TFRI Publication No. 11

VEGETATIVE PROPAGATION OF TREES

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1997

CONTENT

Acknowledgement

The authors are grateful to Dr. B.N. Gupta, Director, Tropical Forest Research Institute, Jabalpur for his encouragement; to Dr. A. K. Mandal, Head, and Sri S. Kumar, Scientist 'SC', Genetics and Plant Propagation Division, TFRI, Jabalpur for their critical comments and valuable suggestions during the preparation of this publication. Lastly, the financial assistance provided by the World Bank FREE project for undertaking the publication of this technical bulletin is gratefully acknowledged.

1. Vegetative Propagation : Theoretical Aspects

1.1 Significance of vegetative propagation

The vegetative or asexual propagation involves plant regeneration by means of its vegetative parts. It circumvents seed generation and, thereby, ensures a genetically uniform plantlet population identical to donor (mother) tree. In nature, some plant species also propagate themselves by special vegetative structures (propagules) such as runners, bulbs, corms, rhizomes, tubers, etc. The vegetative propagation constitutes a very important component of the "**tree improvement programme**" and helps achieve the following objectives :

- Conservation of selected superior genotypes, i.e. establishment of germplasm banks.
- Establishment of clonal seed orchard.
- Clonal multiplication of superior genotypes for clonal forestry, facilitating quick genetic gains.
- Curtailing "**long seeding cycle**" and "**size**" of woody perennials for undertaking breeding work, i.e. creation of breeding populations.
- Propagation of special breeding material, e.g. exceptional hybrids, etc.
- Capturing physiological status such as early flower and fruit set for quick economic return.

1.2 Historical

The art of vegetative propagation has evolved much ahead of its scientific understanding which could develop towards the end of the previous century only. The literature, however, reveals enormous examples of flori-horticultural crops which have been propagated asexually since antiquity. For instance, the popular seedless grapes, e.g. "**Cabernet Survignon**" or "**Sultana**" has been vegetatively propagated for the last 2,000 years. Similarly, the Chinese fir (*Cunninghamia lanceolata* {Lamb.} Hook), China's major timber producing conifer, has been perpetuated by cuttings for over 1000 years with an estimated productivity gain from 193.5 m^3/ha to 1,170 m^3/ha.

1.3 Principles of vegetative propagation

The vegetative propagation encompasses following three very important biological principles :

- Totipotency
- Juvenility
- Polarity

1.3.1 Totipotency

The term, introduced in 1839 by Trupin, demonstrates that the detached tissue or organ of a plant has the capability to develop whole plant naturally or under specific circumstances (Fig. 1). It implies that each cell (building block) of an individual plant possesses all necessary genetic information for development of the whole plant. However, the same cell, when surrounded by other cells within the plant, is programmed in such a way as to attain only a desired developmental level such as formation of specific tissues or organs, a situation referred to as **homeostasis**. In vegetative propagation, the same "**totipotency**" behaviour is utilized to propagate the individual plant without altering its genetic composition.

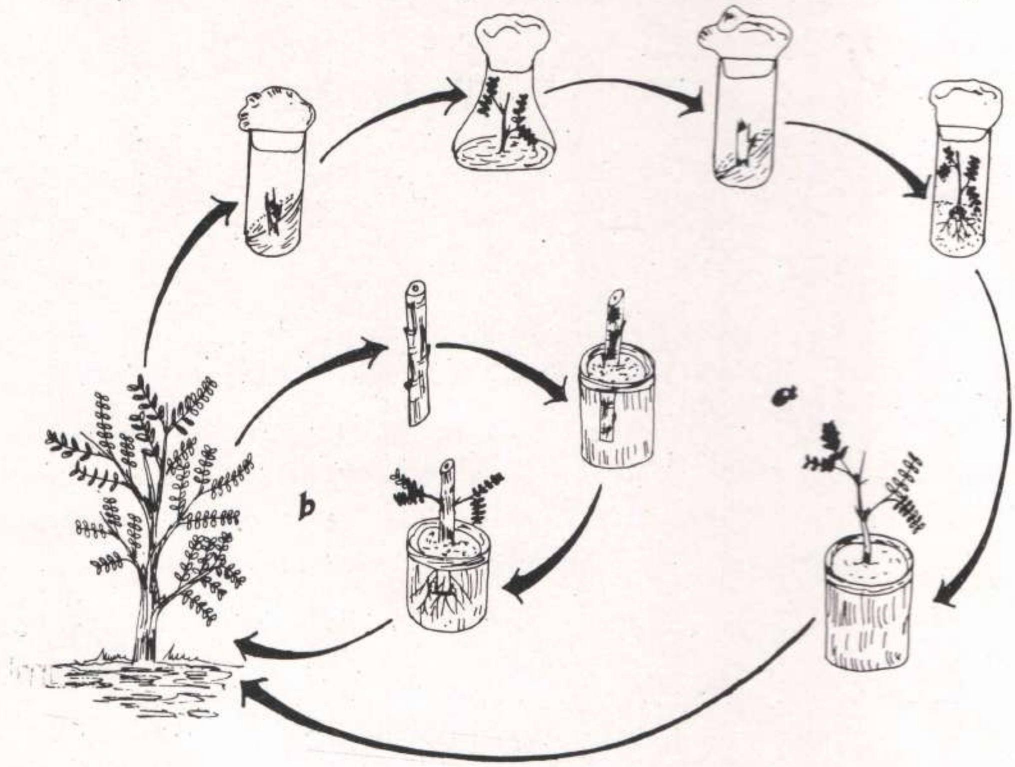


Fig. 1 : Totipotency, i.e. regeneration of whole tree from (a) nodal explants or (b) shoot cutting.

1.3.2 Juvenility

The juvenility is the initial period of growth when the plant does not produce flowers on being challenged by external or internal stimuli, but its tissues or organs exhibit maximum regeneration into whole individual by adventitious roots, shoots or both. In some plant species the juvenile phase may be distinguished easily on the basis of leaf shape, thorniness, vigour and disease resistance. It has been established that the juvenility continuously declines as plant grows from embryo to adult individual, leading to poor regeneration. In trees, the juvenility declines more rapidly with the extension growth than the radial growth; the former remains active almost the whole year with undergoing multifarious cell divisions and the latter usually occurs once or twice a year with a few cycles of cell divisions. Therefore, tissues (e.g. root and shoot apices) and organs (e.g. lateral branches of roots and shoots) situated away from the embryonic axis become less juvenile together with poor regeneration (Fig. 2). The juvenility may be halted by arresting cell division (**cryopreservation of tissues**) or tapped by pruning top branches (**maintenance of tree hedge**) or induction of coppice shoots at the base of the trunk of the tree. Alternatively, serially grafting the mature buds/twigs on young rootstock also recaptures juvenility in some cases (Fig. 3).

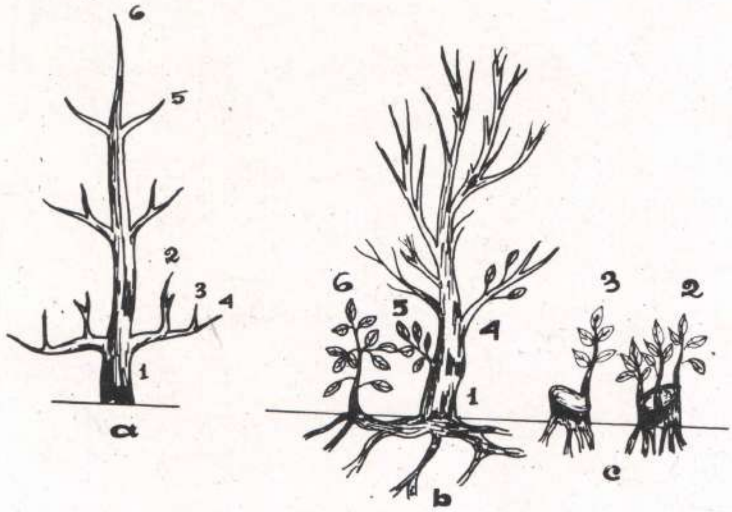


Fig. 2 : Juvenility gradient in trees (a) seedling trees, (b) mature flowering tree with a root sucker and (c) coppice shoots. In these trees, juvenility follows the pattern in the order 1 > 2 > 3 > 4 > 5 > 6.

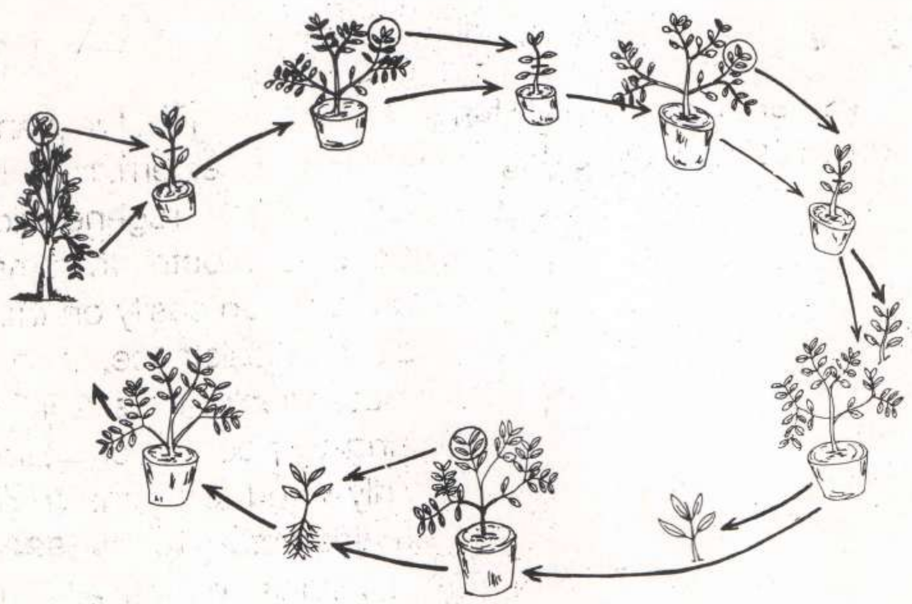


Fig. 3 : Scheme for regeneration by serial grafts exhibits adventitious root formation after sixth serial graft.

