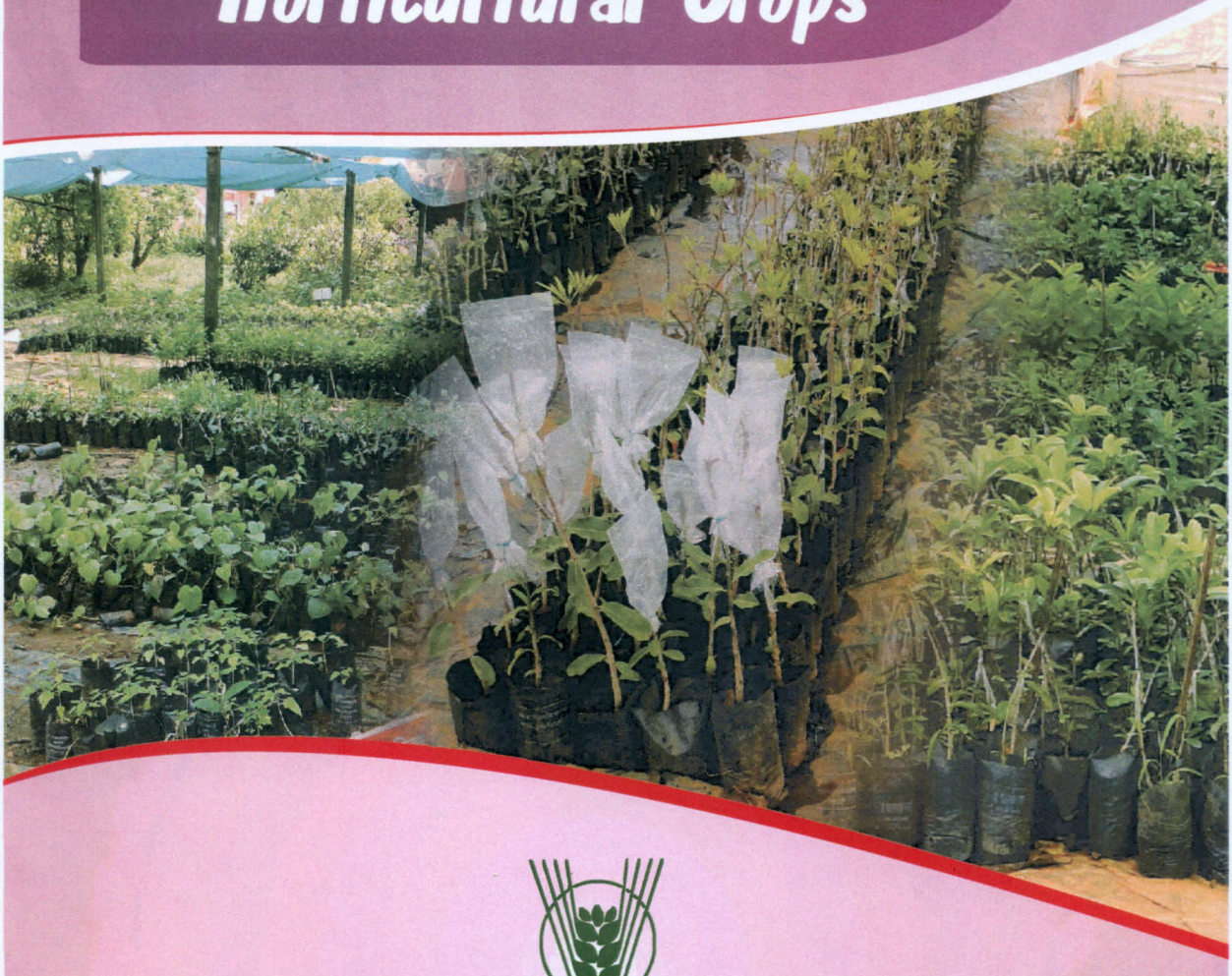
Extension Bulletin No. : 02 / 2013

Vegetative Methods of Plant Propagation in Horticultural Crops



Krishi Vigyan Kendra

ICAR Research Complex for Goa

(Indian Council for Agricultural Research)

Extension Bulletin No. : 02 / 2013

Vegetative Methods of Plant Propagation in Horticultural Crops

ICAR

Krishi Vigyan Kendra

ICAR Research Complex for Goa

(Indian Council for Agricultural Research)

Extension Bulletin No. : 02 / 2013

Published by:

Narendra Pratap Singh
Director
ICAR Research Complex for Goa
Ela, Old Goa - 403 402, Goa (India)
Phone : 91-0832-2284677 / 78 / 79
Fax : 91-832-2285649
Email : director@icargoa.res.in
Website : http://www.icargoa.res.in

Correct citation:

Vegetative Methods of Plant Propagation in Horticultural Crops. 2013. Krishi Vigyan Kendra, ICAR Research Complex for Goa, Ela, Old Goa 403 402

Prepared & Edited by:

Raj Narayan
Programme Coordinator
Krishi Vigyan Kendra - North Goa
ICAR Research Complex for Goa

&

M. Thangam
Senior Scientist (Horticulture)
ICAR Research Complex for Goa

Contributors :

- Mr. Deep Kumar, Farm Manager, Krishi Vigyan Kendra, ICAR Research Complex for Goa
- Mr. V. Y. Gaonkar, SMS (Hort.), Krishi Vigyan Kendra, ICAR Research Complex for Goa

Designed & Composed by:

Vishwajeet Prajapati, Computer Programmer, KVK- North Goa

Printed at: Sahyadri Offset System, Corlim, Ilhas, Goa - 403 110, Phone : 091-832-2285901

Contents

Sr. No.	Particulars	Page no.
	Foreword	i
	Preface	ii
1	Introduction	01
2	Purpose	01
3	Methods of Vegetative Propagation	01
	3.1 Propagation by Cutting	01
	3.1.1 Stem Cutting	02
	3.1.2 Leaf Cutting	03
	3.1.3 Root Cutting	04
	3.2 Propagation by layering	04
	3.3 Propagation by Grafting	07
	3.4 Propagation by Budding	11
4	Propagation by Specialized Vegetative Structure	15
5	Propagation Medium	17
	5.1 Characteristic of a Good Medium	17
	5.2 Types of Media	17
	5.2 Potting Mixture	19
6	Selection and Preparation of Scion wood of Grafting and Budding	20
	6.1 Criteria for Selection	20
	6.2 Preparation of Scion wood	20
7	Contributors	21

Prof. N. P. Singh
Director

Foreword

ICAR Research Complex for Goa
(Indian Council for Agricultural Research)
Old Goa, North Goa (Goa) 403 402

Horticulture is the area of plant science, practiced as a science, an art and a business that caters to the need of a broad range of people, from the small backyard farmer to the large scale producer. Now days horticulture is an important remunerative sector which invariably improved the economic condition of the farming community. Due to invent of technologies, the production and productivity of horticultural crops has increased, ultimately increased the income, employment opportunity and export potential in the sector, besides increased household nutritional security of the country populace. This sector has also played a significant role in the women empowerment, providing employment opportunities through nursery raising and planting material production, vegetable and flower seed production, floriculture, mushroom cultivation, value addition and processing, etc.

The average state and national productivity of horticultural crops is far below than that of developed countries; the reasons for low productivity may be many, but it is mainly due to use of poor quality planting material, poor management practices, unscientific cultivation, etc. Moreover, the area expansion in horticultural crops, especially under improved varieties is not satisfactory. This may be due to insufficient availability of quality planting material. Inferior quality planting material is a major constraint for getting desired productivity and quality of produce in horticultural crops. The quality planting material of improved varieties is most important factor in enhancing the productivity and quality of the produce.

Plant propagation is a specialized technique which requires technical expertise and skill. Good quality planting material gives better field stand and survival, ultimately high and quality yield. Quality planting material in proper management conditions increases 25 to 40 percent yield. Thus, the production of quality planting materials are of paramount importance for increasing the yield potential and meeting the increasing demands of horticultural produce, generating additional income, creating more employment opportunities for both rural and urban youth and women folk.

