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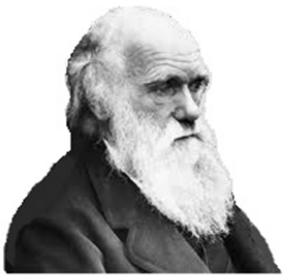

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Vegetative Propagation: A Unique Technique of Improving Plants Growth

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ABSTRACT

Vegetative propagation is any form of asexual reproduction occurring in plants in which a new plant grows from a fragment of the parent plant. Different methods of propagation can be used for plants because they respond differently. Based on plant growing uniformly, increasing the production of these plants, their resistance to pest and diseases, early bearing of fruits and having some certain traits in the new generated plants, various techniques of propagation have been designed for it. Plants can be propagated through sexual and asexual methods. Sexual one involves the use of seeds while asexual involves the vegetative parts of plant in raising new ones. The parts of the stem cutting mostly used are leaves, root, stems and terminal bud, due their simplicity. There are various trees on which stem cuttings can be done based on their maturity. It can be done on either herbaceous, hardwood, softwood or semi-hardwood due to their convenience and the stem cuttings of some more difficult to root than others. Asexual propagation involves stem cuttings, air layering, grafting, budding and micro propagation. Adoption of these forms of vegetative propagation has increased over the years and different species have been propagated through each of these methods with various degree of success. This paper aims at reviewing various techniques in propagating plant species.

***Keywords*:** Propagation, Asexual, Sexual, Seed, Cuttings, Grafting

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1. INTRODUCTION

Plant propagation, can be defined as the reproduction, regeneration and multiplication of plants. It allows plants to reproduce offspring through the seed production [1]. It is a practical way of getting certain traits from tree which can be lost in sexual propagation [2]. While most plants can reproduce sexually, some reproduce by vegetative means and some are induced by hormonal treatments. It has the potential to grow adventitious roots which sprout from other plant part like stem and leaves, roots, allowing development of new plants from parts of another plant. Young plants are easier to propagate through vegetative means [3]. Plants can be propagated by sexual and asexual method. This aims at reviewing the methods of propagating plant species.

2. SEXUAL PROPAGATION

Sexual propagation is a way of using viable seeds to grow plants. It is a convenient and easy method of propagating crops like fruit, medicinal and ornamental plants. It may be quicker, more economical than asexual propagation and for some plants it may be the only means of propagation. It is an easy method of propagation. In sexual propagation of plants, seed has longer gestation period which delays flowering and fruiting. Crops that cannot produce seeds cannot be propagated through this method.

2. 1. Seeds

Figure 1. Germinating seeds under a propagator [8]

Seed is a fertilized mature ovule that has reserve tissue, embryonic axis and cotyledons covered by a coat. Many seeds have three parts: an embryo, endosperm and seed coat [4-5]. The outer layer of a seed is called a seed coat, which avoids entry of water into it till when ready to germinate and guard against disease, insect and any forms of injury. For tree propagation, seeds are of necessity because several rootstocks can develop from it. It is cheap, easy to handle and means of raising timber and agroforestry tree species [6]. Some factors affecting the environment like temperature, water, oxygen and light are needed in a viable seed before germination can occur [7]. Before harvesting time, some seeds need a little effort when in their resting period before they can germinate while some germinate immediately and some seeds can be dormant.

2. 2. Seed Dormancy

Viable seeds that do not germinate are said to be dormant. Seed dormancy is simply the blockage of the state of almost finished germination of a viable seed placed under a favourable condition [9]. Seed germination occurs when there is a contact with moisture at a suitable temperature in the presence of oxygen. Some species which are exceptional do not germinate despite being placed under favourable conditions: this means the seed is dormant.

A seed is dormant when it is not exposed to enough oxygen, temperature, moisture, and for some species light. However, dormancy is caused by unfavourable environmental conditions and it can only be measured when germination is absent [10]. Dormancy is not just about absence of germination but it's the characteristics the seed possesses that ensure the conditions needed for suitable germination [11]. Dormancy consists of two types: (a) seed coat (or external) dormancy, and (b) internal (endogenous) dormancy. A seed can also exhibit both kinds of dormancy.

