are reduced to half which after fertilization becomes normal. Therefore, the new individual formed in this way is not true-to-type e.g. phalsa, karanda, papaya etc. Grafting is one of the methods of asexual propagation. Grafting is the union of scion (bud) of one plant on or into rootstock (stem, root or branch) of another plant in such a way that a union will be formed and partners will continue to grow e.g. mango, apple, pear etc.

Cite this article: Sable, P.A., Kulkarni, S.S., & Wankhade, V.R. (2020). Propagation by Seed (Sexual Method) and Grafting (Asexual Method) in Horticulture Crops, *Ind. J. Pure App. Biosci. 8*(2), 154-163. doi: http://dx.doi.org/10.18782/2582-2845.8034

Propagation and its type

Plant propagation is defined as multiplication of plants by both sexual and asexual methods. Horticulture crops can be propagated through seed as sexual propagation and grafting as vegetative propagation are given below.

Seed formation

There are four important steps involved in seed propagation are given below.

(i) Development of gametophytes and gametes
(ii) Pollination
(iii) Fertilization (syngamy)
(iv) Post fertilization development (formation of seed and fruit)

Development of gametophytes

A normal flower consists of calyx, corolla, androecium and gynoecium. The last two parts of flowers have great significance in entire process of reproduction. When, androecium and gynoecium both are present in same flower is known as hermaphrodite or bisexual flower e.g. ber, citrus, guava, sapota etc. When, male (androecium) and female (gynoecium) parts of flower are present in separate flower but on same plant known as monoecious condition e.g. aonla, walnut, hazelnut, jackfruit etc. wherein, andromonoecious condition is found in mango, cashewnut in which male and hermaphrodite flower are present in same panicle. Further, the gynodioecious condition is found in some cultivars of papaya e.g. Pusa Delicious, Pusa Majesty, CO3, Coorg Honey Dew (Madhubindu), Sunrise Solo, Taiwan, Surya etc. Wherein, in dioecious condition male and female flowers are found on different plants, separately e.g. pointed gourd, ivy gourd, spine gourd, date palm and Pusa Giant, Pusa Dwarf, Pusa Nanha, CO-1, CO-2, CO-5, CO-6 etc. cultivars of papaya.

Microsporogenesis and microgametogenesis

Production of microspore from pollen mother cell (PMC) is termed as microsporogenesis. Generally, each anther has four pollen sacs which contain numerous pollen mother cells (PMCs). After meiosis, each PMC results into four haploid cells or microspores. After thickening of the cell wall of microspore, it is termed as the pollen grain.

On other hand microgametogenesis refers to the production of male gametes. During maturation of pollen, the microspores nucleus divides mitotically to produce a generative and a vegetative or tube nucleus. The pollen is generally released in this binucleate stage. When the pollen reaches the stigma of flower it is termed as pollination. Shortly after pollination, pollen grains start germination. The pollen tube enters into stigma and grows through the style. The generative nucleus now undergoes a mitotic division to produce two male sperms. The pollen alongwith pollen tube is known as microgametophyte. The process between microspore to microgametophyte is termed as microgametogenesis. Pollen tube finely enters into ovule through a small pore, micropyle, and discharges the two sperms into the embryo sac (Shukla et al., 2004).

Megasporogenesis and megagametogenesis

Megasporogenesis can be defined as production of megaspore from megaspore mother cell (MMCs). Megasporogenesis occurs in ovule which is present inside the ovary. A single cell in each ovule differentiates into megaspore mother cell. The megaspore mother cell undergoes meiosis to produce four haploid megaspores. Three of them degenerate leaving one functional megaspore per ovule.

Under the process of megagametogenesis, the nucleus of a functional megaspore divides mitotically to produce four or more nuclei. The exact number of nuclei and their arrangements varies considerably from one species to another species. In most of the cases megaspore nucleus undergoes three mitotic divisions to produce eight nuclei. Three of these nuclei move to one pole and produce central egg cell and two synergid cell. One synergid is situated on either side of the egg cell. Another three nuclei migrate to the opposite pole to give rise to an antipodal cell. Remaining two nuclei in the center are known as polar nuclei and after fusion forms the secondary nucleus. Megaspore develops into a mature megagametophyte or embryo sac and the development of embryo sac from a megaspore is known as megagametogenesis.