To make the practical manual ***"Vegetative Methods of Plant Propagation in Horticultural Crops"*** useful to the amateurs, farmers, gardeners, nurserymen, and extension workers, various plant propagation techniques have been dealt with in details.

I hope that this manual will be a useful practical manuscript for all those interested in horticulture connected with the field in one or another way.

(N. P. Singh)

Preface

Propagation of horticultural plants vegetative captured man's imagination for perpetuation and maintenance of genetic stability. The propagation of plants has been a fundamental occupation of human kind since civilization began. Progress in agricultural development has involved an interplay of two separate activities i.e. selection of specific kinds of desirable plants and reproduction of these kind in such a manner so as to retain their valuable characteristics in large scale multiplication. The vegetative propagation is the basis of maintaining the purity of most of the planting material in horticultural crops. In fruit crops, propagation involves multiplication of root stock and scion cultivars. The propagation of rootstock is done mostly through sexual or seeds and referred to as seedling root stock whereas propagation through asexual means namely cuttings, layering and micro propagation is done for producing clonal root stocks. The scion are been commonly propagated through asexual or vegetative means.

The invention of green houses, discovery of rooting hormones and medium and development of mist and fogging chambers have greatly enhanced the nursery producers and quality planting material production. A significant step foreword occurred in quality plant multiplication with the development of new biotechnology, genetic engineering and in vitro tissue culture including micro propagation techniques.

Insufficient availability of quality planting material is important deterring factor in area expansion under improved varieties, planting and replanting. Similarly, poor quality planting material is also a major constraint in achieving the desired quality and productivity in horticultural crops. At present hardly 30 to 40 percent demand of planting material is met. Hence, there is huge demand of quality planting material and scope of production of planting material. Keeping in view the demand of quality planting material in horticultural crops, this practical manual on ***"Vegetative Methods of Plant Propagation in Horticultural Crops"*** is prepared which deals with various means of vegetative propagation such as cutting, grafting, layering, budding, etc and technical knowledge of propagation there of in simple language.

In this endeavour, I would like to record my sincere thanks to Prof. Narendra Pratap Singh, Director, ICAR Research Complex for Goa for his kind support, encouragement, able guidance, besides providing necessary facilities and giving us opportunity to pilot this publication.

I am extremely thankful to Dr. B L Manjunath, Principal Scientist (Agronomy), ICAR Research Complex for Goa for his support and suggestions at various stages of preparations of this manuscripts.

The help extended by Dr. M. Thangam, Sr. Scientist (Horticulture), Dr. A. R. Desai, Senior Scientist (Horticulture), ICAR Research Complex for Goa, Mr. Deep Kumar, Farm Manager, Mr. V Y Gaonkar, SMS (Horticulture) in contributing the subject matter to bring out this practical manual is gratefully acknowledged. The help and cooperation rendered by the Mrs. Sunetra Talaulikar, SMS (Home Science), Mr. H R Prabhudesai, SMS (Agronomy), Mr. H R C Prabhu, SMS (Plant Protection) during the preparation of this manuscript is also heartily acknowledged.

I am highly thankful to Mr. Vishwajeet Prajapati (Computer Programmer) for taking keen interest in designing & composing and Ms Bushra Ansari, Stenographer for typing this manual. I am also thankful to our colleagues, scientists, technical and administrative staff for their cooperation and assistance.

The help rendered in terms of financial support received from ICAR Research Complex for Goa under Mega Seed Project is greatfully acknowledged.

(Raj Narayan)

1. Introduction:

Plant propagation is simply the reproduction or duplication or multiplication of plant from a source i.e. mother plant. The ultimate aim of propagation is to produce more plants. The fruit plants are propagated both by sexual and asexual means. In sexual methods, plants are raised through seed and such plant called seedlings. However, in asexual or vegetative propagation, a part of plant *viz;* leave, stem, branch, root are used to develop new plant which are called sapling. In some crops like potato, mango, cashew, etc both seed and plant part can be used for multiplication of planting material. In vegetative propagation the plant part is placed in such environment that it develops into new plants.

For successful propagation of plants firstly requires a knowledge of mechanical, environmental and chemical manipulations and technical skills that takes a certain amount of practice and experience to master such as how to bud or graft, how to make cuttings, or how to layering, etc. These areconsider as the Art of Propagation. Secondly the knowledge of plant growth, development and morphology is also essential for successful propagation of plants which refers Science of Propagation. Third aspect of successful plant propagation is knowledge of different kinds of plants and various possible methods by which certain plants can be propagated. The method selected for propagation must be related to the response of the kind of plant being propagated and to the situation.

2. Purpose:

There are two major purpose of plant propagation.

2.1 Conservation of Germplasm:

Germplasm conservation is an important task for saving the any species. Scientists on a crop expedition collect samples of plant materials intended for use endeavours. Such materials are often present in small quantities and must be increased and utilize them in research and improvement programme such as in developing new plant type (variety). The ultimate goal of conservation is to ensure that the original characteristics of the plant are maintained.

2.2 Crop Production:

The plant multiplication in large quantity at commercial scale for production of food material to feed the population is an important continuous process for which appropriate method and material (seed, cutting etc) are used. The goal in propagation in commercial production is to increase or replicate the source of material. The success of propagation, whether to produce in small and large quantity is judged by how closely the progeny offspring plants resemble the parent plant.

3. Methods of Vegetative Production:

Vegetative propagation involves the reproduction from vegetative parts of plants. This propagation method is used successfully because the vegetative organs have capability to regenerate. By and large most of fruit plants are propagated by one or other vegetative method of plant propagation.

3.1 Propagation by Cutting:

A cutting is a detached vegetative part of a plant obtained from any of the three primary plant organs – stem, leaf or root which on separation and planting in suitable medium is able to regenerate the missing parts and develop into a new plant.

3.1.1 Stem Cutting:

Stem cutting are most commonly used asexual method of propagation in horticultural crops. The success in the stem cutting multiplication depends upon many factors such as condition of the mother plant, part of the tree, season, care while planting and after care. Cuttings can be made during monsoon and spring season. Based on the age, maturity, parts of the plant and tissue succulancy of detached shoots, stem cuttings are classified as given below.

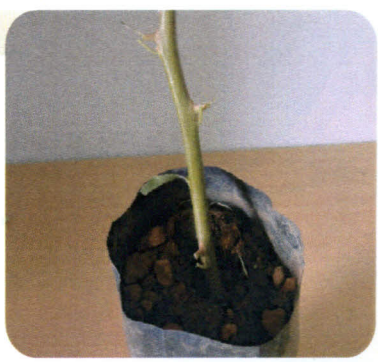
3.1.1.1 Herbaceous or Softwood Cuttings:

Softwood cuttings of shrubs or deciduous trees are the herbaceous immature shoots separated from the plants in the growing season. They are about 10 to 15 cm long. Terminal 2 to 3 leaves are retained and the rest are removed. Retention of leaves are essential, because cutting do not have enough food reserves. They need special conditions such shade and humidity for rooting and to develop into new plants. Citrus, cherry, apple, peach, plum, pear, apricot are propagated under mist chamber by softwood cuttings, however, coleus, chrysanthemum, dahlia, carnation, etc are propagated through herbaceous method of propagation.

Procedure:

- Select healthy plants of desired kind.
- Cut and remove healthy succulent immature 10-15 cm long shoots 4-6 months old from each plant.
- In each softwood cutting retain 2 to 3 leaves at the terminal end remove rest of leaves.
- Dip the basal portion of cutting in rooting powder for better and faster rooting.
- Prepare a sand bed 100 cm long, 50 cm wide and 20 cm high under shade and water it.
- Plant the cuttings in sand bed at a spacing of 7 to 8 x 15 to 18 cm.
- While planting, make sure that half the portion of cutting is buried in the sand.
- Lift the cuttings one month after planting and observe for rooting at the basal portion.
- If sufficient numbers of roots are produced, lift them and plant each cutting in a separate pot.
- The softwood cuttings pots are kept in green or polyhouses or in a mist chamber where high humidity is maintained.