2. 2. 1. Techniques to Break Dormancy

2. 2. 1. 1. Cold or warm water

Soaking of seeds in water should be below 40 °C; this helps improve germination only if the seeds have a permeable seed coat (passage of water). This method of breaking dormancy is done mostly for tropical species [12].

2. 2. 1. 2. Boiling water

Weight or volume ratio of seed to water is hard and the soaking time differs between species. The seed is deepen for 4-10 min in the boiling water (100 °C), the heat source is removed, and the seed is soaked in the cooling water for 12-24 hrs. The nature of the container and operation of the scale is influenced by the rate of cooling. This particular method is done for African species which gives better results [13]. To break dormancy, the cuticle and part of the palisade layer of seed coat can be effectively removed by boiling the seeds in water.

2. 2. 1. 3. Hot water

For effective breaking of seed dormancy in hot water, the seeds must be soaked in water at 60–90 °C. This is reliable and effective as soaking in 100 °C but there can be a change of the seed being damaged at a lower temperature [14].

2. 2. 1. 4. Scarification

Physical scarification

External dormancy results when a seed's hard seed coat is impervious to water and gases. The seed will not germinate until the seed coat is altered physically. Any process of breaking, scratching, or mechanically altering the seed coat to make it permeable to water and gases are known as scarification.

Manual scarification

Chipping, piercing, nicking or filling the test of individual seeds with a mounted needle, knife, hand file or abrasive paper is a technique especially suitable for small quantities of seed. This is usually considered to be the most reliable method of pre-treatment and the germination percentage; following this operation probably is approximately closely to the germination capacity [15]. After the dormancy in seed has been broken by any of this method, the seed can be planted to germinate.

2. 2. 1. 5. Germination

Germination can be defined as appearance of the embryo from the seed caused by the different catalytic anabolic activities [16]. Germination rate of some seed is dependent on the strong seed coat and period of storage of the seed which is a factor for making the seed dormant [17]. Seedling vigor [18], germination time [19], germination percentage are all affected by the size of the seed for disseminating such plant over the habitat [20]. There are different types of seeds. Recalcitrant seeds are seeds that germinate fast and easily when freshly sown but are easily affected by freezing and dehydration when stored [21]. Majority of the trees found in tropical and subtropical region have recalcitrant seeds [21]. Intermediate seeds are seeds which can withstand dehydration but have high water content [21]. Orthodox seeds are seeds found in the tropics with low moisture content which do not have effect on germination when sown [22]. They can be stored for a longer period. Another method of propagating, apart from sexual (seed), is through asexual means.

3. ASEXUAL PROPAGATION

Asexual propagation is also known as vegetative propagation. It is based on the application of vegetative parts (shoot, leaves, root, stem, etc.) of plants for raising new ones. It is when a replica of a clone from the ortet (mother plant) is collected and sown to raise new ones. This process ensured the meristematic, undifferentiated cells that distinguish the various organs that will form a whole new plant [23]. Vegetative propagation is an option to avert the extinction of the specie [24]. It is easier and faster than sexual propagation for some species and can produce mass genetic copies of selected specie for planting. It can speed up domesticated trees needed for urgent planting with mixtures of higher selections, allows raising of trees any time so that unavailability of seed will not affect a suitable planting stock [25].

It also allows propagation of special types of growth, such as weeping or pendulous forms, has the ability to capture rapidly a larger portion of additives and non-additive genetic variation and eliminating inbred individuals from plantations [26], it further increase yields, rapid early fruiting and quality of a plant.

Cloned plants can be attacked by bacteria, fungi or viruses that can kill them. It is more expensive and no new variety can be evolved. Asexual propagation is the only alternative to save the species from potential threats of extinction and the process of taking a piece of a desirable plant and reproducing new plants from these tissues. Asexual propagation allows also cloning of plants, meaning the resulting plants are genetically identical to the parent plant. All the traits possessed by the mother tree are transferred to offspring. For multiplication of species, whose seeds are not readily available, asexual propagation is used because it no longer depends on the fruiting season of the specie [27]. The major methods of asexual propagation are cuttings, layering, budding, grafting, and micro propagation (tissue culture) [24].