Since vegetative propagation mostly involves regeneration of adventitious roots in shoot cuttings collected from the donor tree, the totipotency in such cases is viewed with special reference to ease of adventitious rooting that, inturn, depends upon juvenility of the donor tree. Thus, the rooting potential of the cuttings generally declines with the aging of the donor tree. It also depends upon the position of the cuttings, being maximum and minimum in cuttings collected from the base and top branches, respectively, of the crown of the donor tree.

1.3.3 Polarity.

The growth and development of plants/trees follows a predetermined course that becomes well established with the first transverse division of zygote. Of the first two cells thus formed, the cell towards micropyle, i.e. proximal cell constitutes future hypocotyl (radicle) or root system and the other cell away from the micropyle, i.e. distal cell forms future epicotyl or shoot system. Thus, the embryo maintains distinct polarity, i.e. root pole and shoot pole that remains prevalent through out the life of the tree. In fact, the cytology of the egg - the presence of a large vacuole in its proximal end and dense cytoplasm and nucleus in its distal end with respect to micropyle of the ovalue - suggests that polarity may have well established before fertilization. The concept of polarity has great relevance in induction of adventitious roots in shoot cuttings of trees. Thus, the root (proximal) end of shoot cuttings is always the site of adventitious root formation and kept downward inside the substratum, and usually receives rooting treatment.

1.4 Factors affecting vegetative propagation

There are several exogenous and endogenous factors which influence the regeneration from the excised organ or tissue. They are enlisted below :

1.4.1 Exogenous factors

- Seasonal variation
- Temperature
- Humidity
- Light
- Plant growth regulators

1.4.1.1 Seasonal variation

Success of the vegetative propagation is a season specific phenomenon and usually attains the highest value when the donor tree is about to resume active growth after winter dormancy. At this time, the bud break starts with concurrent synthesis of auxin and other co-factors which help differentiate adventitious organs specially roots at the expense of reserved food material of the vegetative part. In most tropical and sub-tropical deciduous trees, the season coincides with the emergence of new sprouts (after complete leaf fall) and the resumption of cambial activity, and begins from the end of February to end of May. The narrow-or broad-leaved evergreen species have one or more flushes of growth during the year and cuttings/buds can be obtained year-round in relation to these flushes of growth.

1.4.1.2 Temperature

The optimum temperature for vegetative propagation is variable for different species and in the range of 18°C to 25°C for temperate climate species and 7°C higher for warm climate species. Also, different stages of root formation have different temperature requirement such as 30°C for root initiation and 22°C to 25°C for root development (elongation of primordia and emergence of roots from the stem cuttings) in *Forsythia* and *Chrysanthemum.*

1.4.1.3 Humidity

Maintenance of adequate humidity, i.e. 60-80 % RH is of paramount significance as it facilitates regeneration by way of avoiding water loss of the vegetative part (propagule) used for regeneration.

1.4.1.4 Light

It influences vegetative propagation by three ways viz., light intensity, light duration (photoperiod) and light quality. Low light intensity usually favours regeneration especially of roots in many plants e.g. blueberry, weigela, forsythia, viburnum and hibiscus. The acceptable light ranges are 20-100 W/m^2/day. Further, orange - red end of light spectrum seems to favour rooting of cuttings. As for light duration, there is no general recommendation. However, it is believed that the photoperiod favouring flowering in a species counters its vegetative regeneration.

Keeping above factors in view, there is growing trend for simulating environmental conditions for optimum vegetative propagation. This is achieved through construction of a growth-cum-mist chamber which is equipped with control devices for manipulating and recording temperature, humidity and light (Fig. 4).

Fig. 4 : Inner view of growth-cum-mist chamber.

1.4.1.5 Plant growth regulators

They are organic substances responsible for growth and differentiation of plant tissues and organs and have proved indispensable for success of vegetative propagation. Of these, indole-3 acetic acid (IAA), indole-3-butyric acid (IBA), naphthalene acetic acid (NAA) and B-vitamins, especially vitamin B_1 (thiamine) and B_6 (pyrodoxine) assume significance for optimizing adventitious root formation in shoot cuttings of a wide range of horti-forestry species and are usually effective in low concentrations.

For external application, ppm (parts per million) formulations of these substances are prepared, taking mg substance in 1000ml liquid (alcohol/water) or 1000g talcum powder. Except B-vitamins, they are insoluble in water, but get very easily dissolved in ethanol. Therefore, a known weight (mg) of these substances is dissolved in minimum volume of alcohol which is subsequently diluted to 1000ml with distilled water or mixed homogeneously with 1000g talcum powder.

1.4.1 Endogenous factors

Physiological status of donor tree influences vegetative propagation which may be optimized if following points are kept in mind :

1.4.2.1 Collection of vegetative material after winter dormancy ensures good regeneration. At this time, the reserved food material and auxillary substances, including auxins (IAA, IBA, etc.) are maximum in vegetative parts of the donor tree.

1.4.2.1 Collection of vegetative material from vigorously growing vegetative part of the donor tree which is likely to be in vegetative phase.

1.4.2.3 Retention of a slice of old wood (heel) with shoot cutting favours regeneration of adventitious roots due to presence of preformed root initials.

2. Methods of Vegetative Propagation

There are three main methods of vegetative propagation

- Root/shoot cuttings
- layering
- Grafting

2.1 Propagation through root/shoot cuttings

Root or shoot cuttings are collected from donor trees for regeneration of whole plant by way of inducing shoots or roots with or without application of plant growth regulators. The propagation through root cuttings, i.e. root suckers deserves special mention as it is a less common method in clonal forestry and will not be taken up in subsequent write up. For collection of root cuttings, a drench around the base of the donor tree is made, damaging old roots, which produce shoots in due course of time. The portion of old root with newly formed shoots is collected and planted in the polybags. However, propagation by shoot cuttings is a preferred method and has been investigated with considerable details. The method involves several steps for a successful vegetative propagation :

2.1.1 Selection of donor tree

Cuttings are collected from phenotopically or genotypically superior vigorously growing and disease free trees.

2.1.2 Pre-treatment of donor tree

The adequate level of carbohydrate and auxillary substances in donor tree is essential for adventitious root formation. This may be achieved by following pre-treatment to donor tree.

- Application of sub-optimal dose of nitrogenous fertilizer before the donor tree undergoes winter dormancy.
- Donor tree is allowed to grow in shade (etiolation) or the branch of donor tree selected for shoot cuttings is blanched by wrapping it with black adhesive tape. The possible benefits of light reduction may be to inhibit flowering and vigorous vegetative growth, resulting in release of carbohydrate pools for rooting.

- The girdling of branches selected for collection of shoot cuttings favours accumulation of carbohydrate *vis-a-vis* adventitious root formation.

2.1.3 Position of cuttings on donor tree

- Cuttings are collected from inner region of the lower half of the crown.
- Cuttings are collected from twigs which do not exhibit extension growth.
- Cuttings from epicormic branches are avoided due to their plagiotropic growth, i.e. tendency of new branches to grow horizontally.

2.1.4 Time of collection

- The shoot cuttings are collected when the donor tree returns to active growth phase after winter dormancy. In deciduous trees the period relates to end of February to mid May.
- In order to avoid loss of water, cuttings must be collected early in the morning.

2.1.5 Transport and storage of cuttings

Generally, shoot cuttings are collected from trees within the forest that are situated away from the site of propagation. This needs transport and storage of collected cuttings in suitable conditions without loss of water, physiological status or infection of pathogens. The following measures are recommended :

- Surface sterilize collected cuttings with fungicides, e.g. Captan, Baritein, etc. prior to storage and transport.
- Soak cuttings bases in 2-5 % sterile aqueous sucrose solution for 24 hours prior to storage.
- Provide mist to cuttings and store them overnight at 4^o to 8^oC.
- Keep cuttings in sterile moist burlap bags at 21^o or 2^oC. The treatment has been found successful to store *Rhododendron catawbunse* cuttings upto 21 days.
- Store cuttings in sterile conditions for 5-10 days at 15^o - 30^oC and 15 days at $15\text{-}20^oC$ (e.g. croton).

- Keep cuttings at high humidity, 4°C temperature and low light intensity

Any one or combination of above conditions may be adopted for storage of cuttings.

2.1.6 Types of cuttings

Shoot cuttings are divided into three groups, according to the nature of the wood used :

2.1.6.1 Hardwood cuttings

They are made from matured, dormant hardwood after leaf fall and before new shoot emergence. They are least expensive, easy to prepare and transport, and are not readily perishable. The diameter and length of the cutting may be in the range of 0.6-5cm and 10-76cm respectively. These cuttings are further sub-grouped into three classes.