3.1.1.2 Semi Hardwood Cuttings:



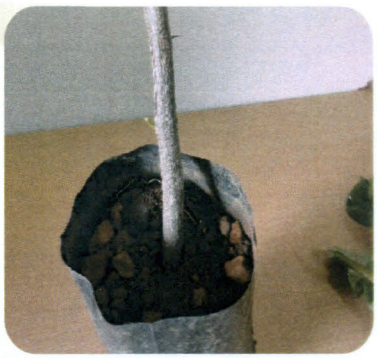
As name implies semi hardwood cuttings are derived from partially mature, slightly woody shoot/tissues. These are succulent and tender and are usually prepared from growing wood of current season's growth of trees and shrubs. The fruit plants like mango, guava, lemon, jackfruit, olives, azalea, rhododendrum and other broad leaved green ornamentals etc are propagated by this method.

Procedure:

- Select new healthy shoots just after flush of growth taken place from a healthy desired plant kind.
- Cut and remove these healthy shoots of 7 to 15 cm length from plant during summers.
- Retain 2 to 3 terminal leaves and remove rest of leaves.
- Give slanting basal cut just below the basal node of the cutting.
- Dip the basal portion of cutting in rooting powder for better and faster rooting.
- Prepare a sand bed 100 cm long, 50 cm wide and 20 cm high under the shade and water it.
- Plant the cuttings in the sand bed at 7 to 8 x 15cm spacing and allow them for rooting in the bed.
- While planting, assure that the basal two nodes of the cuttings are inserted in the sand.
- Water the cutting bed regularly.

- Lift the cutting from the bed after a month of planting and observe for rooting at the base of cutting.
- See, if sufficient number of roots are produced, lift the cuttings and plant each rooted cutting in a separate pot.
- Shift the pot under intermittent mist spray or cool moist climate. The cutting wood should be obtained in the cool, early morning when the stem is turgid.

3.1.1.3 Hardwood Cuttings:



Hardwood cutting is derived from mature or woody stem material. It is prepared during dormant season, usually from one year old immature shoots of previous season's growth. Generally, grape, fig, mulberry, kiwi fruit, pomegranate, olive, quince, hazelnut, chestnut, plum, apple, gooseberry, acalypha etc can be propagated through hardwood cuttings.

Procedure:

- Select healthy plant and select healthy shoots of previous season growth.
- Cut and remove fully mature and lignified shoots of pencil thickness.
- Make the cuttings of 10 to 75 cm in length and 0.5 to 2.5 cm diameter depending upon species. Long cuttings should be taken when they are used as root stock for fruit trees. Length may also vary according to the length of inter node.
- Each cutting should have at least 2 to 3 nodes/buds
- Give a straight cut at the base of shoot below the node while a slanting transverse cut 1 to 2 cm above the bud is given at the top.
- Remove all lower basal axillary buds prior to sticking cutting to prevent suckening from the base of the cutting.
- Dip the basal portion of cutting in rooting powder for better and faster rooting.
- Prepare a sand bed 100 cm long, 50 cm wide and 20 cm high under shade or partial shade or open sun and then water it.
- Prepared cuttings are planted in nursery bed at a distance of 10 x 45 cm.
- During planting ensure that 2/3rd portion of cutting with 1 to 2 basal nodes are buried in soil.
- Water the cutting bed regularly.
- Lift the cutting after two months of planting and examine for rooting.
- If sufficient roots are produced, lift the rooted cuttings from nursery bed and plant each cutting in a separate pot.
- Keep the pots in cool, moist place for rooting.
- Sprinkle water as and when necessary.

3.1.2 Leaf Cuttings:

Leaf bud, leaf petiole, leaf lamina, leaf vein etc are also used for propagating the plants.

3.1.2.1 Leaf Bud Cutting:

Leaf bud cutting is applicable in propagating large number of plants where parent material is in limited or in species where leaves develop root system and die because of non development of shoot system. Leaf bud cutting consists of a leaf blades, petiole and shoot piece of stem with attached axillary bud of active growing leaves. In case of small size planting material, 1 to 1.5 cm stem portion is used. Rubber plant, raspberry, lemon, blackberry, kalenchoe, philodendron, etc can be multiplied by leaf bud cutting.

3.1.2.2 Leaf Cutting:

Leaf cutting is also divided into leaf petiole cutting, leaf lamina cutting, vein cutting (split vein), etc. the leaf portion is inserted into rooting media (soil, sand, etc) to regenerate as new plant. Bryophyllum, begonia, sanseviriea, saintpaulia are the classical examples of propagation through leaf cuttings.

3.1.3 Root Cuttings:

This method is applicable in plants which produce suckers freely. Root pieces are taken from young stock plant in late winter or early spring when roots are well supplied with stored food but before the new growth starts. However, in temperate fruits, root cuttings are prepared in month of December and are kept in warm places in moss grass for callusing and then planted in February, March.

Root cutting is to be prepared by cutting of roots in 1 cm thickness and 10 to 15 cm long. These cuttings are inserted vertically so that top is above soil level or horizontally 2 to 5 cm deep avoiding the possibility of planting them upside down. Sweet potato, cherry, kiwi fruit, raspberry, blackberry, bread fruit, curry leaf, etc can be propagated by this method.

Precautions to be taken while propagating plants by Cutting:

- Do not use shoots growing in the shaded interior for propagation of cuttings.
- Do not retain too many leaves at the time of planting.
- Avoid fast growing shoots.
- Mature and lignified shoots should be used for propagation of cuttings in case of hardwood cutting.
- Cuttings should be maintained under high moisture condition and misting to be done regularly to reduce moisture loss.
- The propagating material must be sterilized before use.
- Rooting hormones may be mixed with fungicides to protect cut surface from rotting under humid conditions.

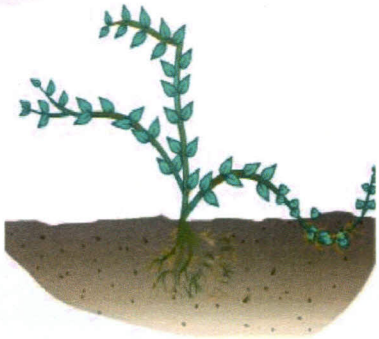
3.2 Propagation by Layering:

Layering is the process of development of roots on a stem while it is still attached to the parent plant. The rooted stem is then detached to become a new plant growing on its own roots, such rooted stem is known as layer.

The success of layering depends on ringing or wounding, etiolation (absence of light), use of rooting hormone (IBA, NAA) and favourable environmental conditions (temperature, humidity) etc.

Layering includes several forms of ground and aerial layering (Gootee). The best results from layering are obtained during monsoon and spring season from the branches of 1 to 2 years age. Different types of layering are described below:

3.2.1 Simple or Tongue Layering:

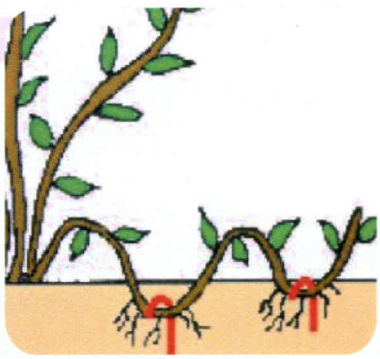


It is easy and effective method of plant propagation. In this method a partial cut is made on a branch and it is bent to the ground and the treated portion of it is covered by soil leaving the terminal end of the branch exposed. Root initiation takes place at the bud and buried portion. Bougainvillea, azalea, climbing roses, rhododendron, guava, litchi, lime, lemon, filberts etc are propagated by this method.