Fertilization (syngamy)

Fusion of the one of the two sperms with egg cell, producing a diploid zygote is known as fertilization or syngamy. While, fusion of remaining sperms with the secondary nucleus leads to the formation of a triploid primary endosperm nucleus is termed as triple fusion. When, triple fusion and syngamy takes place simultaneously it is termed as double fertilization.

Post fertilization development

A series of changes in the ovule fallows as the fertilization is over. Synergids and antipodal cells become disorganized, and the egg cell becomes covered with a cell wall, known as oospore. This follows the development of seed. The various part of gynoecium develop into ovary-fruit, ovule-seed, integument outer testa (outer seed coat), integument inner tegmen (inner seed coat), secondary nucleus after fertilization-endosperm (triploid), egg cell (after fertilization) embryo, nucellus-perisperm (nutritive tissue like endosperm).

Asexual propagation

It does not involve the gametes from parents. It takes place due to mitosis division. Mitosis division continues in shoot tip, root tip and cambium. When, some portion of plants is wounded, mitosis division takes place. Under mitosis division chromosomes divide longitudinally to form two daughter cells. This forms the basis of asexual propagation. It is simply a vegetative or somatic extension of one parent and there is no chance of inheriting a mixture of characters. The plants raised through asexual process are identical to mother plants.

Modes of reproduction in relation to fruit breeding

The reproduction system is principally responsible for perpetuation and preservation of particular genotype. Further, the mode of reproduction also determines the genetic constitution of fruit crop whether it is homozygous or heterozygous.

Asexual propagation

i. By using apomictic seeds. e.g. citrus, mango and apple
ii. By using vegetative parts of the plant

By using apomictic seeds (Apomixis)

Apomixis refers to the development of embryo without fertilization. The plants developed from apomictic seeds are true to type. Obligate apomictic seeds developed with or without pollination but without fertilization e.g. *Malus* sp. Wherein, in case of facultative apomictic seeds both type of embryo may develop i.e. zygotic as well as nucellar embryo e.g. citus and polyemdryonic cultivars of mango (Shukla et al., 2004).

Classification of apomixis

Recurrent apomixis

The embryo sac (female gametophyte) develops from the megaspore mother cell where meiosis is disturbed (sporogenesis failed) or from adjoining cell (megaspore mother cell disintegrates). The egg cell is diploid and embryo developes directly from the diploid egg cell without fertilization. Generally, somatic apospory, diploid parthenogenesis and diploid apogamy falls under recurrent apomixis e.g. raspbery (*Rubus* sp.), *Malus hupehensis, M. sikkimensis, M. sergeant and M. toringoides* (Gupta, 2014).

Non recurrent apomixis

The development of embryo takes place from haploid haploid egg cell without fertilization. Such type of apomixis rarely occurs. Generative apospory, haploid parthenogenesis, haploid apogamy and androgamy fall under non-recurrent apomixes e.g. mango, citrus, jamum.

Adventitive embryony / nucellar or polyembryony

In this case more than one embryo develops in a single seed. In the seed both types of embryo develops i.e. nucellar embryo from nucellar cell and zygotic embryo from egg cell with the result of syngamy. e.g. Olour, Goa, Kurukkan, Bappakar, Vellaikolamban, Chandrakaran cultivars of mango and most of the sp. of citrus except citron (*C. medica*), pummelo (*C. grandis*) and tahiti lime (*C. latifolia*) (Shukla et al., 2004).

How to differentiate the poly embryonic and sexual seedlings

It is difficult to differentiate in the nursery. Generally more vigorous seedlings are considered to be polyembryonic. By rejecting about 10 per cent of weaker and weakest seedlings, one can have fairly uniform poly embryonic seedlings.

Vegetative apomixis

This is not common in fruit crops. However, in some cases like *Poa bulbosa* and some *Allium*, *Agave* sp. produces vegetative buds or bulbils instead of flowers in the inflorescence.