- **Straight cuttings** : do not possess any amount of older wood at the base (Fig. 5a).
- **Heel cuttings** : contain a small piece of older wood at the base (Fig. 5b).
- **Mallet cuttings** : include a short section of stem of older wood (Fig. 5c).

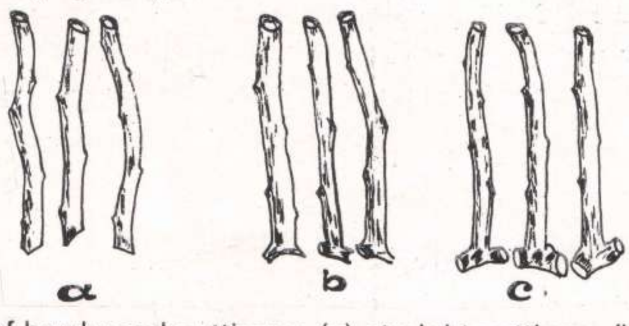


Fig. 5 : Types of hardwood cuttings : (a) straight cuttings, (b) Heel cuttings and (c) Mallet cuttings.

2.1.6.2 Semihard wood cuttings

They are collected from partially mature woody branches of the donor tree and also include leafy cuttings. They are 7.5-15cm long with leaves retained at the upper end (Fig. 6).

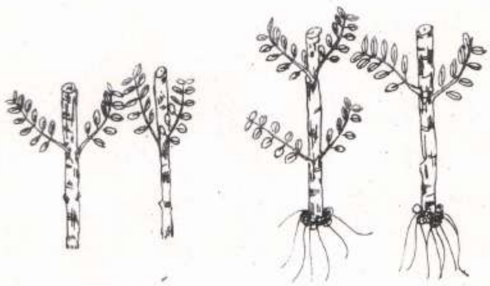


Fig. 6 : Semihard wood cuttings.

2.1.6.3 Softwood cuttings

They are prepared from the soft succulent newly growing twigs of deciduous or evergreen donor tree and are 7.5-12.5cm long with two or more nodes and top few leaves. The basal cut is made just below the node.

2.1.7 Treatment of cuttings

The collected cuttings are given physical or chemical treatments for optimum formation of adventitious roots. There are two distinct ends of cuttings viz., basal or proximal (towards root) and terminal or distal (towards shoots). The adventitious roots always arise from the basal cut end of the cuttings which is kept downward at the time of their planting, and receives the above two treatments before being sealed at the terminal end with paraffin wax.

2.1.7.1 Physical treatment

The basal end of the cuttings is wounded or split (Fig. 7) for promotion of maximum adventitious root formation.

Fig. 7 : Basal split physical treatment.

2.1.7.2 Chemical treatment

The basal end of the cuttings is treated with root inducing plant growth regulators which include auxins (IAA, IBA, NAA, etc.) and B-vitamins. The nature and concentration of these substances are variable for different species of trees (Table 1) and need to be worked out systematically for each of them. However, ppm concentrations of these substances are administered as basal treatment to cuttings ranging from a few seconds (quick dip) to overnight.

Table 1 : Standardized technique for vegetative propagation of important tree species and bamboos

Species	Best month for rooting	Age of the donor tree	Nature of the cutting	Dia. of the cutting (cm.)	Optimum period for rhizogensis	Best treatment	% of rooting
Tectona grandis	May & June	20 to 30 years	Hardwood	1.0 to 1.5	2 to 3 months	IAA 200 ppm + Thiamine 200 ppm	50%
Dalbergia sissoo	March	5 to 10 years	Softwood	0.5 to 1.0	1 to 2 months	IAA 100 ppm	90%
Azadirachta indica	Feb.	10 to 15 years	Semi-hardwood	1.0 to 1.5	1 to 2 months	IBA 1000 ppm	80%
Pongamia pinnata	March	10 to 15 years	Semi-hardwood	1.0 to 1.5	1 month	IBA 800 ppm	100%
Bambusa vugaris var. yellow	March	Branch from 1-2 year old culm	2 nodal	0.5 to 1.0	1 month	IAA 50 ppm	80%
Dendrocalamus strictus	Feb.	Branch from 1-2 year old culm	2 nodal	0.5 to 1.0	2 months	IAA 50 ppm	35%

2.1.8 Planting of treated cuttings

Until formation of adventitious roots, the treated cuttings are maintained on rooting medium under ambient temperature, i.e. 30±2°C, high humidity, i.e. 70-80% RH and requisite photoperiod, i.e. short or long day. These conditions are ideally met in the specially designed growth-cum-mist chambers that are equipped with automated devices for controlling temperature, humidity and light.

The composition of rooting medium also plays a very significant role and needs to be adjusted to possess following properties:

- To hold the cuttings in place during the rooting period.
- To provide moisture for the cuttings.
- To permit penetration to (and exchange of) air at the base of cuttings.
- To create a dark or opaque environment by reducing light penetration to the cutting base.

An ideal propagation medium provides adequate porosity for aeration with high water holding capacity, yet is well drained and free from pathogens. Usually, a mixture of sand, soil and farmyard manure in the ratio of 2:1:1 is recommended. In place of soil/sand, synthetic inert material such as soilrite or perlite is also recommended. The mixture is autoclaved or fumigated with formaldehyde or methyl bromide for disinfection before being used as rooting medium.

2.1.9 Maintenance of cuttings in mist chamber

The cuttings are kept in growth-cum-mist chamber until the formation of adventitious roots. The chamber environment is also ideal for proliferation of pathogenic fungi and other micro-organisms. These organisms are controlled by scheduling a programme for administeration of moderate fungicide dose alongwith mist at a regular interval, i.e. weekly or fortnightly.

2.1.10 Hardening of rooted cuttings

The rooted cuttings possess delicate root system and new foliage which may not survive on exposure to natural high temperature, high light intensity and low atmospheric humidity. To overcome, the rooted cuttings are transferred to an ambient environment in shadehouse that curtails natural light intensity upto 80%, brings temperature below 30°C and may maintain adequate humidity on being equipped with misting system. The rooted cuttings remain in the shadehouse for 15-30 days before being outplanted in the field.

2.1.11 Precautions

- Collect disease free cuttings with vegetative buds.

- Collect cuttings at the time of resumption of the active growth by the donor tree.
- Transport cuttings without loss of moisture.
- Treat cuttings with suitable root inducing substance(s) for an adequate period of time.
- Maintain optimum conditions in growth-cum-mist chamber for rooting.
- Avoid pathogens during the entire period of root formation.

2.2 Layering

This is an *in situ* vegetative propagation method as the propagule remains on the donor tree until the development of adventitious roots.

The vegetative propagation by layering offers following advantages in comparison with that by cuttings:

- Problems of water loss and nutrient supply are avoided due to maintenance of xylem connections with the donor tree until formation of adventitious roots.
- Accumulation of phytosynthates and rooting co-factors at the point of girdling (where phloem disrupts) favours induction of adventitious roots, especially in difficult-to-root species.
- Problem of leaf fall *vis-a-vis* poor rooting in recalcitrant leafy cuttings under the mist conditions may be overcome as the method does not require misting.
- Elimination of light from the part of the branch, where adventitious roots are expected to develop, expedites the process of root formation.
- Production of large sized plants within short period of time is possible.

2.2.1 Timing of layering

The period for layering relates to the movement of carbohydrates and other substances towards the roots of the donor tree at the end of a seasonal cycle of growth. For deciduous tropical trees, the period coincides with the onset of rainy season, i.e. June to October.

2.2.2 Procedures of layering

The vegetative propagation through layering is achieved by four procedures:

- Ground layering
- Air layering
- Mound (stool) layering or stooling
- Trench layering

2.2.2.1 Ground layering

Dormant one year old flexible shoots are bent to the ground, fixed with the peg and covered with soil in active growth phase in such a way that the apex with a portion of the shoots remain above the ground (Fig. 8a). After the lapse of a period, the adventitious roots develop at the point of bending under the ground (Fig. 8b). The rooted branch is detached for propagation (Fig. 8c). The ground layering is of two types viz., simple and compound. Simple layering produces only one plant from a branch as a result of bending only at one place. In compound layering, the branch is bent at several points due to its high flexibility, resulting in production of multiple plants.

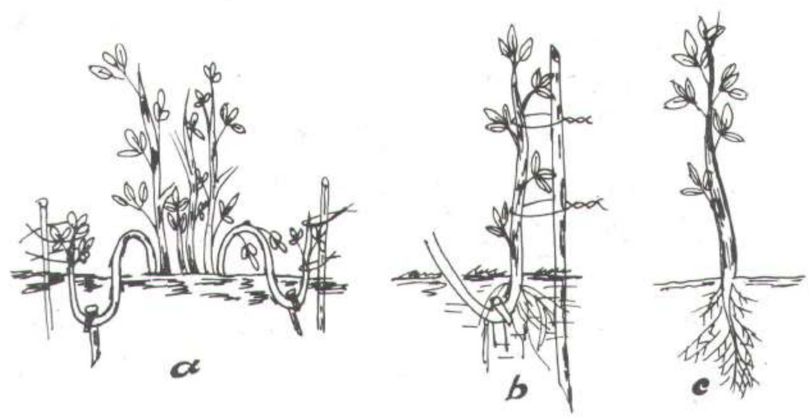


Fig. 8 : Illustration of ground layering.