Procedure:

- Select a healthy and flexible branch towards the base of the plant from a healthy plant of desired kind. The branch should be nearer to the ground and sufficient long (50 to 60 cm).
- At a distance of about 15 to 30 cm from the tip, give a sharp slanting inward cut and insert a wood piece.
- Bend these trimmed branches to the ground so that the cut part can be inserted into the soil.
- Cover the rooting region (5 to 7.5 cm) with soil leaving about 15 to 30 cm tip exposed above the soil.
- Keep a stone on the part covered with soil to keep the layer in place.
- Drive a vertical stake into the soil by the side of layered branch.
- The branch to be staked properly with gunny thread.
- The soil around the buried stem is kept moist at 70 to 80 per cent field capacity.
- In favourable rooting conditions, layer will root within 30 to 45 days depending upon the species.
- Remove the rooted cane and plant it in cool shady place.

3.2.2 Compound or Serpentine Layering:

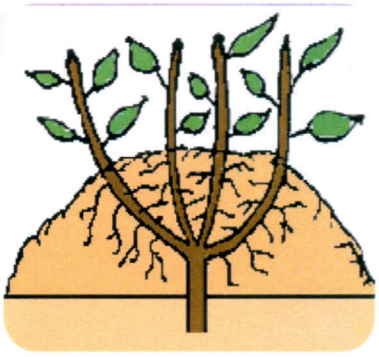


Compound layering is essentially the same as simple layering except that the branch is alternatively covered and exposed along its length in which several layers are result from a single stem. Grape, bougainvillea, jasmine, clematis, pothos, wisteria, philodendron, etc are propagated by this method.

Procedure:

- Select one year old healthy, flexible and long branch (100 to 250 cm) which is near to the ground.
- Give a sharp slanting inverted cut of about 2.5 cm passing through the node at 30 cm, 60 cm, 90 cm and 150 cm from the tip or ringing or girdling is made on the shoot which is to be covered inside the soil.
- Insert a small stick in the tongue.
- Bend the shoot (cane) gently to the ground and insert the cut portions of the stem alternatively into the soil and cover the rooting region with soil.
- For this purpose, each buried and exposed section should contain at least one bud exposed and one bud covered.
- Keep a stone on covered soil if necessary to keep the branch in place.
- Leave the 20 to 25 cm of tip above the ground.
- Water the layered/buried portion regularly till the rooted layer is separated.
- Detach the new plant after 45 to 60 days.
- Layered branches cut into the section after rooting takes place.
- After separating each rooted portion, plant them in nursery.

3.2.3 Mound or Stool Layering:



In this method, plant is headed back to 15 to 20 cm above the ground level during the dormant season. This pruning causes new shoots to grow within two months in spring. At the onset of new growth, soil is heaped around the base of the newly developing shoots. Mound layering is commercially used for propagation of apple, rootstocks, guava, currants, gooseberries, quince, etc. however this method is also advocated for propagation of plum, cherry, pecan nut, hazelnut, litchi and jackfruit.

Procedure:

- Select the desired plant kind to be mound layered.
- Behead the plant to 15 to 20 cm above the soil surface during the dormant season.
- Allow the beheaded plant to develop new shoots. Dormant buds will produce new shoots within two months.
- These new shoots are girdled near base and rooting hormone (IBA), prepared in lanolin paste is applied to the upper portion of cut.
- These shoots are left for the two days for proper absorption of rooting hormone before they are covered/ mound with soil.
- When these shoots have grown 7 to 15 cm long draw up the loose soil around each shoot to half of its height.
- When shoots have grown to 20 to 25 cm, add soil again to half the height of the shoot.
- Add soil again when the shoots have grown to a height of about 35 to 45 cm.
- Water the heaped soil regularly and allow sufficient time for the development of roots.
- Root will form at the bases of young shoots within 20 to 30 days.
- After two months, the rooted stools are separated from mother plants by cutting them close to their base and plant them in nursery.

3.2.4 Air Layering or Gootee:

It is also known as Marcottage or Chinese layering. In this, roots develop on an aerial shoot where the stem has been girdled. For getting root initiation, the ringed portion is covered with rooting medium. The best rooting medium for air layering is Sphagnum moss as it holds large amount of water till root initiation and their development. The crop plant such as guava, fig, litchi, kagzi lime, jackfruit, cashew nut, croton, rubber plant, azalea, dieffenbachia, magnolia, oleander, camellia, etc are been propagated by this method.

Procedure:

- Select healthy branches of one year of age or partially hardened shoots of previous season and about lead pencil thickness (1 to 1.25 cm thick) and 30 to 40 cm long from the desired plant kind..
- Wound the branch by girdling just below a node about 25 to 35 cm away from the growing tip.
- Remove the strip of bark completely from girdled area (about 2 to 4 cm wide ring).
- Scrap the exposed surface gently to remove any trace of phloem or cambium.
- Required concentration of growth hormone (IBA) in lanonin paste or rootee or rootex is applied to upper part of wound.
- Place two handful of moist not wet lanonin paste or Sphagnum moss grass around the wounded bark less area. The moss grass can be substituted with a mixture of soil, sand and leaf mould in a ratio of 2:1:2.

- Wrap the medium carefully with a strip of a clear polythene film (200-300 gauge) of 20 to 25 cm square so as to moisture holding material is completely covered. Gunny bag pieces of 20 to 25 cm can substitute for polythene film as a wrapping material.
- In case wrapping material is gunny bag, frequent watering is essential, but in case of polythene film no further watering is needed as polythene film permits the exchange of gases (CO^2 and O^2) and low transmission of water vapour.
- Tie both the ends tightly.
- Rooting commences within 25 to 30 days from the upper cut portion.
- After observing the fully developed roots through the transparent polythene wrapper, separate the layered shoot after 45 to 60 days from the parent plant by a gradual cut.
- Shoots are severed below the medium and transplant the layer in cool partial shady place in nursery.
- Excess leaves are removed before planting in the nursery.

Precaution to be taken while layering:

- Layering should be done in early spring.
- The branch to be used for layering should be nearer to ground.
- Ensure that the selected shoot should be quite flexible.
- Ensure that the exposed part of the stem has at least one bud to develop into a new shoot.
- Ensure that the rooted layers are cut close to their base to keep the height of the stool (mother) plant low.
- In case of air layering/gootee, large numbers of active leaves are to be retained on layer to speed up root initiation.
- Scrap the exposed surface to ensure complete removal of phloem and cambium to prevent wound healing.
- Rooting medium to be kept always moist but not too wet.

3.3 Propagation by Grafting:

Grafting is the science and technique of joining of two living parts from different plants together in such a manner that they will unite and continue to grow as one plant. To accomplish this, one of the two plants serve as the bottom part which contact with soil and is called rootstock or stock and the other as the top part or scion. In this plant union, only scion is allowed to grow as new shoot of the plant union and the stock serves as the root. There are two basic strategies for bringing about the union between the two plant parts in a graft. Detached scion grafting is the strategy in which the scion is detached; only the stock remains rooted. This technique is most commonly used for grafting, in this strategy, two plants are united at a pre determined and prepared site i.e. the scion and the stock both remain an integral part of the respective parent plant. This procedure is used when detached scion grafting is not feasible. The produce harvested from the plant reflects only the characteristics of the scion parent and not both stock and scion. The stock serves only as ground support.

3.3.1 Spliced Approach Grafting:

In this method both the stock and scion are of essentially equal in diameter. About one year old rootstock is required for grafting.

Procedure:

- Select stock plant of 1-1 1/2 years of age.
- Place the stock plant along the side of mother plant (scion plant).
- Select a branch from the mother plant of the same thickness as that of rootstock.

- Place the scion branch running parallel to the stock plant.
- Bring the stock and scion together.
- Mark out an area of 3.75 to 5.0 cm in length, where stock and scion pieces meet together easily.
- Slice out a thin layer of bark along with wood from the marked area on the stock.
- Give a similar cut of same size on the scion branch as on stock from the marked area.
- The depth of cut given on stock and scion should not be deeper than the 1/3rd of total thickness of the piece. If stock and scion are of unequal in diameters then thicker one should be sliced deeper, so that cambium layers meet easily.
- Bring together two cut surfaces as soon as possible.
- Tie the cut surface together in such manner so that no space is left in between them.
- The tying can be accomplished either by sutli or cloth or polythene strips.
- After 6 to 8 weeks when union has completed the stock is cut above the bandage and the scion below the bandage.
- Keep the newly grafted plant in a cool shady place.