Apospory

Sometimes when, embryo sac develops from archisporial or from the nucellus or from other cell. If it is developes from haploid megaspore cell it is known as generative or haploid apospory. On the other hand, if it develops from diploid cell i.e. nucellus of other cells it is termed as somatic or diploid apospory.

Parthenogenesis

Development of embryo from egg cell with or without pollination but without fertilization. Depending upon the ploidy levels of egg cell, parthenogenesis can be haploid (non recurrent) and diploid (recurrent) e.g. mangosteen (*Garcinea mangostana*).

Apogamy

Development of embryo from synergids or antipodal cells within the embryo sac with or without pollination but without fertilization is termed as apogamy. This type of apomixis is also grouped into haploid and diploid apogamy depending upon the ploidy level of cell. Diploid apogamy is recurrent whereas haploid apogamy is non recurrent.

Androgamy

Development of the embryo from male gametes inside or outside of embryo sac is known as androgamy. Since the cells are haploid in nature therefore, it comes under non recurrent type (Shukla et al., 2004).

Grafting

Grafting is the union of scion (bud) of one plant on or into rootstock (stem, root or branch) of another plant in such a way that a union will be formed and partners will continue to grow. There are some conditions related to successful grafting are given below

Stock

Below portion of the union called as rootstock. Stock is that part of a graft which has the root thereby supports to growth of union. A stock is called” seedling root stock” if it is grown from seed and “clonal roots stock” if it is propagated by vegetative methods of propagation e.g. cutting, layering etc.

Scion

Above portion of the union called as scion. Scion is a portion of the stem or branch of the variety which is desired to propagate. It may be a shoot or a branch 15-20 cm long consists of dormant buds. It may be taken from current or past season’s growth or even old wood, but in most species current or past season growth performs better as scions than the old wood. The scion for grafting is a stick consists of dormant buds wherein, the scion for budding is only a single bud along with a little bark.

Matrix

Matrix is the place on the rootstock which is preferred for joining the scion or the bud. Inspite of these there might have some limitations of graftage as given below. For the successful union of the two parts, three conditions must be fulfilled.

- Compatibility.
- Close botanical relationship and
- Continuous contact of cambium layers and tight fitting (closeness of fit).

Compatibility, rootstock and scion must be compatible. The word compatible designates the suitability of the reciprocal influence of stock and scion on each other. If the influences of one on the other are suitable to each other we say that both are compatible. If some influences are not suitable we say that they are incompatible. A union will not be successful if the stock and scion are not compatible. Incompatibility or incongeniality is indicated by a) complete failure to unite b) the union may be short lived 3) the union may be long lived but the joint maybe swollen or the stock may overgrown the scion and vice-a-versa. This will result in an obstruction in the easy sap flow. Probably, but not always, varieties of the same species will be the most compatible. Distantly related ones will be less compatible or cannot make a successful graft combination but there are always exceptions.

There is no direct way of telling in advance whether a trial will be successful or not.

Close botanical relationship (stionic effects) term is used to designate the relationship between stock and scion. Stionic effects are the reciprocal influences of stock and scion on each other.

Continuous contact of cambium layers and tight fitting (closeness of fit), the vascular cambium of the scion must be placed in direct contact with that of rootstock. Vascular cambium is nothing but tissues are responsible for the formation of xylem and phloem in the successful graft union development. The cut surface is to be held together tightly by wrapping, nailing etc. Rapid union development is necessary so that the scion can supplied with water and nutrients from the rootstock at the time buds start to open. Instead of the above mentioned conditions there are some conditions pertaining successful union are such as

The grafting must be done at a time when the rootstock and scion are in the proper physiological stage. Probably, it means that the scion buds are dormant while, at the same time the cut tissues at the graft union are to be capable for producing the callus tissue which is prerequisite for grafts wound healing. For deciduous species, scion bud-wood selected during winter is to be dormant and must keep inactive by storing at low temperature. The rootstock plant is either dormant or in active growth (Garner, 1947).