4. CUTTINGS

Propagation by cuttings involves rooting a piece of the parent plant thereby new plants are gotten from the tissue (leaf cuttings). The most known propagation technique is cuttings, because it is low cost effective and most successful [28]. Stem cuttings produces uniformly large quantities of plant but low success rates are recorded due to difficult rooting and growth [29]. The ability of stem cuttings to root, all depends on the plant species, some root easily while some are recalcitrant even when growth regulators are applied [30]. For a woody specie stem cuttings to root, the physiological processes in the leaf and stem portions of the cuttings are being affected. And these processes are influenced by many anatomical and morphological factors resulting from interactions with age, ontogenetic phase, condition of the stock, genetic background and post severance treatment such as composition of the nutrient and plant growth regulators [31] (Hartmann *et al.* 2002). Depending on the cutting to be propagated on specie, the maturity of specie, the particular type of cutting is of necessity. Some species root easily in cuttings depending on the wood of the species, may be softwood, semi softwood or hardwood [31-32].

4. 1. Stem cuttings

Stem cuttings are the most extensive and popular used methods of vegetative propagation. These cuttings are important because of the ease by which plants grow from them, although, some are more difficult to root than others.

4. 1. 1. Types of Stem Cuttings

There are four different types of stem cuttings which include: herbaceous, softwood, semi-hardwood, and hardwood. It is the growth stage of the stock plant, which is one of the most important factors influencing whether cuttings will produce roots [31].

4 .1. 1. 1. Herbaceous cuttings

It is a practice used for non-woody herbaceous plants. 3-5 inch of the plant new growth of the stem parent plant is made use in this type of cutting. This method is fast and easy to root with a higher percentage success rate. Examples of herbaceous plants are lemon plant, rosemary, etc. Tthe cuttings of this plant can be taken at any time of the year [33].

Figure 2. Herbaceous cuttings [33]

4. 1. 1. 2. Softwood cuttings

2-3-month old shoot of softwood taken from herbaceous or succulent plants are chosen for this cuttings, example duranta, coleus, etc. Cutting gotten from softwood are taken from tender part but the branches must be matured and these cuttings length differs from 10-12 cm. The cutting materials are best collected in the morning and are kept moist in a cloth. For softwood cuttings, the presence of the physiological process of the leave is dependent on its rooting.

4. 1. 1. 3. Semi-hardwood cuttings

Figure 3. Semi-wood cuttings planted in rooting media [33]

This is a type of cutting made from partially matured woody evergreen plants taken during its growth season. The leaves are of matured size and the wood is firm. The leafy shoot tip part is used for the cuttings and cut off before the wood hardens and turns brown. A closed propagator is recommended for a successful rooting of the cuttings. Some conifers, broadleaf evergreen shrubs, mango, coffee and pomegranate plants are propagated by this method [34].

4. 1. 1. 4. Hardwood cuttings

Deciduous plants cuttings such as grapes, pomegranate, and hibiscus are propagated through these methods. For raising fruit tree, long cuttings are used to raise the rootstock. 4-5 dormant vegetative bud must be present in each cutting, thorns and leaves when present must be removed in order to monitor the loss of transpiration. A slant cut is done at the base of the cutting underneath the node and a straight cut is done at the top bud. This cut done on it helps in identifying the cutting position. Another way of propagating through cutting is the leaf.

4. 1. 1. 5. Leaf cuttings

Simple leaves which do not have the ability to develop new roots, their roots, shoots, succulent and semi succulent can still propagate through their leaves by the presence of intercalary meristematic activity [35]. Examples of plants that can be propagated by leaf include African violet, peperomia, episcia and plants belonging to the Crassulaceae family [36, 37]. The cloned cuttings are placed in a germination tray filled with potting mixtures, then replicated before placing in the propagator [38]. Some growers think this method of propagation through leaf cuttings is totally unpredictable [39].