3.3.2 Whip or Tongue Grafting:

This is a good method for young stock plant up to 1.0 to1.5 cm in diameter. The scion and stock should be as close in diameter as possible to provide maximum contact between the cambia of both parts. This method is best employed in the winter.

This method is as same as that of spliced approach grafting. It differs from the simple approach grafting in manner that a tongue is made on both stock and scion for better cambium contact.

Procedure:

- Prepare the stock and scion exactly in the same manner as described in spliced approach grafting.
- A 2.0 to 5.0 cm long tongue like cut at the top of the stock and corresponding cut at the bottom of the scion are made. It is better to make the cut in one single stroke of knife so that the outer surface is very smooth.
- Starting from the middle of the sliced area of the stock give sloping cut into the wood above 1.25 cm deep in such a manner that tongue thus made points upward.
- Similar cut is given in the scion pointing downward.
- On each of these cut surfaces, reserve cut are made, which when stock and scion are joined fit into each other, giving a large area for coming together of cambium layers of stock and scion.
- Place two cut surface in such a manner that tongue of each other are inserted in the slit of each other.
- After joining the stock and scion, they should be tied securely with plastic strip or banana fiber.

3.3.3 Side Grafting:

This method of grafting is very useful when the rootstock is thick being older. In this, an angled cut is made into the stock. A scion is prepared and fitted into the cut by bending the scion gently backward to open up the cut. The thickness of the stock is generally more as compared to the scion. This method is practiced in mango, fig, sapota, and mangosteen.

Procedure:

- Prepare the root stock by making an angled cut in the stock.
- A slanting cut of 2.5 to 4.0 cm at the base of rootstock at an angle of 20 to 250 are made.
- Prepare scion from terminal shoots of past season's growth by

removing the leaf lamina, while petiole are kept intact before 7 to 10 days of grafting.

- In the scion, two slanting cuts, one 2.5 to 4.0 cm long on one side and other 1.0 cm on other side are given, exposing cambium layer.
- Insert the scion into the cut made on rootstock.
- After insertion of scion, wrap and tie it with polythene strip or gunny piece or with coir string.
- After a month, buds in scion begin to grow.
- When they (buds) grow to 7.5 to 9.0 cm long the rootstock stem above the joint is removed.

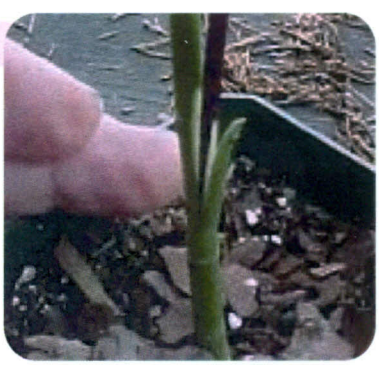
3.3.4 Cleft or Wedge Grafting:

This method is useful for grafting older plants with thick stem. It is practiced in rootstocks having equal and/or greater diameter that the scion. This method is commonly employed in rejuvenating the old orchard by top working. Grape, walnut, hazelnut, etc are propagated by this method. Cleft grafting is to be done in late winter or early spring.

Procedure:

- Prepare base of the scion in the form of a wedge.
- Select root stock of 5 to 7 cm or more girth from the desired plant kind.
- Decapitate the stock at 45 cm above the ground level.
- The stock is given a vertical smooth cut 7 to 9 cm down and then it is split at the centre.
- This straight vertical split is kept open with the help of wedge placed in the centre of the stub.
- Scions 8 to 9 cm long and having 2 to 3 buds are selected and made into a tapering wedge.
- Two such scions are inserted in the sides of the vertical split so that cambium layer of the stock matches with that of the scion and secured tightly with waxed cloth.
- After the successful graft union, one of the scions, which is well developed is allowed to grow.

3.3.5 Veneer Grafting:



This method is modification of side grafting and most commonly used method for propagation of fruit crops. It is a simple method and one year old rootstock having 1.0 to 1.5 cm diameter and 3 to 6 month old scion with similar diameter is selected. The terminal and next to terminal shoots are most ideal. The mango is commercially propagated through verneer grafting. It is most ideal for establishing *insitu* orchard and top working of old unproductive orchards.

Procedure:

- Select stock plant of 10 to 12 months old of 1 to 2 cm in diameter.
- The shoots are defoliated 7 to 10 days prior to the actual grafting leaving the petiole attached to force the latent bud.
- Make a shallow downward and inward cut of about 3.0 to 5.0 cm on one side of the seedling plants at a height of about 10 to 15 cm from the soil surface or just above the crown of stock plant with the help of a knife.
- At the base of this, cut a second short inward and downward cut is made intersecting the first cut.
- Remove the bark along with wood thus making an oblique cut.
- Cut should not be deeper than 1/3rd thickness of the stock at the lower end of the slanting cut.

- Select branch of the desired variety of 10 to 15 cm long and a lead pencil thickness.
- Remove the leaves of the selected branch while still attached to the mother plant about 8 to 10 days before the actual date of grafting.
- After 8 to 10 days, severe the selected branch from the mother plant day on which operation is to be done.
- On the basal end of the scion give an identical slanting cut as that on stock plant.
- Place the cut parts of the scion along with that of stock in such a manner that the cambium layers can be matched as close as possible.
- Tie the union portion tightly either with wax cloth or polythene of 200 gauge of 1.25 to 2.00 cm wide strips leaving the terminal end free.

3.3.6 Softwood Grafting:

In this method grafting is done with mature, procured scion (defoliated 7 to 10 days prior to grafting) on the emerging soft coppery red shoot of rootstock which is about 3 to 8 months old. The leaves of the stock must be retained while grafting to get high success. The grafts are secured firmly using 1.5 cm wide, 200 gauge polythene strip. The cleft or wedge grafting technique is used for softwood grafting. This grafting technique is effective in dry hot weather or in area of low rainfall. It is being used successful in propagating the mango, cashew, sapota, avocado, tamarind, etc.

3.3.7 Epicotyl Grafting or Stone Grafting:

In this technique, two weeks old seedling rootstocks are used for grafting. This technique requires mild temperature and high relative humidity for better success. It has been commercialized for rapid propagation of mango in Konkan region of Maharashtra. June- July are the most suitable months for stone grafting.

Procedure:

- Select two weeks old seedling rootstock having tender stem and coppery leaves.
- Treat rootstock with 0.1 percent carbendazium for five minute.
- Headed back the seedling stem leaves 6 to 8 cm long stem with stone.
- Make a 3.0 to 4.5 cm longitudinal cut into the middle portion of the cut stem/epicotyl.
- Select a scion stick of 10 to 15 cm long, 4 to 5 months old with plumpy terminal buds.
- Make a wedge shaped, slanting cut on the lower side of the scion stick
- The scion stick then inserted in the cleft of the seedlings properly so that cambium of the root stock and scion overlap each other.
- Tie the union with 2 cm wide, 10 cm long polythene strip of 150 gauge.
- Then plant the grafts in polythene bags or nursery.

3.3.8 Inarching:

Inarching is also known as approach grafting or scion attached method of grafting. It is done in evergreen plants which are generally unsuccessful when using other methods of grafting e.g. mango, litchi, guava, and chickoo. In low rainfall area it should be done with the onset of rains, while in heavy rainfall area, it should be done after the rainy season is over, provided temperature does not fall below 15° C.