Immediately after the grafting is completed, all cut portion must be protected from desiccation by covering with polythene tape and grafting wax etc or grafts are to be kept in moist condition or grafting frame.

De-suckering is to be done frequently as observed from the rootstock below the union for vigorous growth of scion.

Demerits of sexual (seed) propagation

- Varietal purity cannot be maintained as fruit trees propagated by sexual propagation (seed) (Singh *et al*., 2018).
- Juvenility-seedling plants take decade for fruiting.
- Seedling plants canopy covers larger area.

Merits of grafting (vegetative) propagation

- True to type-plant retains the characteristics of the mother plant.
- Precocity in flowering and fruiting- plant get flower and fruit earlier than seedlings.
- Plants remain comparatively smaller and economical for plant protection, harvesting etc cost.
- High density planting- more plants accommodation per unit area (Singh *et al*., 2018).
- Harvesting can be done at uniform time.
- Yields earlier and gives higher economic returns and
- Grafting methods are also used to repair broken limbs, injured trunks thereby conversion of inferior varieties into superior one.

Types of grafting

Typed of grafts can be grouped as a) detached scion graftage, consists of removed scion shoot and grafted to the apex or side of rootstock e.g. whip grafting, tongue, cleft (split graft), wedge, saddle graft, side tongue graft, side-veneer, bark graft etc. b) approach graft, the root system of the scion and shoot system of the rootstock are not removed until successful graft union formation and c) repair graft used for repairing or reinforcing injured or weak trees e.g. Inarching, bridge grafting etc. The detail of grafting in horticulture crops (trees) as given below.

Whip grafting can be done in those trees that unite easily. It is also known as splice graft and simple and easy to make. This method is same as the whip-and-tongue grafting except that the second (tongue) cut is not taken on rootstock or scion. Generally, one year old rootstock (10-15 mm diameter) is to be used for union with scion having same thickness. A simple slanting cut of the same length (2.5 to 6 cm) and angle is to be taken on both the rootstock and scion then placed together followed by wrapping, immediately (Garner, 1947). As scion is found smaller than the rootstock, it is to be set at one side of the rootstock so that the vascular cambium layers will match along that side. Apple, mango, pear etc can be propagated by this method. Splice grafting (whip grafting) done in mango during August to November gives success up to 80 per cent but shows poor survival (Singh et al., 2018). Factors like varieties, time of grafting, method, growing conditions, defoliation period of scion, age of the scion, leaf and node retention on rootstock etc influenced the success and survival per cent of mango grafts. Rainy season grafting in mango shows best results of growth and survival per cent than seasons.

Whip-tongue grafting is modified form of whip grafting**.** This method is common in grafting of relatively small rootstock and scion (about 6 to 13 mm thickness). If tongue grafting is to be done neatly makes a strong union because of considerable vascular cambium contact thereby quick wound healing. It is practiced, especially in pear, apple, walnut, apricot trees etc. In this method a slanting cut similar to whip grafting is taken on rootstock and scion. The scion is containing 2 to 3 buds and the grafting is to be done on smooth internodes portion below the lower bud. The cuts taken at the top of rootstock is to be same as those made at the bottom of the scion. First slanting cut is to be taken 2.5 to 6 cm long by sharp blade knife in a single stroke, satisfactory union will not be formed because of uneven cuts taken by blunt knife; longer cuts may be taken as stock and scion is large. A second cut is also taken in reversed direction on previous cuts in root stock and scion. The second cut is started downward at about 1/3 rd distance from tip and should continue to about ½ the length of first cut. The stock and scion are to be inserted into each other with tongue interlocking (Singh, 2011). While, matching cut portions of scion and rootstock the cambium layer of both must match. The lower tip of the scion should not overhang the rootstock because it increases the formation of large callus knots, so that scion larger than rootstock is to be avoided. After uniting rootstock and scion, union is to be wrapped using polythene tape. In order to avoid desiccation the graft union is to be sealed with grafting wax, grafts may be provided high relative humidity. In apple, the tongue grafting can be done on M_4 (semi dwarfing, 5 m height) and M_9 (very dwarfing, 3 m height) rootstock.