4. 1. 1. 6. Root cuttings

This is a complicated process whereby the exact genotype of the parent plant is copied due to some basic traits, such as totipotency and dedifferentiation. Totipotency: is the ability of a single cell to divide and produce all of the differentiated cells in an organism; examples are spores and zygotes while, dedifferentiation is a transient process by which cells become less specialized and return to an earlier cell state within the same lineage [40]. For the root cuttings, it begins with healing process, formation of new cells, root formation selection and matching the vascular tissue in the stem cuttings with the roots. The duplicated root grows and develops to become a plant. Numerous endogenous and exogenous factors affect the positivity of this process [23].

4. 1. 1. 7. Procedures for Rooting Woody Stem Cuttings

Cuttings should be taken from healthy and disease free plants. The flower buds and flower should also be removed. Collection should be done early in the morning or immediately after rain. It's important to keep the cuttings cool and moist. Long shoot can be divided into several cuttings [25]. The cuttings should be trimmed to a reasonable size between 4-6 inches. A scalpel is used for cuttings and it is cut into single or more nodes. Larger amount of cuttings are gotten from a single node for species with small leaves; multi-nodes with short internodes are the best and where two buds are at each node spilt, cutting can be used [25].

4. 1. 1. 8. Rooting Media

Rooting media is a substrate that encourages root growth. It is any media used for growth and support to propagate new plants either by seeds or cuttings [41]. The best type of rooting medium depends on materials, plant species or type of cutting [42]. Water can be used as a rooting medium because it is not aerated and less expensive, sterilized sand can also be used. The media to be used must be porous, allow draining, with uniform texture and well moistured [43]. Rooting media are often used with organic or synthetic rooting hormone to speed up the root growth as well as protecting the root cuttings from fungi attacks.

4. 1. 1. 8. 1. Types of Rooting Media

Sawdust

Saw milling is an economic activity done in most countries with forest resources, in which saw dust is among the byproduct [44]. It is mostly used in agriculture as soil conditioner [45] and the carbon present in it is up to 50% [46]. It is added to soil to help enhance the building up of the soil organic carbon pool which decomposes slowly. Organic matter is of utmost need in soil because of the normal degradation and crop rotations which help to maintain soil compost at a chosen level. Saw dust is a sterile media that cannot hide microorganism because of low nutrient content present in it [44-47].

Livestock manure

Example of livestock manure is cow dung, it has 25 – 30 nitrogen ratios which is relatively low but needs the necessary energy for microbe's activity in holding high water capacity. The macro nutrients concentration in cow dung gives initial nutrients needed for the decomposition process and these factors help in the mixture of cow dung and saw dust that enhance decomposition to meet plant requirement [48].

Soil

Soil contains a small rock particle which can be gotten from natural forests. It has weight but lacks essential nutrients and may contain different pathogen, weeds seeds and weeds. Before using it as a growth media for seedlings growth in the nursery, addition of inorganic fertilizer in a minute quantity is recommended [49]. Livestock manure is highly rich in microbes which help organic matter decompose quickly compared to sawdust that has low plant nutrient [50].

Peat moss

Peats are formed when accumulation of plant underwater with low oxygen, low temperature and level of nutrients does not decay completely [51]. Different types of plant, such as sedges, grasses and mosses can be decomposed by peats. To determine peat mosses value as a growing media component, water quality, plant species, degree of decomposition, and local climate variation adds to the difference [52].

Perlite

Is a mineral (alumino-silicate) that broken from a volcanic rock, screened, mined and exposed to heat as high as (1,832 F//1000 °C). Its characteristics makes it suitable as a growing

media due to the light weight particles produced from it after mining and subjecting it to temperature. Growing media containing perlite are known to be lightweight and well drained. Water coheres to the surface of the perlite particle only, it is well porous, very rigid and does not squash easily. Perlite enlarges the aerified passage of peat- based media [53].