Procedure:

- Grow the seedling in a circle around a trunk or in pots.
- Bend a strong branch of scion tree so that the shoots to be inarched with the seedling stock in pot.
- Secure the branch in this position by trying to pegs fixed in the ground.
- Select shoots and stocks of the equal thickness.
- Remove the thin slice of bark about 6 to 8 cm long, 8 mm thick at about 20 cm height above the ground level with the sharp knife from stock.
- Make a similar cut in the selected scion shoot. Thus the cambium layer of both stock and scion are exposed.
- These cut are brought together.
- Tie the shoots with a polythene strip (100 to 150 cm gauge) so that they remain in the same position.
- Undertake the operation only when the cell sap in the stock and scion is flowing i. e. during rainy season.
- After about one month, give a 1/3rd deep cut on the stock, 6 cm above the graft union.
- Give similar cut on the scion shoot below the graft union.
- Sever the scion shoot from the mother plant and remove the top portion of the rootstock by deepening the cut further after two months from the date of inarching.
- Place the grafted plants under shade for a week.
- Spray water twice or thrice as day on the plant if weather is dry.
- Transplant the grafts about four weeks after separation from mother plant.

Precautions to be taken while Grafting:

- Ensure that root stock and scion should be healthy.
- Select shoots and stock of the same thickness for grafting.
- Ensure that root stock and shoot should have compatibility for union.
- The scion is usually no longer than the size of a regular lead pencil.
- Grafting is usually done using dormant plants. These plants have no leaves (except evergreen plants). In some cases root stock may be actively growing, but the scion should not be growing.
- Ensure that the cambium tissues of both the parts (stock and scion) must be properly aligned.
- Ensure the scion placed properly on to the stock and also wrapped properly.
- Always use sharp knife and make sharp, clean cut to ensure good contact of tissues.

3.4 Propagation by Budding:

Budding may be described as pseudo grafting and sometimes called 'Bud Grafting'. It is a form of grafting in which scion consists of a single vegetative bud with bark rather that the piece of stem of twig as in grafting. This single bud inserted into the stem tissue of rootstock plant which unites and develops into a composite plant. It is important that budding is to be done when the root stock is actively growing (i.e. spring, late summer or rainfall). Budding is common method of propagation of many fruit tree, roses and many ornamental trees and shrubs.

3.4.1 Shield or 'T'-Budding:

It is widely used method for propagation of fruit trees and ornamental plants. As the name indicates, bud prepared has the shape of 'Shield' and 'T' is the shape of cut given on the rootstock for the operation. This method may be practiced for propagation of citrus, ber, peach, plum, cherry, rose, etc.

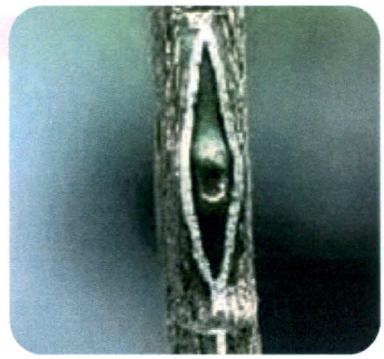
Procedure:

- Select one to one and half year old rootstock seedling of 25 to 30 cm in height and 2.0 to 2.5 cm in thickness (lead pencil thickness).
- Remove the thorns (if any) and side branches up to a height of 20 to 25 cm from the ground level.
- Select a spot at height of about 15 to 20 cm from the ground level in between two inter nodes, which is smooth, other than southern aspect.
- Make a horizontal cut of about 1.25 to 2.0 cm in length, deep enough to cut bark only with sharp budding knife.
- Starting from centre of the horizontal cut, make a vertical cut deep enough to cut the bark only about 2.5 to 3.57 cm long making the shape of 'T'.
- The two flaps of bark are then loosened slightly with the help of budding knife.
- Select healthy shoot of a current season's growth for scion.
- Select the bud from middle portion from the selected shoot.
- Remove these buds from bud wood by cutting shallowly about 5 to 6 mm below and 2.0 to 3.50 cm above the bud.
- Slice the deep enough to include a thin layer of wood also.
- Take out wood though this is not necessary.
- Now this 'Shield' shaped bud is ready for inserting in the 'T' shaped cut given on the stock.
- Hold the bud in such a manner that the eye of the bud is facing upward.
- Push down the bud into the 'T' shaped cut made on stock.
- Continue pushing of the bud till entire bud is covered by vertical cut on the stock and the eye of the bud lies almost in the centre.
- Tie the bud firmly, but not so firmly that it will impede the flow of sap. Tying may be started from any end with polythene strip 200 to 300 gauge or sutli or banana fiber.
- While trying, care is to be exercised that a space about 0.6 cm above leaf petiole is left for growth of bud.
- Care should be taken that very little time is elapsed between opening of bark on the stock and inserting of bud.
- After the bud has sprouted, the stock is cut to about 10 to 15 cm above the bud.

3.4.2 Inverted 'T'- Budding:

In this method, a cut reverse to that of 'T' is made on rootstock. It is most suitable method in areas of high rainfall and for propagating the species which bleed badly during budding such as chest nuts. Inverted 'T' budding allows better drainage and better graft healing.

3.4.3 'I' – Budding:



In this method two transverse cut are given and both are joined to gather at their centers by a vertical cut giving the 'I' cut shape on the rootstock and then a bud patch is inserted in this cut flaps. The patch is tied as usual. 'I'- budding is successful in plant species having thicker bark than that of bud stick.

3.4.4 Patch Budding:

In this budding technique, a patch of equal size containing a bud is obtained and fitted into the stock plant. It is successfully used in species having thick bark such as walnut, pecan nut, cocao, rubber, etc.

Procedure:

- Select rootstock 1 to 11/2 years old of about lead pencil thickness (1.0 to 1.25 cm)
- Make two transverse parallel cuts 3.5 cm apart and 2.5 cm long on the ground level with the help of patch budding knife.
- Connect these transverse cuts at each side of by vertical cuts.
- Select scion branch from healthy plant of desired kind.
- Remove similar size patch of bark containing the one eye bud from the bud stick.
- Place/insert the scion patch of bark on the stock patch.
- Ensure that all the four sides of scion patch are in close contact.
- Tie/wrap the bud with polythene film leaving room 0.62 cm for the bud to resume its growth.
- After sprouting from bud, cut back the stock completely just above the union.

3.4.5 Chip Budding:

This is only the method that can be done at times when the bark is not slipping. This method can be used with a fairly small material (1.0 to 2.5 cm in diameter). It is applicable to a dormant stock since the bark does not need to be separated from the wood as in 'T' – budding. Apple, pear, grape, etc are being propagated by this technique.

Procedure:

- Remove a chip of bark and wood from smooth surface between the nodes of the stock.
- Also remove a chip of similar shape and size from the bud wood of desired cultivar. For which a 2 to 3 cm long downward cut is made through the bark and slightly into the wood of the stock.
- Then make a second cut of about 2.50 cm so that it bisects the first cut at an angle of 30 to 450. In this way chip of wood is removed from the stock.
- The bud chip then slipped in the place of rootstock from where chip has been removed.
- Wrap the inserted chip tightly.
- After sprouting from bud, cut back the stock completely just above the union.

3.4.6 Ring Budding:

In this technique of budding, a complete ring of bark from the stock and a complete ring with a bud from the bud stick preferably of same size are removed and inserted on to the stock. New shoots arising from the heavily pruned plants of ber, peach, cherry, mulberry, etc are capable of giving such buds for budding which can easily be separated.

Procedure:

- Select healthy rootstock plants of 1 to 11/2 year old of about lead pencil thickness.
- Head back the plant at a height of 10 to 15 cm from soil surface.
- Remove a ring bark of 3 to 5 cm in length from top of the stock by giving two circular cuts.
- Select scion branches of the same thickness as of stock.
- Remove the leaves, keeping the petiole intact.
- Remove the ring of bark from the basal end of the scion, containing an eye (bud).
- The ring of bark to be removed should be of same size as that of stock.
- For removing the ring of bark from the scion and stock, the girdled portion is first twisted followed by pulling up the snug.
- Now, slip the scion ring down over the barkless stock, till it reaches the bark.
- If ring does not fit tightly, more bark from the stock is removed and ring lowered. This process continues till the scion ring fits securely on stock plant.
- Tie the bud tightly leaving enough space for sprouting the bud.