2.2.2.2 Air layering

The partial hardwood shoots of the donor tree are selected, and a strip of bark 1.8-2.5 cm, depending upon the kind of tree, is completely removed from around the stem. The exposed surface is scrapped thoroughly to ensure removal of phloem and cambium for retarding healing. The sterilized sphagnum moss or any inert spongy substratum (e.g. soilrite, perlite, etc.) wet with dilute (50-100 ppm) solutions of IAA, IBA or NAA is put around the portion of the shoots whose bark has been removed. It is finally wrapped with a black polythene sheet and aluminium foil and tied on either ends in such a way that entry of rain water is eliminated (Fig. 9). These layers are removed when adventitious roots are formed and the rooted-shoots are removed from the donor tree for field plantation after proper hardening.

Fig. 9 : Air layering in *Albizia procera*.

2.2.2.3 Mound (stool) layering or stooling

The young donor trees of medium size (Fig. 10a) are planted on loose, fertile, well-drained soil one year before the propagation to be undertaken. Before new growth starts (Fig. 10b), the donor trees are cut 2.5 cm above the ground level (Fig. 10c). 2-5 new (coppice or stool) shoots develop from the base at the second year and more in later years. When these shoots attain 7.6-12.7 cm height, loose soil, sawdust, or a soil-sawdust mixture is drawn up around each shoot to half of its height (Fig. 10d). When the shoots have grown to a total height of 19 to 25 cm, a second hilling operation with additional rooting medium around the bases of the shoots upto half of their height is done (Fig. 10e). Finally, the third hilling operation is done in mid summer when the shoots have developed to a total height of about 45 cm. By the beginning of rainy season, i.e. the end of growth, these shoots produce sufficient root system to be detached from the donor tree for field plantation (Fig. 10f). The same donor trees again get ready for stooling (Fig. 10g).

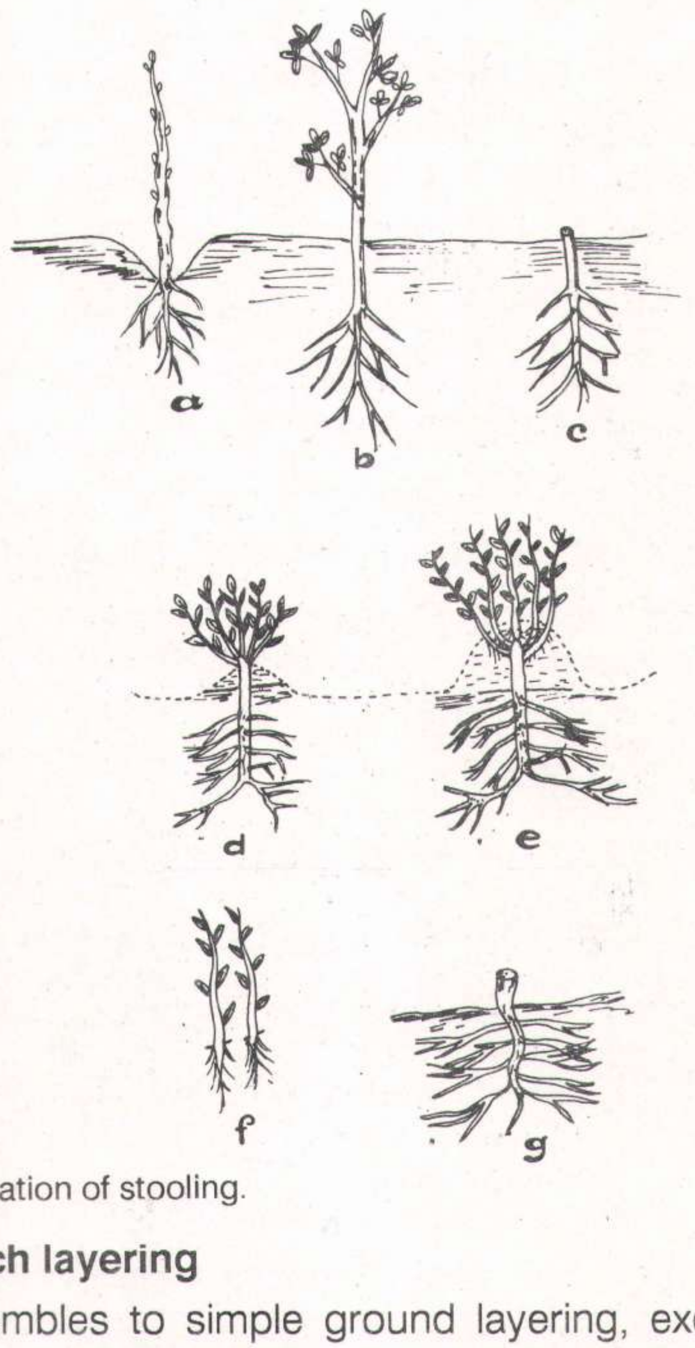


Fig. 10 : Illustration of stooling.

2.2.2.4 Trench layering

It resembles to simple ground layering, except the flexible branch of the donor tree is continuously buried in the trench, leaving its apex exposed. The axiliary buds situated along the branch produce new shoots which remain etiolated at their base (due to being covered by soil) for favouring adventitious root formation. These rooted shoots are subsequently excised from the branch for field plantation. The technique is successful with difficult to root species.

2.3 Grafting

It is preferred when the donor tree is mature and fails to get propagated through above two methods. In this case, vegetative parts from two parents, (i) rootstock for root system and (ii) scion for shoot system are allowed to establish union for facilitating development into single individual. The method suffers the problem of union incompatibility. Hence, the grafting is preferred only in following circumstances:

- Propagation of clones that cannot be readily maintained by cuttings, layers or other asexual methods.
- Conferring beneficial influences of certain rootstocks.
- Hastening reproductive maturity and selections in hybridization programmes.
- Modifying plant growth and habit in order to produce desirable plant form for speciality pruposes.
- Repairing damaged parts of trees.

2.3.1 Accessories of grafting

2.3.1.1 Grafting knife : It has a straight edge (Fig. 11a).

2.3.1.2 Budding knife : It has a curved edge and a blunt end for opening the bark and inserting the bud (Fig. 11b).

2.3.1.3 Double bladed knife : It is used for patch budding (Fig. 11c).

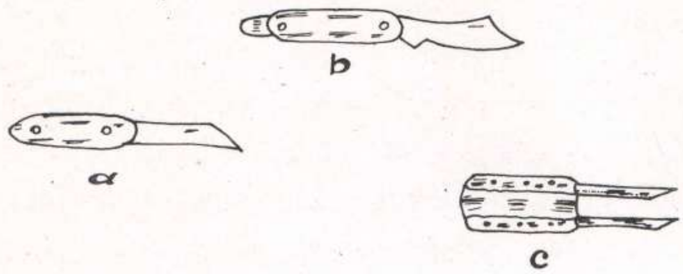


Fig. 11 : Accessories of grafting; (a) grafting knife, (b) budding knife and (c) double bladed knife.

2.3.1.4 Sharpening stone : There are stones for oil and stones for water. The stone should be hard and have a plain surface. Medium type grit gist stone is for rough work and hard-fine grit stone for final sharpening (Fig. 12a). The stone is made wet with oil or water and the knife is sharpened holding its blade at about a 20° angle on the stone (Fig. 12b) and using whole width of the stone (Fig. 12c).

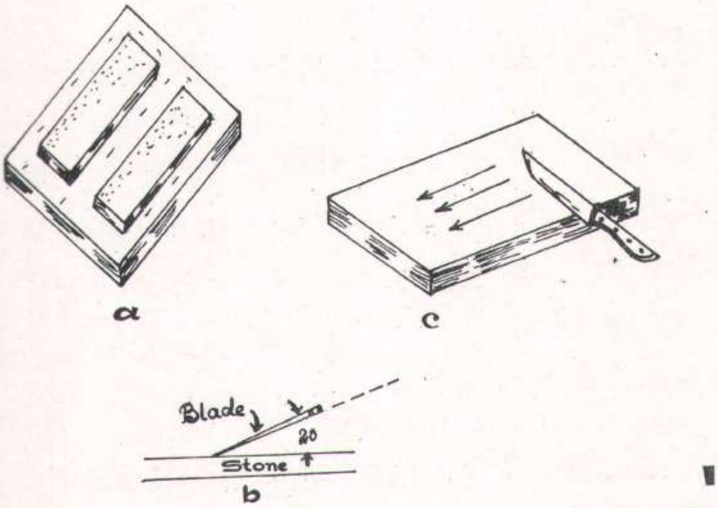


Fig. 12 : (a) Sharpening stones and (b,c) their appropriate use for knife sharpening.

2.3.1.5 Pruners or secaturs : Many types of pruners are available in market (Fig. 13) for performing heavy or light pruning and taking out twigs for grafting.

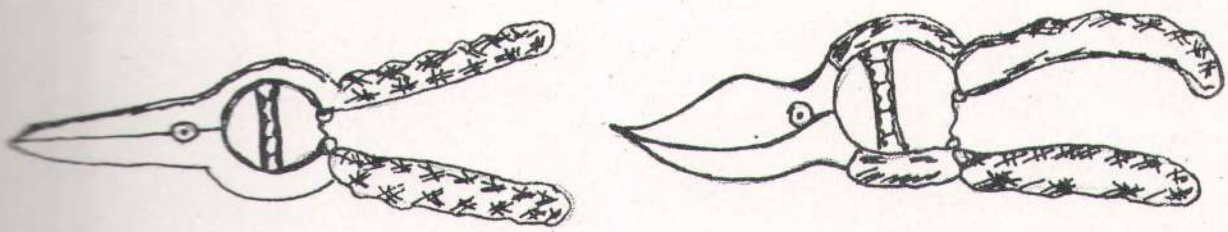


Fig. 13 : Pruners.