Vermiculite

It is sterile, light weighted that has a distinct properties needed for horticultural use. It is a mineral (aluminum-iron-magnesium silicate) with different parallel, thin plates; it is mined, heated at (1,832 F/1000 °C) and expanses the particles of the vermiculite to 15-20 times of its initial volume to give accordion-like structure. Vermiculite holds large quantities of water, air and nutrients with four particle sizes [54].

Figure 4. Cuttings in the rooting media [55]

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5. LAYERING

When a stem roots and is removed from the mother plant, that rooted stem is called a layer. The root is developing on the stem when it's still attached to the mother plant and it is called layering. There are different forms of layering.

5. 1. Air layering

It is also known as marcotting, a method originated by the Chinese several centuries ago. It is one of the techniques in propagation whereby the aerial stem is covered in the rooting media in order to re-produce roots at the upper part of the branch on the mother tree [55]. Naturally, some plant propagates by layering but at times the help of a plant propagator is required in the process of propagation. The advantage layering is that the propagated portion, while forming roots, taps water and nutrients constantly from the mother plant. This method

improves existing roots and it is good for developing new shoot. For a successful layering of woody plant, time of the season is important, because rooting is affected by temperature, moisture and light [56].

Figure 5. Air layering on a mother plant.

5. 2. Tip layering

Figure 6. Picture of a tip layering [57]

The tip of the season shoot must be dipped inside 3-4 inches rooting medium and should be covered with soil. Tip layering pushes the point of a stem or the tip to the stem underground, holding it with a pin. The formation of root bends and the re-curved tip forms a new plant in early or late spring. The layer of the tip removed is planted at that time. An example of tip layering includes trailing blackberries, purple and black raspberries and dewberries.

5. 3. Simple layering

Plants with low-growing branches are mostly done with simple layering: it is a propagation technique for boxwood, hazel-nut, honeysuckle, wax myrtle and forsythia. When the plants are in their dormant period, the stems can be bent to 20-25 cm deep trench and then covered with soil, the top part of the stems have 2-3 buds on it and remains above the surface [34].

Figure 7. Picture of a simple layering.

5. 4. Compound layering

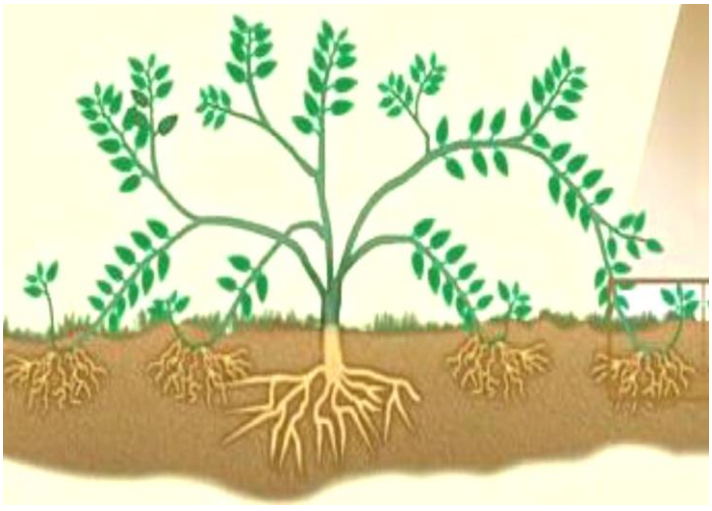

Figure 8. Compound layering.

It is a layering whereby a single stem produces several layers. This particular method produces two or more plants in place of one. It is done on plant with vine-like growth, examples of such are grapes, heart-leaf philodendron, wisteria and clematis, etc. It is also similar to simple layering. For simple layering, the stem tends towards the rooting medium but covering and exposing the stem section; exposing at least one section bud while the soil covers another bud and the lower side of each section of stem covered is wounded.

5. 5. Natural forms of layering

Examples of plant that propagate naturally are spider plant, strawberry, etc. Natural layering sometimes occurs without the use of propagator. The structures that help fasten propagation by layering are the runners and offsets. Runner gives formation of new shoots when placed in a growing medium and these runners propagate new plants from their parent stems. Scion runner's tip may be rooted while attached or detached to the parent plant in the rooting medium.