3.4.7 Flute Budding:

It is a modification of ring budding. The heading back of shoot is avoided in this method. The ring of bark is removed by giving a small narrow cut, which encircle the stock except with a narrow bark connection between the upper and lower cuts on the stock. The bud in the form of flute is inserted in the stock. It is used in ber, beal, and jamun.

Procedure:

- Select the required healthy root stock and bud stick from the desired kind.
- On the stock plant, give two vertical cuts 3 to 5 cm long and parallel to each other.
- The distance between the two vertical cut may be above 1/8th of the circumference of the stock plant.
- Join the ends of these two vertical cuts by two parallel horizontal cuts and remove the bark piece.
- Similar cuts are also given on the bud sticks to remove the bark piece with bud.
- Insert the scion patch immediately on the stock patch.
- Wrap the bud joint with budding tape while keeping the bud exposed.

Precautions to be taken while budding:

- Budding should be done only when the stock plant is in active growth and the cambial cells are actively dividing.
- Always use fresh bud stick, if the bud stick can not be used immediately store them in cool and humid place.
- In case of flute and ring method of budding, select the stock and bud stick of same size.
- Use rubber or polythene budding strips to wrap the bud union and some times waxed to hold the bud securely

- The length, width and thickness of the chip taken from the stock should exactly be same as the chip of bud stick so as to get better union.
- The cuts given should be bark deep except in chip budding.
- Remove the sprouts developing on the rootstocks, as and when they appear.
- Buds possess polarity; hence bud should be inserted in the right position and orientation i.e. not upside down.
- Care should be taken that the bud is not damaged and that the bud is left fully exposed.
- Bud should not be covered with wrapping material or wax.
- When two parts have united and the bud sprouted, the top of the stock are removed.

4. Propagation by Specialized Vegetative Structure:

Specialized structures are usually modified stems such as runner, sucker, offset, rhizome crown, etc which are used for propagation of plants.

4.1 Runner:

A runner is a specialized stem which develops from the axil of a leaf at the crown of a plant. It grows horizontally along the ground and strikes roots at the nodes and produces now plants, e. g. strawberry.

4.2 Sucker:

Sucker is a shoot which arises from the roots, sometimes sucker arises from the stem also as in pine apple and banana. In banana, two types of suckers are produced i.e. (i) Water sucker and (ii) Sword sucker. Water suckers are broad leaved while sword suckers are pointed in shape of a sword. Sword suckers are preferred for propagation over water suckers. A critical example of a sucker is chrysanthemum.

4.3 Offset:

An offset is a lateral branch produced from the base of stem of a monocotyledonous plant. The branches may develop roots on the plant itself. They can be induced to develop roots after separation e.g. date palm, pineapple.

4.4 Rhizome:

A rhizome is a specialized stem structure in which the axis of the plant grows horizontally just below the ground level or the surface of the ground. Propagation is done by cutting rhizomes into parts with each part having at least one bud or 'Eye', e.g. ginger, canna, lily of the valley, banana, etc.

4.5 Crown:

It is part of a plant at the surface of ground from which new shoots are produced. In strawberry plant where leaves are appeared in groups is oftenly referred as crown of plant. Similarly, at the top is the crown of pineapple plant which can be used for propagation purpose e.g. pine apple.

4.6 Bulb:

It is a specialized underground organ consisting of a short, fleshly, stem axis (basal plate), bearing at its apex a growing point or a flower primordium enclosed thick fleshly scales, e.g. onion, garlic, daffodil, tulip, lily etc.

4.7 Corm:

Corm is the swollen base of a stem axis enclosed by the dry scale like leaves e.g. Elephant foot yam, colacosia, Gladiolus, etc.

4.8 Tuber:

A tuber is special kind of swollen modified stem structure that functions as underground storage organ. Propagation by tuber can be done either by planting the whole tuber or by cutting them into pieces, each piece contain one or more 'eyes' or buds, e.g. potatoes, caladium, etc.

4.9 Tuberous Stem:

Tuberous stem are produced by the enlargement of the hypocotyls section of the seedling plant, but may include first nodes of the epicotyls and the upper section of the primary root, e.g. Begonia tuberhybida, cyclamen, persicum etc.

4.10 Fleshly and Tuberous Roots:

Various herbaceous perennials show enlargement of secondary roots e.g. sweet potato, dahlia. Sweet potato has fleshly root which are produced both adventitious buds and roots, where as dahlia has tuberous root with a section of attached crown. The tuberous roots are propagated by dividing the crown so that each section bears a bud. The root cluster is divided before planting.

5. Propagation Medium:

A propagating medium is defined as one that enables and helps the seed or any part of a plant kept in to germinate or root.

5.1. Characteristics of a Good Medium:

- The growing medium must be sufficiently firm and dense to hold the seed or cuttings in place during rooting or germination.
- The volume of the media must be fairly constant when either wet or dry. Excessive shrinkage after drying is undesirable.
- It must have good water holding capacity so that watering does not have to be done frequently.
- The medium must be sufficiently porous so that excess water drains away permitting adequate aeration to the roots.
- It must be free from disease-pest organisms, nematodes and weed seeds.
- It must have normal/suitable pH level for the plant being propagated or grown and must be free from salinity, alkalinity.
- It must have sufficient plant growing nutrients and provide adequate nutrient to facilitate propagation, especially where plants remain in it for long period. Although supplementary slow release fertilizers are frequently recommended.
- It should with stand steam sterilization without any undesirable effects and changes.
- The growing media should not undergo any chemical changes during sterilization or afterwards.

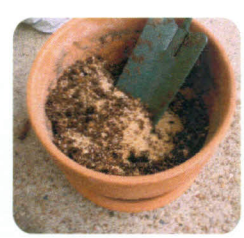
5.2 Types of Media:

Various type of materials and mixtures of materials are used as media for germinating seeds and propagation of plants through cutting, grafting, etc.

5.2.1 Soil and its Composition:

Soil is composed of materials in solid, liquid and gaseous form in proper proportion for satisfactory plant growth. Soil texture consists of sand (2 to 0.5 mm size of soil particle), silt (0.05 to 0.002 mm) and clay (less that 0.002 mm). On the basis of predominance of soil particles/texture, soil can be classified into sandy, sandy loam, silty, silty loam, clay, clay loam soils. A typical sandy loam soil may consist of 70% sand, 20% silt and 10% clay whereas a clay loam might have 35% silt and 30% clay. Soil structure refers to the arrangement of the above particles in the entire soil mass.

5.2.2 Sand and its Composition:



Sand consists of small rock particles (0.05 to 2.0 mm) formed as a result of weathering of various rocks. Quartz sand, generally used for propagation purpose which consists chiefly of a silica complex. The type of sand used for plastering is satisfactory for rooting of cuttings. Sand is the most widely accepted rooting medium for cuttings especially for ever green species. It is relatively inexpensive and readily available. It is not a retentive of moisture as other media, hence need frequent watering. It should be fine enough to retain some moisture around the cuttings, yet coarse enough to allow water to drain off. It is used mostly in combination with organic materials.

5.2.3 Peat and its Composition:

Peat consists of the remains of aquatic marsh, bog, or swamp vegetation, which has been preserved under water in a partially decomposed state. Peat is often added to sand in varying proportions, mainly to increase the water holding capacity of the mixture. The combination makes an excellent rooting medium for cuttings of most of species.

5.2.4 Vermiculite and its Composition:

Vermiculite is a micaceaous mineral which expands markedly when heated. It is hydrated magnesium, aluminum-iron-silica. It is very light in weight, neutral in reaction, insoluble in water and able to absorb and retain large quantities of water. These are three types of peat as classified by the U.S. bureau of Mines i.e. moss peat, reed sedge, and peat humus.