2.3.2 Time of grafting

The graft union is facilitated by cambium that undergoes periodic active and inactive phases in most trees, deciding the time for grafting. The cambial activity ensues after winter dormancy and is marked with vegetative bud swelling and emergence of new sprouts. Therefore, grafting is usually done towards the end of February and continues until May.

2.3.3 Graft-compatibility

The success of grafting depends upon physio-morphological matching between two parents, i.e. scion and rootstock which needs intensive experimentation. A mis-match between two parents leads to development of incompatibility that may appear in following ways.

- Failure to form a successful graft or bud union in high percentage of cases.

- Yellowing of foliage in the latter part of the growing season *vis-a-vis* early leaf fall and poor vegetative growth accompanied by shoot die bock.
- Marked differences in growth rate or vigour of scion and rootstock.
- Differences between scion and rootstock in the time when vegetative growth for the season begins or ends.
- Overgrowth at above or below the graft union.
- Graft components breaking clearly at the graft union.

This may, however, be overcome by working out suitable combination of scion and rootstock. Subsequently, the selected rootstock may be vegetatively propagated for completion of grafting. It may, however, be recommended that rootstocks procured from the seedlings of scion-donating tree are less likely to develop incompatibility due to half-sib similarity between the two. The incompatibility in some cases may be avoided by inserting mutually acceptable interstock between scion and rootstock.

2.3.4 Scion collection

Following characteristics are considered for scion collection.

- It is taken from upper part of the tree.
- Vigorously growing disease free branches with vegetative buds are chosen.
- The vegetative bud(s) of the scion should be in dormant phase.
- Scion diameter must conform to the size of rootstock.
- Scions are kept moist and cool until the grafting takes place.

2.3.5 Rootstock

Seedling with well developed root system and resistance to soil- borne diseases are chosen for rootstock. For good development of root systems, seedlings to be used as rootstocks are grown in big containers or in beds, ensuring good aeration and drainage.

2.3.6 Union of scion and rootstock

A proper union between scion and rootstock leads to successful grafting and depends upon the skill of the propagator. However, the following points will help in achieving successful grafting.

- The cut made on scion and rootstock should be complementary to each other and clean and smooth with no fibers on either side.
- The size matching between scion and rootstock should be proper as per requirement of the type of graft.
- While fixing scion and rootstock together, there must be no gap among exposed wood and cambium on either side.
- The two joined parts should have maximum cambial contact.
- The two joined parts are brought together by wrapping around grafting tap or string in order to fix scion and rootstock firmly together and check evaporation from and entry of pathogens at the joint.

2.3.7 Procedures of grafting

Thouin in 1821 described 119 procedures of grafting. Some of these methods, being routinely followed in horticulture and forestry are illustrated below.

2.3.7.1 Splice graft

A complementary slant cut is made at proximal ends of scion and rootstock. The slant ends of the both are fixed, tied and wrapped together. The method is useful in pithy woody stem.

2.3.7.2 Whip graft

Two complementary slant cuts (resulting in tongue like structure) at proximal ends of scion and rootstock are made (Fig. 14a). The resultant proximal ends are fixed like jig-saw, tied and wrapped together firmly (Fig. 14b). The method is applicable to flexible woody stem.

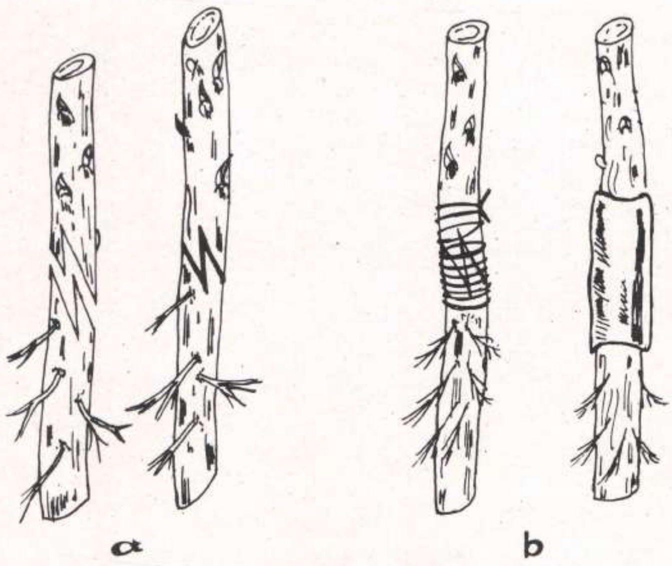


Fig. 14 : Whip graft; (a) complementary tongue like slant cuts on scion and rootstock and (b) fixation of graft union.

2.3.7.3 Stub graft

In case of dissimilar size of scion and rootstock, a slanting cut of 20^{o} angle is made deep into the stock in such a way that cleft appears on pulling the branch back (Fig. 15a). A scion possessing 2-3 buds and about 7.5 cm long is wedged complementarily at proximal end by cutting its both sides (Fig. 15b). The wedged scion is inserted in the stock wrapped and tied (Fig. 15c).

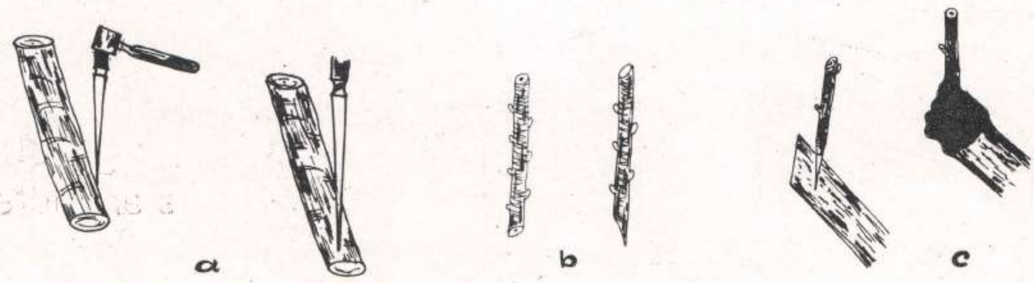


Fig. 15 : Stub graft ; (a) slant cut in rootstock, (b) scion preparation and (c) graft union and its covering.

2.3.7.4 Side-veneer graft

It is also called side-spliced graft. A slanting cut is made in the stock which penetrates as far as the xylem and the piece is removed (Fig. 16a). The scion is prepared at proximal end so that the cut fits that in the stock (Fig. 16b). The two parts are fixed, wrapped and tied together (Fig. 16c).

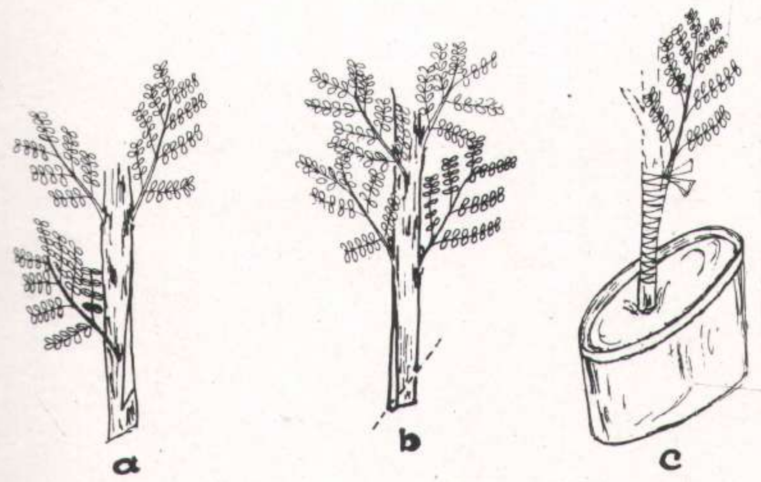


Fig. 16 : Side veneer graft; preparation of (a) rootstock and (b) scion by removal of complementary bark and wood pieces and (c) fixation of rootstock and scion with the help of fastening tape.

2.3.7.5 Side tongue graft

It is similar to side-veneer graft, except the grooves on rootstock and proximal end of scion is made like a tongue. The procedure is illustrated in Fig. 17.