Figure 9. Picture of a natural form of layering [57]

6. GRAFTING

Grafting is the union of the stems of two plants to grow as one (rootstock and scion). Rootstock can either be a cutting, seedling or a micro-propagated plant while scion is a little portion of shoot cut from a chosen tree whose buds are dormant and when grafted together forms new stem and branches [31]. Grafting plants of the same species is called Auto-grafting, grafting the same species of two different plants is called Homo-grafting and grafting plants of different species is known as Hetero-grafting [58]. Majority of the hetero-grafting methods do not survive because they are incompatible, the scion, rootstock or both may die after grafting. Most times combination of grafting done on agricultural produce is successful due to their compatibility and grows till flowering [59]. There are different methods of grafting, as lollows:

6. 1. Whip and tongue grafting

It is mostly done for plant that can combine or unite easily. The scion and the rootstock must be of the same diameter of a pencil size up to 10-15 mm. Root, top and stem can be used for grafting. This method of grafting gives a perfect contact to the cambium and it heals quickly [34].

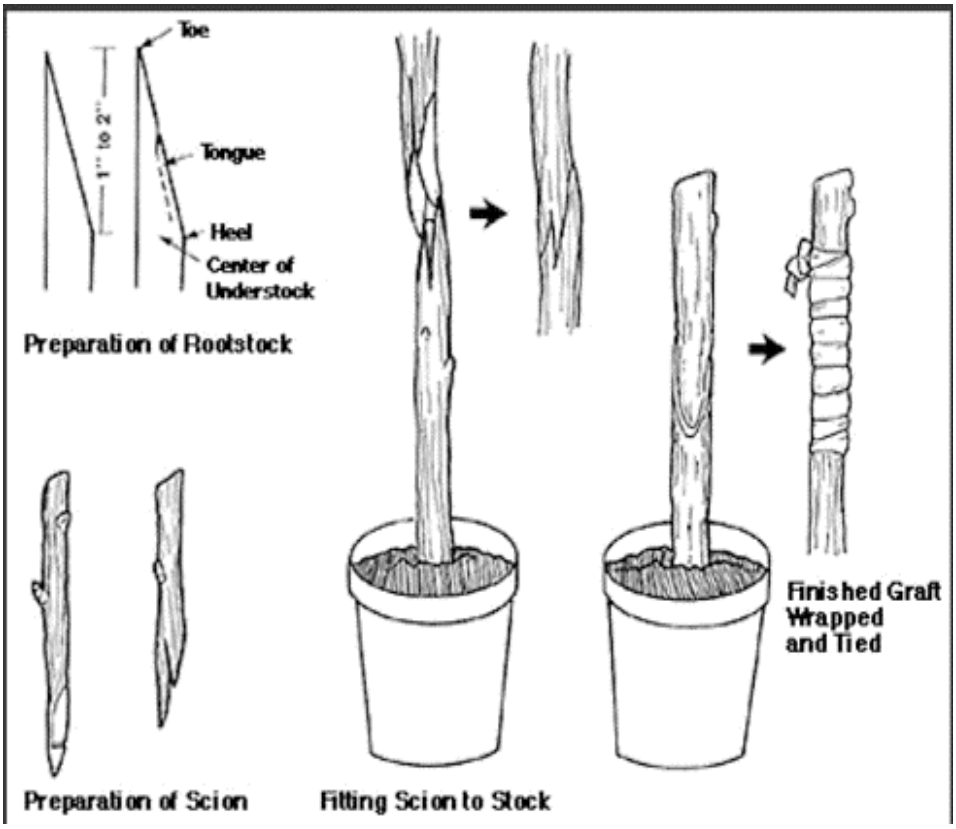

Figure 10. Picture of steps of whip and tongue grafting.

6. 2. Cleft grafting

This is the most common method of grafting whereby a wedge shape is cut out from the scion base and the rootstock is then horizontally cut before cutting into cleft. It is done when the bud on the stock plant gradually swells before the commencement of the active growth. However, the scion must be in a state of dormancy and it is best done in early spring [60].