Cleft grafting (split grafting) is one of the oldest top working techniques adopted in trees like mango, hazelnut, pecan-nut, grape etc (Singh, 2011). It is required for topwork trees, either in the trunk of a small tree or in the scaffold branches of a larger tree. Cleft grafting is used for crown grafting. In case of top working trees, the use of this technique is to be limited to branches of about 2.5 to 10 cm diameter and to species with fairly straight-grained wood that will split evenly. Although cleft grafting can be done any time during the dormant season but the chances for successful wound healing of the graft union are found best when the work is to be done in early spring (when the rootstock's buds starts to swell) but before active growth has started. When, cleft grafting is done after the tree is in active growth, the bark of the rootstock can separate from the wood, hence difficulties may found in the successful graft union. As this separation is to be found, the loosened bark must be firmly nailed back in original position. Unless the grafting is done early in the season, scion is to be collected well in advance and refrigerated (Garner, 1947). The perpendicular cut to the main axis of the branch is to be taken. On the stub to be grafted, a downward vertical split 5 to 8 cm in length is to be taken, centrally. The vertical incision is to be taken on two side of the stock. After a split is taken a chisel like wedge shape portion is to be inserted into the top of the split to hold it open. Two scions shoots about 8 to 10 cm in length and 10-13 mm thickness (pencil thickness or 1 year old) having 2-3 buds is to be preferred. Gentle wedge shape cut about 5 cm in length is to be taken on lower portion of scion. The bark of the rootstock is to be always thicker than the scion bark in order to match the vascular cambium layers of both, unitely. Top portion of the stub, stub splits and top portion of the scion is to be waxed but not the bark or buds of the scion. After 2 or 3 days inspection, if the openings are to be found rewaxing is to be done otherwise, failure may be found in this type of graft. The sprouting can start after 3 to 4 weeks then wrapping is to be removed (https:/www.angrau.ac.in).

Wedge grafting method is also used for top working old trees. This method can be adopted in late winter i.e. mild climates or early spring season which coincides condition before the bark begins to slip. The thickness of the rootstock and scions are to be preferred same as cleft grafting. V-shape incision about 5 cm in length is taken on the side of stub of the plant. Downward matching incisions are to be made on lower portion of the scion (s). With two vascular cambium layers matching, the scion is tapped downward firmly into place and slanting outward slightly at the top so the vascular cambium layers cross. For 5 cm wide stub 2 scions are to be inserted 180 ^{O} apart wherein, for 10 cm wide stub 3 scions are to be inserted 120 ^{O} apart. The incised portions including tip of the scion (s) are to be waxed properly.

Bridge grafting is mainly used to repair damaged trees or branches and not for propagation. Damages may be caused because of injury to trunk by cultivation practices, rodents, pest and diseases or winter injury etc. When damage is to be found more the tree may be died because of roots will be deprived for their carbohydrates supply from the top of the plant. Wherein, probably woody plants with severely damaged bark are to be repaired by this method. This can be done in early spring season when active growth of the plant is beginning thereby bark is slipping softly. The scion (s) in dormant stage of one year old growth having thickness 6 to 13 mm of same compatible species is (are) to be preferred. The compatible species scion (s) is (are) to be kept in the refrigerator till grafting. It may be done in late spring season but scion used is to be in buds growth starts condition thereby the developing buds or new shoots are to be rejected. Where bark of the branch or trunk is damaged and dead first clean the same portion upto undamaged tissues followed by V shape cut in the bark horizontally. In next step, prepared scions according the size of the damaged portions are to be inserted every 5 to 7.5 cm around the injured portion and attached at both the above and below ends into live, undamaged bark. It is to be fixed using nail and then sealed using grafting wax, especially at graft union. The sprouted buds from inserted stick (s) are to be removed time to time. Slowly and slowly, it grows in diameter and covers the damaged portion. Damaged wood of fruit tress like apple, pear, cherry, walnut etc can be repaired by this method.