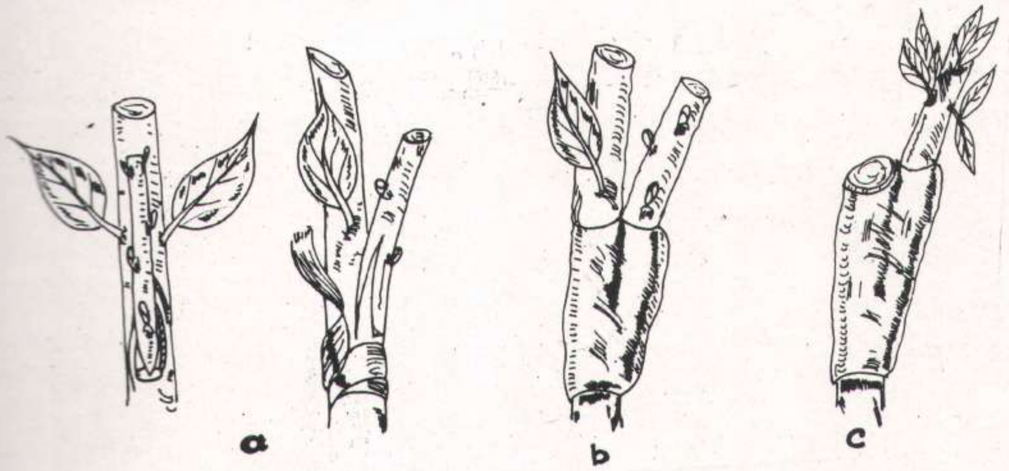


Fig. 17 : Side tongue graft; (a) front and side view of scion and rootstock union, (b) covering of graft union and (c) removal of excess portion of rootstock.

2.3.7.6 Cleft graft

It is adapted to top working trees, either in the trunk of a small tree or in the scaffold branches of a larger tree. The rootstock is decapitated and split vertically (Fig. 18a). The scion is perpared at proximal end from both sides (Fig. 18b). The taper end is inserted in the split of rootstock (Fig. 18c). The cut surfaces are thoroughly covered with grafting wax.

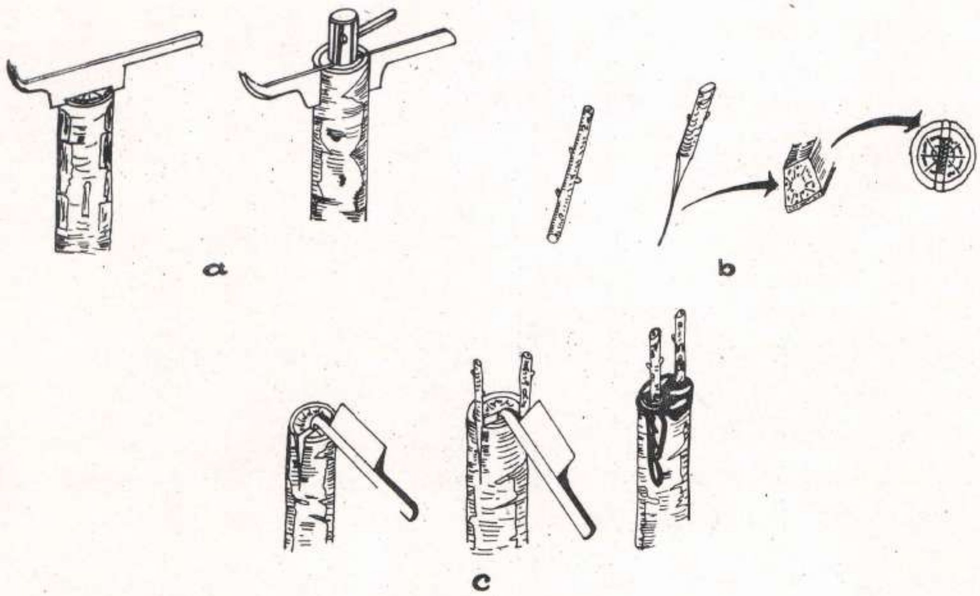


Fig. 18 : Cleft graft; (a) vertical split in the decapitated rootstock (b) scion preparation and transverse view of prepared scion and (c) insertion of scion on the top of the root and sealing of graft union with paraffin wax.

2.3.7.7 Wedge graft

A V-wedge about 5 cm long in the side of the stub is made (Fig. 19a). The proximal end of scion is tapered from both sides (Fig. 19b) and inserted in the wedge of the stock (Fig. 19c). The cut surfaces are thoroughly covered with grafting wax.

Fig. 19 : Wedge graft; (a) top splitting of decapitated rootstock at three corners, (b) scion preparation and (c) insertion of scions in the rootstock and sealing of graft union with paraffin wax.

2.3.7.8 Bark graft

A vertical cut 2.5 - 5.0 cm long is made through the bark to the wood of the stub (Fig. 20a). The bark on both sides of the cut is slightly separated from the wood (Fig. 20a). At proximal end, the scion is given a long cut with a shoulder on one side and a shorter cut on the opposite side (Fig. 20b). The prepared scions are pushed downward between the bark and the wood just under each cut and the grafted stub is thoroughly waxed (Fig. 20c).

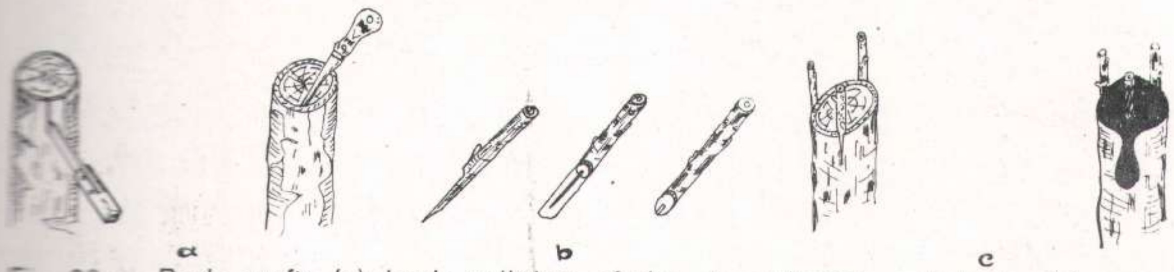


Fig. 20 : Bark graft; (a) bark splitting of the decapitated rootstock, (b) scion preparation and (c) insertion of scions in the splitted bark of the rootstock and sealing of graft union with the paraffin wax.

2.3.7.9 Spliced approach graft

The scion and rootstock donating trees having stems of approximately same size are spiced off bark and wood, brought and tied together until union develops (Fig. 21). Subsequently, top portion of the rootstock and root system of the scion donating trees are severed.

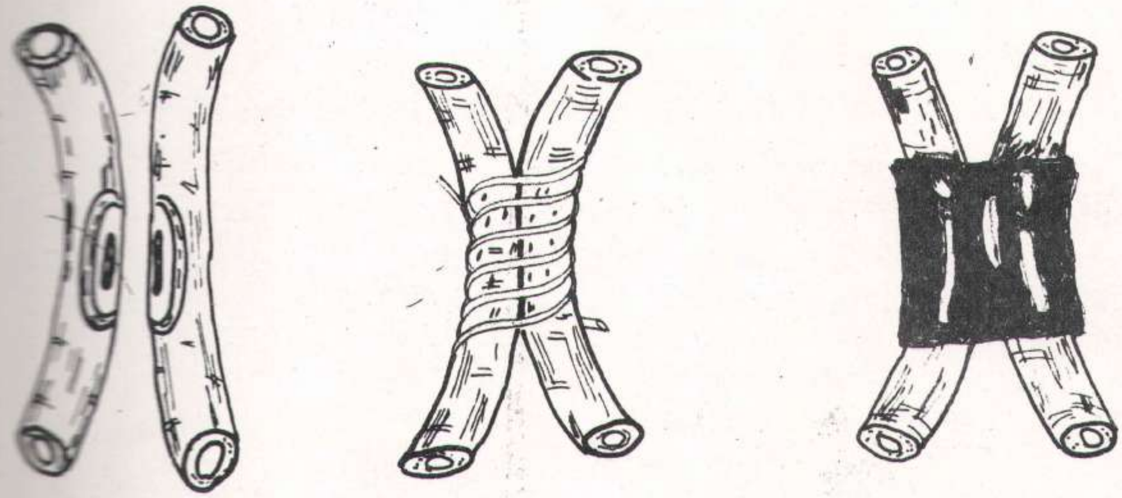


Fig. 21 : Spliced approach graft.

2.3.7.10 Tongue approach graft

It is similar to spliced approach graft, except the tongue shaped grooves are made on the scion and rootstock. The procedure is depicted in Fig 22.

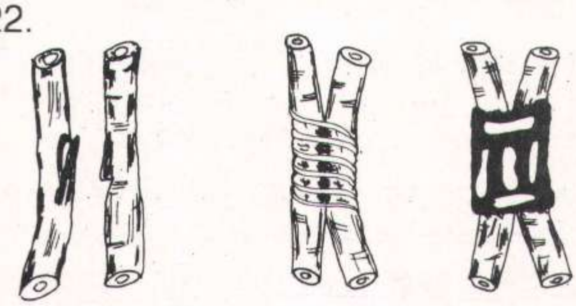


Fig. 22 : Tongue approach graft.

2.3.7.11 Inlay approach graft

It is followed if the bark of the stock plant is considerably thicker than that of the scion plant. A narrow slot, 7.5 to 10 cm long, is prepared in the bark of the stock plant by making two parallel knife cuts with removal of bark strip between them. The slot size conforms as that of the scion to be inserted. The stem of the scion at the point of slot contact is given a shallow cut of the size equal to the slot along one side (Fig. 23). The scion is nailed to the stock at 2-3 places and covered with grafting wax.

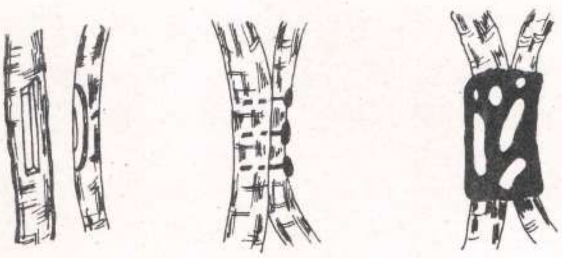


Fig. 23 : Inlay approach graft.