7. BUDDING

Is a form of grafting whereby one or more axillary bud is attached to a scion (reduced to a small stem) [61]. Successful grafting method varies from crop to another and it is influenced by present environmental conditions. Budding is the primary method for propagating fruit trees used by nursery workers.

7. 1. T-budding

This is a type of budding done when the bark can be easily separated from the wood, (bark is said to be slipping). The rootstock can be a year old or a rooted layer. Most budding are done during latter season but T-budding is done in summer season. Varieties of scion bud sticks are prepared from the mid-portion of the season growth. It is a common type of budding, also known as dormant or fall budding. Many fruit trees are propagated by this method.

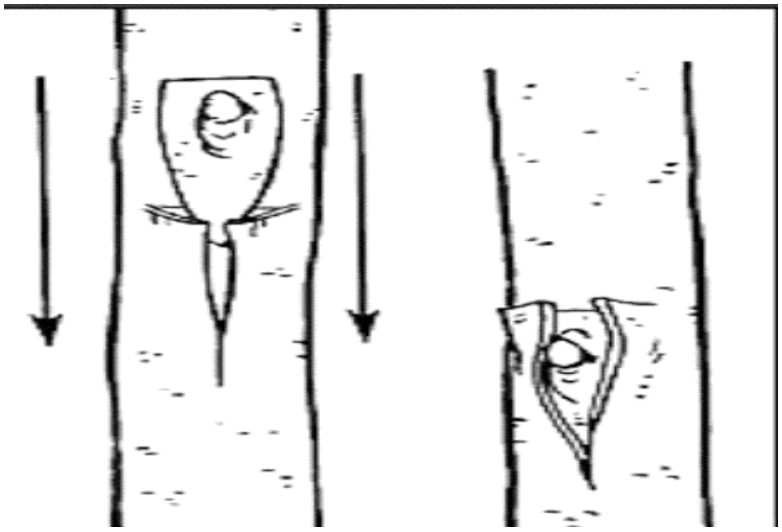

Figure 11. T-budding cut [61]

7. 2. Chip budding

It is one of the primary methods of asexual propagation for woody plant for reproducing trees, shrubs, fruits and nut trees. It is a type of budding for rootstock with dormant or active vascular cambiums. To achieve a successful chip budding, something has to be in place, a sharp budding knife, budding tape (for wrapping the bud tightly to the rootstock) to prevent the bud from dehydrating and to keep excessive moisture from soaking the bud union. The rootstock must be of the same species and genus with (12 mm) stem diameter of active or dormant cambium.

8. MICROPROPAGATION

This method or practice is used to generate or propagate plants placed under a controlled environment or it is a sterile condition for cloning of plants. Micro propagation is also plant tissue culture. For multiplication and growth of these tissues in this process, they must be maintained under conducive condition and these conditions are proper gaseous, liquid environment, supplied of nutrient and temperature. Within a short period of time, large quantities of plants from the small pieces of stock plant can be produced through micro-propagation. The tissue to be used can be gotten from the leaf, lateral bud, stem, and shoot tip and root tissue. Immediately the plant is put in the culture medium, the accumulation of lateral

bud and adventitious shoot forms callus which brings about the increase in the number of shoots ready for rooting. Plantlets or micro-cuttings have been recorded to be grown in containers or field successfully and various species have been established through this method [61].

9. CONCLUSION

Generally, plant can be reproduced sexually and asexually. Application of any of these asexual methods of plant propagation is more important to increase production of each crop, respectively. Many plants can be grown from cuttings as long as a right part of plant is chosen to cut and a right tool for each technique is used thereby, a healthy plant can grow. Air layering is mostly used by farmers due to its success rate and low mortality rate is recorded. To get virus free grafted plants, desirable rootstock for commercial purpose, micro-propagation technique is utilized. However, several propagation techniques are available which can be adopted by the growers and farm owners but each specie needs a special method of care and management.

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