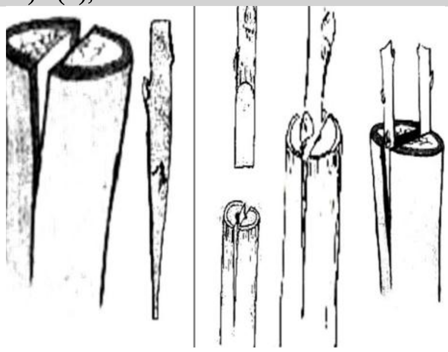
Double working- in some instances, scion cultivar fails to grow if grafted directly over the rootstock. To avoid this situation, an intermediate stock is to be used in between rootstock and scion. Care is to be taken that intermediate stock is to be compatible to both rootstock and scion. The process of double top working is to be accomplished in two successive years. During first year, grafting of inter stock is to be made on rootstock then during second year grafting of scion cultivar in to be made on inter stock (Singh, 2011). The interstock may be less than 2.5 cm in length or enough to include the trunk and secondary scaffold branches of the tree. Double working can be practiced chiefly in pear, Beurre Hardy is the widely used interstock besides this Old Home, Vicar of Winkfield, Pitmaston Duchess also found suitable interstock. There are three genetically distinct parts and two graft unions in a double worked plant (Garner, 1947). The pear cv. Bartlett scion is to be grafted on an Old Home interstock then grafted to dwarf quince rootstock. Double working can be done as double-shield budding (T-budding). A nursery tree is obtained in 1 to 2 years after budding. The interstock can be budded on the scion buds inserted about 15 cm apart in late summer. The budded interstock shoots are to be removed with the budded scion at the terminal end of each piece and grafted by whip graft on seedling rootstocks during late winter (Garner, 1947). After callusing, the completed graft now consists of rootstock, interstock and a budded scion is to be ready for planting in the nursery.

Inarching (approach grafting) some trees are very difficult to graft like mango, macadamia nut etc in these cases approach grafting method can be used. The special feature of this method is that two independent plants are to be grafted together. When the union is established, the top portion of the rootstock plant above the graft and the lower portion of the scion plant are to be removed below the graft. It is mostly performed with one or both of the plants growing in a container. Rootstock plants in containers may also be placed adjoining an established plant that is to furnish the scion part of the new grafted plant. This type of grafting is to be done when plant growth is active and rapid healing of the graft union will take place. In the spliced approach grafting method, the two stems are to be approximately the same size. At the point where the union takes place, a slice of bark and wood about 2.5 to 4 cm in length is to be cut from both stems. This cut should be the same size on each so that vascular cambium of both plants is mate. The cuts must be flat as possible so that closer contact of the vascular cambium layers of both stems can be take place. The union is to be wrapped tightly by polythene grafting tape.

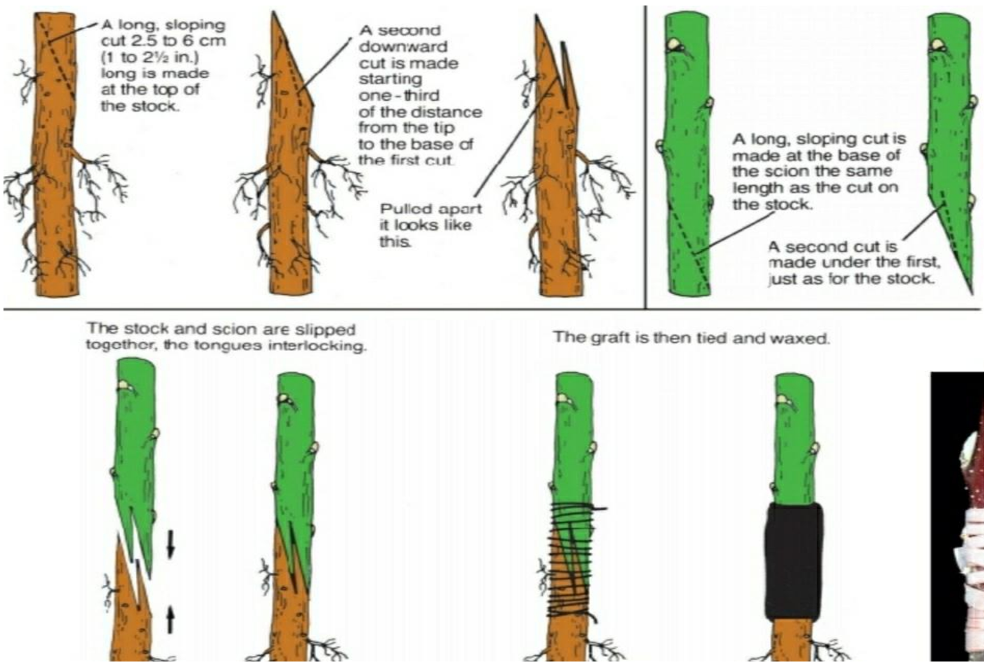
Frame working, grafting on many small secondary scaffold branches in the tree constitute frame working. It requires insertion of grafts throughout the main frame of the tree. A large number of scions are to be required to replace the small laterals and scaffold branches. Growth coming out of the previous frame of the tree is to be removed time to time to favours establishment of scions. Frame working is to be restored using budding or grafting technique. This technique is being cumbersome and expensive so it is not practiced economically in the fruit crops (Singh, 2011).