2.3.7.12 Inarching

It is a type of repair grafting, resembling to approach grafting, except the rootstock plant does not extend above the point of the graft union (Fig. 24). The inarching is used to repair roots damaged by cultivation implements, rodents or disease and helps in saving a valuable tree.

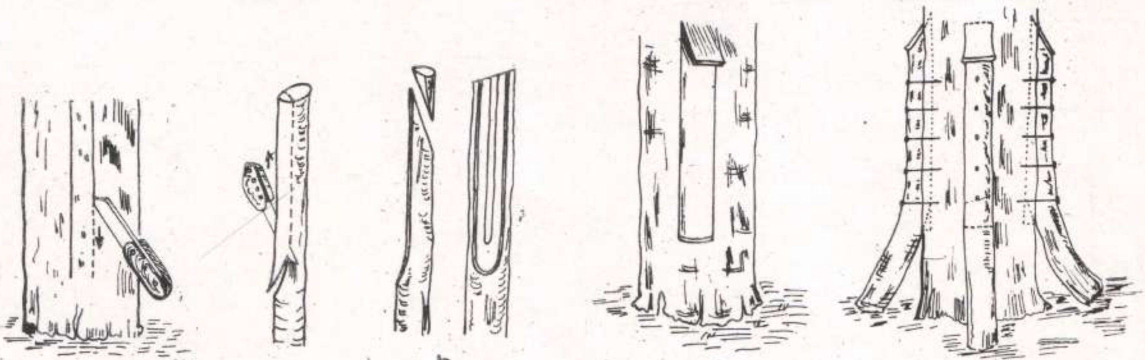


Fig. 24 : Various steps of inarching; (a) preparation of tree to be inarched, (b) Preparing the seedling for inarching, (c) removal of bark from the tree and (d) fixation of prepared seedlings with nails and sealed with paraffin wax.

2.3.7.13 Bridge grafting

It is also a type of repair grafting when the trunk of the tree is damaged. All dead and damaged bark around the wound is trimmed back to live healthy tissue and the bark margins are grooved as shown in Fig. 25a. The scion length is adjusted as per the size of the bark exposed and given slanting cut at either end on the same side (Fig. 25b). The prepared scions are fixed in the bark groves, nailed in place and covered with grafting wax (Fig. 25c).

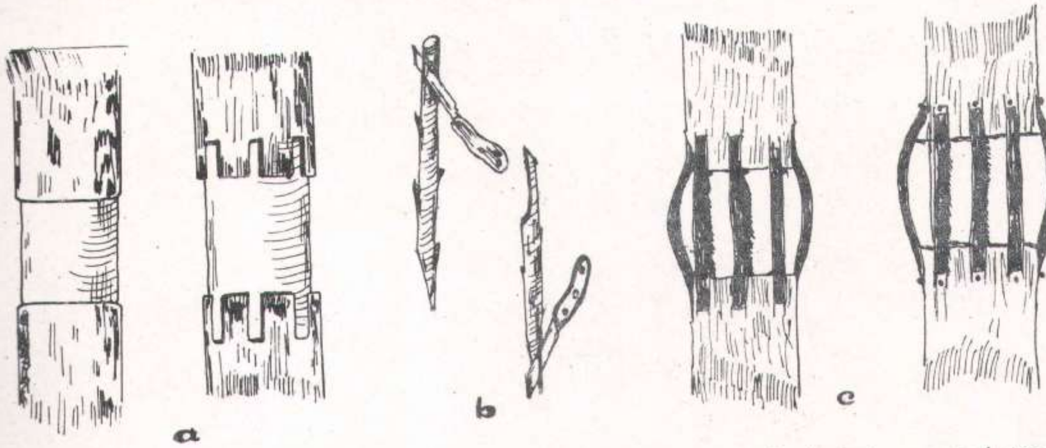


Fig. 25 : Bridge grating; (a) removal of dead bark of the damaged tree and preparation of bark grooves, (b) scion preparation and (c) fixation of scions on damaged tree with nails and covering joints with paraffin wax.

2.3.7.14 T-Budding (Shield Budding)

The vertical (about 2.5 cm long) and horizontal cuts like the shape of "T" are made in the rootstock (Fig. 26a). A single bud with bark and cambium layer (Fig. 26b) is excised from the scion, inserted in T-shape cuts of the stock and tightly tied with polythene tape avoiding entry of water (Fig. 26c).

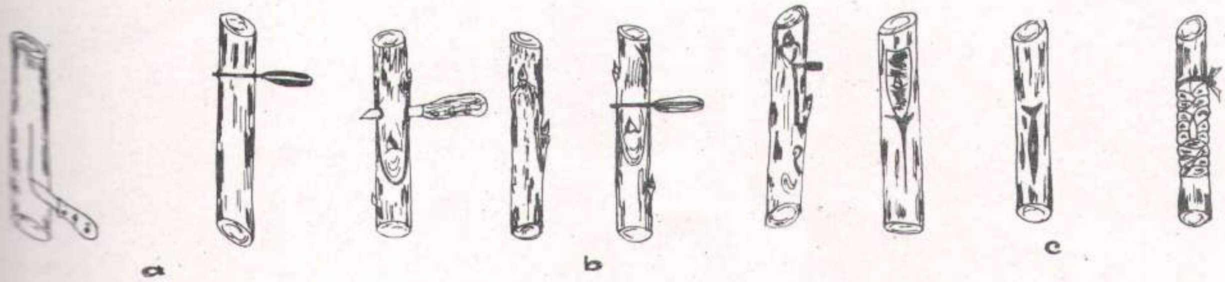


Fig. 26 : T-Budding; (a) making a "T" shape cut in the bark of the rootstock (b) various steps for procuring scion, i.e. bud and (c) insertion of bud in the rootstock and covering it with a polythene tape.

2.3.7.15 Inverted T-Budding

It is similar to T-budding, except incisions made on rootstock takes the shape of an inverted T. The inverted T-Budding efficiently avoids the accumulation of water at the graft union.

2.3.7.16 Patch Budding

A rectangular piece of bark is removed completely from the rootstock. From the scion, the bud with similar size of bark is removed, fixed on the stock and tightly tied with the polythene tape (Fig. 27a). Patch budding also includes flute bud graft (Fig. 27b), ring or annular bud graft (Fig. 27c) and I-bud graft (Fig. 27d).

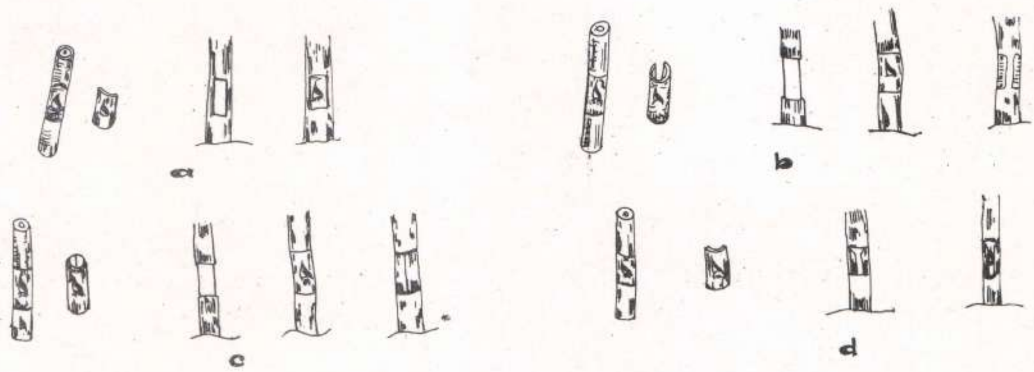


Fig. 27 : Various types of patch budding; (a) normal patch bud, (b) flute bud graft, (c) annular bud graft and (d) I- bud graft.

2.3.8 Precautions

- Establish compatability between scion and rootstock before undertaking grafting on a large scale.
- Collect twig or bud as scion only from vegetative phase just before resuming active growth.
- Ensure maximum cambial contact between scion and rootstock at the time of grafting.
- Select disease free scion and rootstock.
- Maintain adequate moisture content in scion at the time of grafting.
- Avoid desiccation of (pathogen entry at) graft union.

3. Vegetative Propagation of Bamboo

Bamboos represent diverse woody perennial grasses (Poaceae) with high economic values in tropical developing countries. They are part of the life and culture of southeast Asian people, providing raw material for food, agricultural implements, house construction, household utensils, handicrafts and over a thousand other uses. They are also the major source of raw material for pulp and paper industries. However, the bamboos exhibit peculiar behaviour of gregarious flowering and seeding at the end of very long intermast (vegetative growth) phase. This prevents their perennial propagation by seeds and their improvements by hybridization. Therefore, they are ideal for vegetative propagation which is achieved by following ways.

- Rhizome
- Offset cuttings
- Culm cuttings
- Branch cutting

3.1 Rhizome

This is the most common propagation method for bamboo. The bulky rhizomes of bamboos are dug out in the rainy season and planted in the field (Fig. 28).