Moss peat is the least decomposed and derived from Sphagnum moss or other mosses. It has high moisture holding capacity (15 times of its dry weight), high acidity (pH 3.2 to 4.5) and contain small amount of nitrogen (about 1 percent) but little or no phosphorous and potassium. Reed sedge peat consists of the remains of grasses, seeds, sedge, and other swamp plants. Its water holding capacity is about 10 times of its dry weight and pH ranges from about 4.0 to 7.5 but it is not used for horticulture purposes. Peat humus is in such an advanced state of decomposition that the original plant remains can not be identified, it can originate from either hypnum moss or reed sedge peat. It has low water holding capacity and high nitrogen content of 2.0 to 3.5 percent.

5.2.5 Sphagnum moss and its Composition:

Commercial sphagnum is the dehydrated remains of living portion of such acid bog plants in the genus Sphagnum such as S papillosum, S. palustre and S. capillaleum. It is relatively sterile, light in weight and has very high water holding capacity as it absorbs 15 to 20 times of its weight of water. It contains very small amount of minerals. It should be shredded before it is used as propagating medium. Sphagnum moss has a pH of about 3.5 to 4.0. it contains a specific fungi static substance(s), which has the ability to inhabit damping off of seedlings germinated in it.

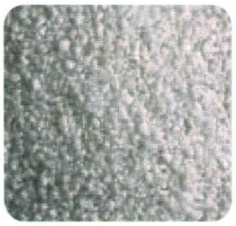
5.2.6 Shredded bark, Saw dust, Wood shavings, Coconut coir dust:

Shredded bark, saw dust, wood shavings, and coconut coir dust are also used in soil mix serving the same purpose as peat and moss. Because of their relatively low cost, light weight and availability these materials are very popular and widely used in soil mixes, but supplementary nutrients must be added for growing the plants in these medium.

5.2.7 Leaf mould and its Composition:

Generally, rain tree, mango and pongania are among the leaf type are used for leaf mould and are most suitable leaf type propagating material. In preparing such medium alternate layers of leaves and soil are heaped up under shade. Watering once daily is to be done to hasten the decomposition of leaves. The leaf mould will be ready for use in about 10 to 11 months. It should be sterilized to kill harmful insect-pests and diseases, micro-organisms, weed seed, nematode, etc.

5.2.8 Perlite:



Perlite is a gray, white silicaceous material, is of volcanic origin, mined from lava flows. It holds 3 to 4 times more water of its dry weight. It is essentially neutral with a pH of 6.0 to 8.0 but with no buffering capacity; unlike vermiculite, it has no cation exchange capacity and contains no mineral nutrient. It is most useful in increasing aeration in a mixture. It in combination with peat moss, is a very popular medium for cuttings.

5.2.9 Pumice:

Pumice is mostly silicon dioxide and aluminum oxide, with small amounts of iron, calcium, magnesium and sodium in the oxide form. It increases aeration and drainage in a rooting mixture and can be used alone or mixed with peat moss.

5.2.10 Rockwool:

Rockwool is used as a rooting and growing medium for horticultural plant propagation. It will hold a considerable amount of water, yet retains good oxygen levels.

5.2.11 Synthetic Plastic:

It can be used a substitutes for sand and perlite. Expanded polystyrene flakes improve drainage and aeration and decrease bulk density. They are chemically neutral, do not absorb water and do not decay, but they can be difficult to incorporate uniformly in the media. This material should not be used in plant growing media until the odor of formaldehyde has disappeared.

5.2.12 Compost:

Compost is in bulk decomposed organic waste. A compost mixture may be useful as a moisture holding material; mixed with soil to add organic matter since compost may contain weed seeds and nematodes as well as noxious insects and pathogen, hence it should be pasteurized before use as medium/mix.

5.3 Potting Mixture:

- For potting of rooted cuttings and young seedlings: 1 to 2 parts sand + 1 part loamy soil + one part peat moss or leaf mould.
- For general container grown nursery stock: Two part sand + four part loamy soil + two part peat moss + four part peat moss or leaf mould + one part well rotted FYM.\

Procedure:

- Note down physical characteristics of each medium.
- Weigh a suitable quantity (20 to 25 gm) of propagating material.
- Shift the propagating medium to the glass container, do not compress the medium.
- Add measured quantity of water so that rooting medium should be immersed completely in water.
- Allow it to stand for about five minutes, do not disturb or compress the medium.
- Drain off the excess water from the container by decantation after certain time/ required time.
- Measured the water drained in milliliter.
- Repeat this process for all other media.

Calculations of water holding capacity:
Water holding capacity of the medium can be calculated by applying following formula: $\left(\frac{W \times X}{X}\right)100$

Where

W = quantity of water held by the medium
X = weight of the medium

Precautions:

- Ensure the quantity and type of medium.
- Avoid pressing of medium in a container while determination of water holding capacity.
- Sterilize the medium to avoid insect-pest-disease infestation and weed problem.
- Nutrient starter solution can be applied in medium, if deficient in nutrients.
- Use neutral medium; the medium should not have excess salt, and it should not be saline or alkaline.

6. Selection and Preparation of Scion wood of Grafting and Budding

6.1 Criteria for Selection:

Following points are to be taken into consideration while selecting the scion wood for budding and grafting:

- The scion wood should be selected from previous season's growth, but it should not be older than one year.
- Current season shoots are desirable in most of cases except in case of fig and olive where 2 years old scion gives better results.
- The flowering shoots and shoots from where fruits have been harvested should be avoided for scion, because such shoots are usually not in active stage of growth due to depletion of nutrients.
- Always select healthy, well developed vegetative buds. The vegetative buds are mostly narrow and pointed while flowering buds are plump and broad.
- The vigorous and viable shoots should be selected for scion wood.
- Water sprouts gives better results, hence prefer them for use as scion.
- Thickness of scion stick is important; generally select the shoots of ½ to 1 cm diameter to use as scion.
- Select the scion from disease-pest free plant as most of diseases particularly viral diseases transmitting through scion material. Hence, avoid to take scion stick from diseased plants.
- Always select the scion from the trees with well known performance for high yield and quality.
- A tree of unknown performance though clonally propagated from a choice of variety should be avoided.

6.2 Preparation of Scion wood:

Preconditioning:

Evergreen fruit trees do not undergo in dormancy and as such, the buds are mostly under developed during the grafting and budding season. Hence, the buds need to be activated before removing them from the mother trees. This is known as 'Preconditioning' and 'Forcing of bud'.

- A heavy pruning in the previous seasons encourages vigorous shoot growth which makes excellent scion material.
- Defoliation the shoots intended for use of scion sticks completely or partially forces the development of buds. For example, in mango, removal of ¾th of leaf blade up to 15 cm shoot length 7 to 10 days before serving the scion sticks from the mother tree, activate the buds adequately.

Storage of Scion wood:

The scion wood of evergreen fruit plant can not be stored for a long time, even at low temperature. Where as scion wood of deciduous fruit trees can be stored for a long time (few months), In case scion wood is taken during dormant period, their storage life can further be extended, if stored at 00 C temperature. In temperate regions, scions collected during dormancy are stored in the field by covering them with soil and use them for grafting in spring.

Procedure:

- Select healthy tree of well known performance.
- Select straight shoots of about 18 to 20 cm in length, 0.5 cm in diameter (pencil thickness).
- Remove ¾th of leaf blade with the help of a sharp secateurs or scissors in half of the shoots.
- Leave the petiole along with ¼ leaf blade intact with the shoot (X).
- Do not remove the leaves from the remaining half shoots (Y).
- Label these shoots properly giving the data and shoot number.
- Cut the labeled shoots to about 15 cm in length with the help of secateurs after about 7 days of defoliation.
- Store them in closed plastic bag in moist Sphagnum moss or waste papers.

Precaution:

- Avoid scions with under developed or over developed buds for use in grafting and budding.
- Always use a sharp secateurs or scissors for cutting the leaf blade to avoid bud damage.
- Always take the scion from healthy tree of well known performance.

***

Tel fax : 0832-2285475
e-mail : pckvknorthgoa@gmail.com
website : www.kvkicarrcgoa.in