Epicotyle grafting is known as stone grafting. This method can be adopted during mansoon (June-July) as the environments remains enough moist during said period. The mango stons (seeds) are to be sown in nursery beds by spreading 5 to 7 cm thick layer of well decomposed FYM (farm yard manures). Sand as medium is to be preferred in more proportion for bed preparation so that seedlings are to be uprooted easily at the time of grafting. Seeds can be germinated in about 15-20 days and grafting is to be done on these seedlings (rootstock) of 7 to 10 days old which shows coppery colour leaves. A 2.5 to 4 cm vertical spit is to be taken on the rootstocks which are beheaded at 10 cm from ground surface. Shoots 2 to 3 months old having pencil thickness is to be preferred as scion for grafting on seedlings (rootstock). The sprouting of scion buds can be favoured by defoliating scion stick leaves 10 days well in advance of grafting. As union takes place such grafted plants are to be maintained in other beds or pots in the protected structures. When stone grafting in mango done during first week of July using 7 to 10 days old seedling as rootstock, cv. Mulgoa gave 100 per cent successful graft wherein, average sprout length was recorded under June grafting and survival after 180 days was highest in August grafting (Yadav & Singh, 2018).

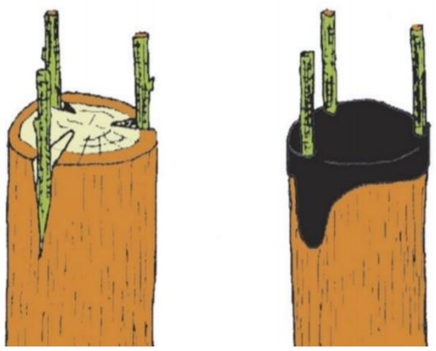
Soft wood grafting is very successful technique of in-situ grafting mostly adopted in mango. In this method, the mango stones (seeds) are to be sown at appropriate distance in the field at the monsoon season. Germination per cent can be checked by sowing 2 to 3 seeds in each pit well in advance. As the plant becomes one year old thereby attains pencil thickness, it is to be used for grafting. The grafting is to be done at permanent site of planting in field itself (in-situ). Grafting is to be done during monsoon when new growth appears on the rootstock as new growth leaves start turning yellow from coppery colour grafting is to be performed. Scion 10 to 15 cm in long having 3 to 5 months of age along with pencil thickness is to be selected for grafting. The rootstock is to be beheaded at 15 to 20 cm height from ground level. A vertical slit same as in epicotyle grafting is to be taken on the rootstock. On scion shoot, slanting cuts matching with rootstock cut is to be taken on both sides in lower portion. It is to be inserted in the slits on rootstock followed by polythene tape wrapping, tightly. Sprouting can start in about 3 to 4 weeks thereby graft starts growing (Singh, 2011). Due to in-situ grafting plant shows better survival per cent in the field. Softwood grafting in mango can be done during June to October in Andaman region whereas, higher grafting success is recorded when grafting is done in August (Singh & Suryanarayana, 1996).