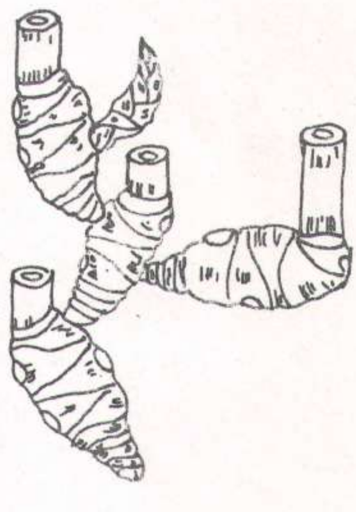


Fig. 28 : Bamboo rhizome.

3.2 Offset cuttings

In some bamboos, the rhizome alone is incapable of vegetative propagation and rhizome + base of culm (offset cutting) is utilized for their propagation (Fig. 29).

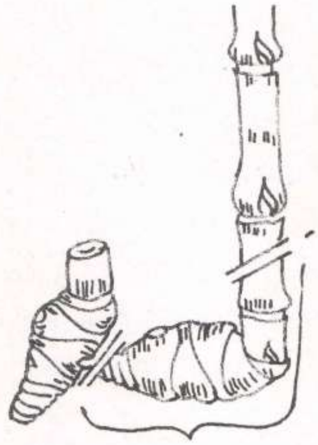
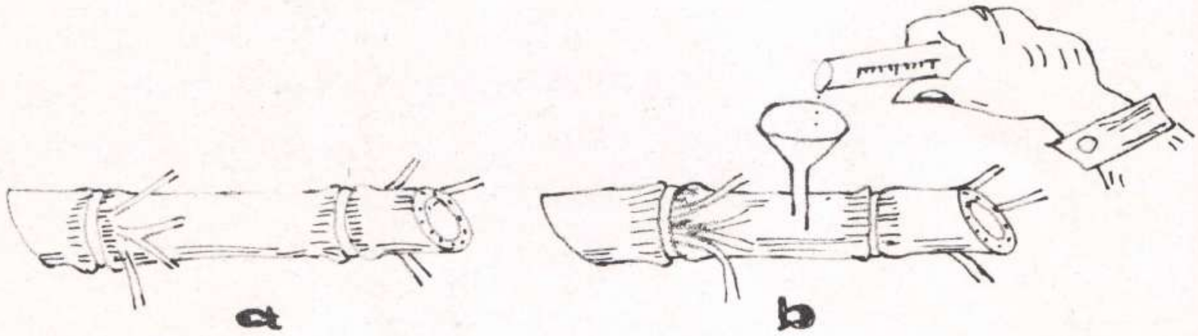
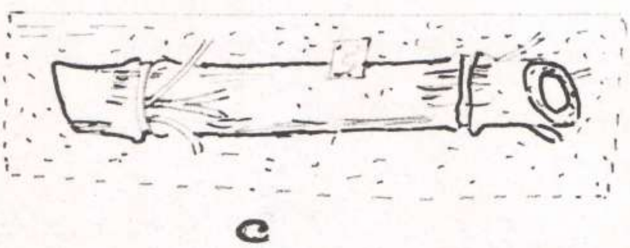


Fig. 29 : Offset cutting of bamboo.

3.3 Culm cuttings

1-2 year old culms are collected and made into 2-nodal segments (Fig. 30a) which are drilled, filled with boric acid solution (Fig. 30b) and planted horizontally in the bed (Fig. 30c). After 2-3 months, each node of the segment producing adventitious roots (Fig. 30d) is detached and planted separately in the field (Fig. 30e).





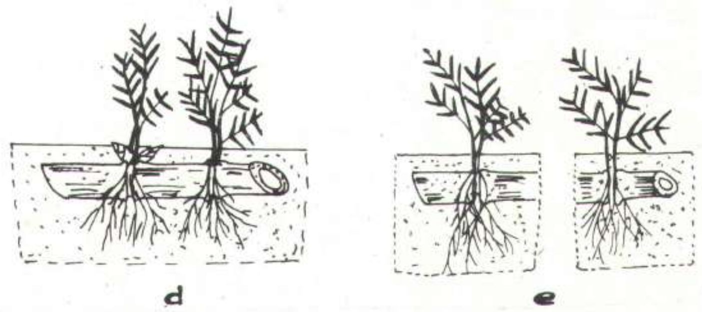


Fig. 30 : Propagation of bamboo by culm cutting; (a) 2-nodal bamboo culm, (b) drilling and filling of culm with boric acid, (c) horizontal planting of treated culm in the bed, (d) adventitious root formation on the nodes of the culm and (e) separation of bamboo propagules for field planting.

3.4 Branch cuttings

Young branches of the culm are collected and made one or two nodal segments (Fig. 31). The segments are surface sterilized and immersed for few hours to overnight in 100-500 ppm auxin (IAA, IBA or NAA) solution. The treated cuttings are planted horizontally in the bed and, upon formation of adventitious roots, transferred to the field.

Fig. 31 : Bamboo propagation by branch cutting.

4. Glossary

This glossary defines selected terms used in the language of vegetative propagation of trees.

4.1 Adventitious : Refers to a structure arising not in its usual place: to roots arising from stems or leaves or roots of old plant; to buds arising other than as terminal and auxiliary structures.

4.2 Annual : A plant completing its life cycle in one year.

4.3 Banding : Localized pretreatment that excludes light from the portion of a stem to be used as the cutting base. It is applied to etiolated shoots or to light grown softwood shoots.

4.4 Blanching : Refers to banding of stock plant shoots after accomplishment of their initial growth in light.

4.5 Cambium : A thin tissue of the plant located between the bark and the wood. Its cells are meristematic, i.e. they are capable of dividing and forming new cells. For a successful graft union, it is essential that the cambium of the scion be placed in close contact with the combium of the stock.

4.6 Clone : A population of genetically identical cells or individuals. Such a population is obtained by mitotic division or by asexual reproduction from a single individual.

4.7 Cyclophysis : Irreversible variation of growth habit of vegetative propagules due to their origin from different positions (i.e. juvenility gradient) of the donor tree, e.g. decrease in rooting potential from trunk base to tree crown.

4.8 Distal : The distal end of either root or shoot represents a portion that is the farthest from the stem-root junction of the plant and nearest to the tip of the shoot or root.

4.9 Dormant/dormancy (buds) : A bud which have stopped its development for a period due to unfavourable environmental conditions (e.g. a dry or cold season). A dormant bud will sprout as a response to improved growth conditions or a "biological clock" e.g. longer days.

4.10 Etiolation : Development of plants or plant parts in the absence of light resulting in such characteristics as small unexpanded leaves, elongated shoots and lack of chlorophyll (yellowish or whitish leaves).

4.11Girdling : Removal of complete ring of bark, cambium and pholem around the trunk/twig that prevents downward transport of photosynthates and auxiliary substances.

4.12 Grafting : The connection of two pieces of living plant tissue in such a manner that they will unite and subsequently grow and develop into a single individual.

4.13 Grafting Wax : Substance applied on the graft union in order to minimise desiccation and exclude water access.

4.14 Graft union : The site of the grafted plant where the scion and the rootstock are united.

4.15 Hedging : Trimming trees and keeping them low in order to overcome or bypass the poor rooting and often poor form of cuttings from old trees. Cuttings from hedged plants tend to maintain their young physiological age.

4.16 Hormone/plant growth regulators : A substance that has a marked effect on a specific plant part and produces this effect when present in very low concentrations, e.g. promotion of root, shoot or flower development. Hormones are produced within the plant but artificially synthesized plant hormones (growth regulators) applied to the plant part have the same effect.

4.17 Incompatibility (graft incompatibility) : Inability of the root-stock and the scion to form or maintain a union that will result in the desired plant growth.

4.18 Juvenility : Opposite to maturity; an initial period of growth when the apical meristem does not respond to internal or external stimuli to initiate flowering.

4.19 Node : A point of the stem from which one or more leaves arise. In the mature stem the nodes are usually well separated by internodes which elongate during growth.

4.20 Off-type : A group of vegetatively raised plantlets showing somatic variations due to occurrence of genetic change in the vegetative part.

4.21 Ortet : The original plant from which a clone has been derived.

4.22 Orthotropic growth : The situation where the vegetative propagule assumes an upright or normal tree form.

4.23 Perennials : Plants completing its life in several years.

4.24 Periphysis : Variation of growth habit of vegetative propagules due to their origin from different environments, such as shade and sun leaves on an individual tree.

4.25 Plagiotropic growth : The situation where the vegetative propagule does not assume a normal tree form but continues to grow like a branch.

4.26 Polarity : The condition that plant parts maintain their spatial orientation when separated from the mother plant. The phenomenon is important in cuttings and grafting.

4.27 Vegetative propagule : A plant part such as a bud, tuber, root or shoot, used to propagate an individual.

4.28 Proximal : The end of either root or shoot that is nearest to the stem-root junction of the plant.

4.29 Ramet : An individual member of a clone.

4.30 Scion : An aerial plant part, often a branchlet, that is grafted on to the root bearing part (stock/rootstock) of another plant.

4.31 Stock/rootstock : The lower portion of the graft, which develops into the root system of the grafted plant. It may be a seedling, a rooted cutting or a layered plant.

4.32 Typefaces : The phenomenon that occurs when scions, buddings and rooted cuttings maintain for some time the branchlike growth habit (plagiotropic growth) as they were behaving on the ortet.

4.33 Totipotency : Capacity of plant tissues/parts to develop whole plant due to possessing complete genetic information.

4.34 True to type : A group of plantlets (raised through vegetative propagation) showing similarity to the donor tree.

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