Whip grafting **Cleft grafting (split grafting)**



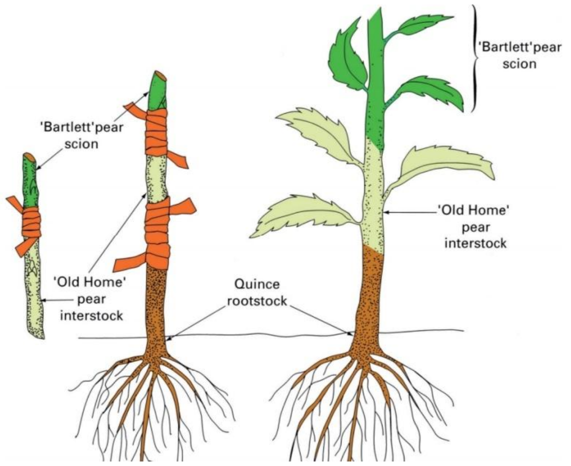
Whip-tongue grafting



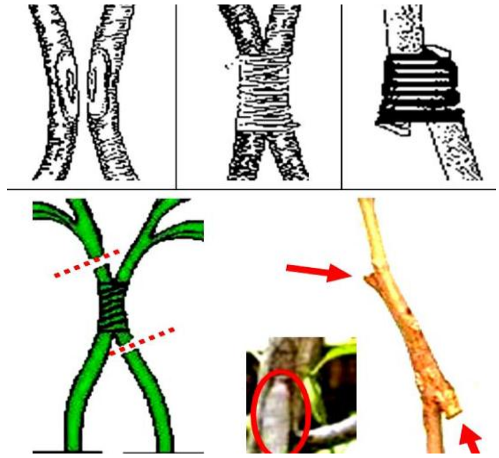
Wedge grafting **Bridge grafting**

Plate: Different methods of grafting

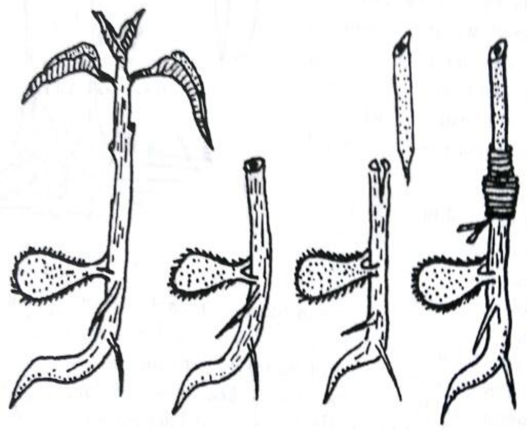
Image source: (Garner, 1947, Singh, 2011 and https:/www.angrau.ac.in)



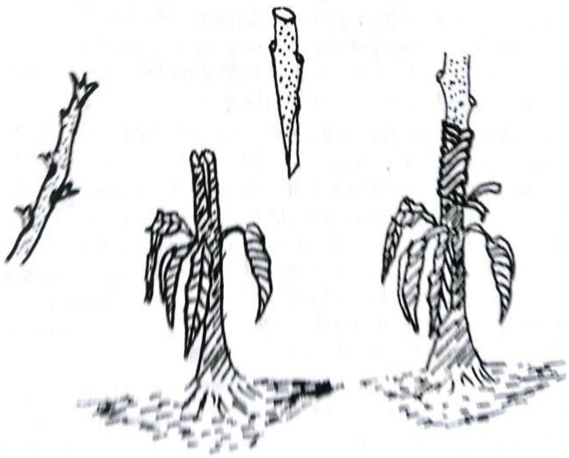
Double grafting



Approach grafting



Epicotyle grafting



Soft-wood grafting

Plate: Different methods of grafting

Image source: (Garner, 1947, Singh, 2011 and https:/www.angrau.ac.in)

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