

Effective Propagation Methods: Vegetative Propagation of Some Fruit Tree Species and Endangered Tree Species

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Abstract

Vegetative propagation is a method used for plant reproduction. This process is commonly used in fruit plant propagation for several reasons, including the maintenance of desirable traits, rapid multiplication of plants, and ensuring genetic uniformity. Vegetative propagation is widely used in agriculture, horticulture, and landscaping for various purposes, including crop production, ornamental plant cultivation, and conservation of rare or endangered species. Various vegetative propagation techniques exploit the ability of plants to regenerate specialized tissues and structures. Commercially valuable crops, such as seedless fruits (e.g., seedless grapes and bananas) and sterile ornamental plants, are propagated through vegetative means because they do not produce variable seeds. Vegetative propagation enables the continued production of these varieties. The mass replication of commercially important fruit species depends on high-quality and consistent planting materials for economic gains. The lengthy gestation period of fruit crops also necessitates high-quality planting material to avoid any economic loss in later stages. The success rate of vegetative propagation methods depends on factors such as plant species, environmental conditions, and propagator skill. This study investigated various vegetative propagation techniques for mango, lychee, guava, jamun, lemon, salai, and Rudraksha trees. The results demonstrate the effectiveness of different methods such as stem cutting, air layering, and grafting, ensuring rapid multiplication, genetic uniformity, and preservation of desirable traits.

Keywords: Vegetative propagation, Air layering, Grafting, Stem cutting, Plant growth regulator.

Introduction

Vegetative propagation is a method of plant reproduction that involves the production of new plants from existing plant parts, such as stems, roots, or leaves, rather than from seeds. This process is commonly used in fruit plant propagation for several reasons, including the maintenance of desirable traits, rapid multiplication of plants, and ensuring genetic uniformity. Vegetative propagation is widely used in agriculture, horticulture, and landscaping for various purposes, including crop production, ornamental plant cultivation, and conservation of rare or endangered species. Vegetative propagation is a fundamental technique in horticulture for reproducing plants with desired traits, and can be used to build a number of phenotypically superior individuals without wild digging. Mango, lychee, guava, jamun,

lemon, mahogany, peepal, teak, salai, and Rudraksha trees are economically and culturally significant species, and their cultivation and preservation benefit from effective propagation methods. This study examined the various and best techniques used for the vegetative propagation of these tree species. Vegetative propagation techniques are extensively used in fruit tree cultivation because of the numerous advantages they offer in maintaining desirable traits, increasing productivity, ensuring genetic uniformity, and overcoming challenges related to seed germination and genetic variability.

Challenges and Considerations

Although vegetative propagation offers numerous benefits, there are also several challenges and considerations that growers must consider when employing these techniques. Vegetative propagation remains a valuable tool for growers in agriculture, horticulture, forestry, and conservation, offering opportunities to propagate desirable plant varieties, increase productivity, and overcome the limitations associated with seed propagation. By effectively understanding and addressing these challenges, growers can optimize the success and sustainability of vegetative propagation practices.

- 1. Genetic Uniformity:** Although genetic uniformity can be advantageous in maintaining desirable traits, it also means that plants propagated vegetatively lack genetic diversity. This can increase their susceptibility to pests, diseases, and environmental stresses. To mitigate this risk, growers should periodically introduce genetic diversity through controlled breeding programs or incorporation of new genetic materials.
- 2. Disease Transmission:** Vegetative propagation can facilitate the transmission of diseases and pathogens from the parent plant to offspring. Infected plant materials used for propagation can spread diseases, such as viruses, bacteria, and fungi, to new plants, leading to reduced vigour, yield, and quality. Strict sanitation practices, regular monitoring of diseases, and use of disease-free plant materials are essential to minimise the risk of disease transmission.
- 3. Propagation Success Rates:** The success rate of vegetative propagation methods can vary depending on factors such as plant species, environmental conditions, and propagator skill. It may be more challenging for some species to propagate vegetatively than others, and certain techniques may have lower success rates. Growers should be prepared for potential failures and invest time and resources in mastering propagation techniques and optimising conditions for success.
- 4. Time- and Labour-Intensive:** Vegetative propagation methods can be time- and labour-intensive, requiring careful preparation, monitoring, and maintenance of propagation materials. Grafting, for example, involves precise techniques and detailed attention to ensure successful union between the scion and rootstock. Layering and cutting propagation methods may require regular pruning, watering, and monitoring to promote root formation and establishment.
- 5. Dependency on Parent Plants:** Vegetative propagation methods rely on the availability of healthy and vigorous parent plants from which propagation can be obtained. If the parent plants are affected by pests, diseases, or environmental stresses, they can affect the quality and viability of the propagated offspring. Growers should carefully select parent plants and implement measures to maintain their health and vitality.
- 6. Environmental Conditions:** Environmental factors such as temperature, humidity, light, and substrate composition can influence the success of vegetative propagation. Optimal environmental conditions vary depending on the plant species and propagation method used. Growers should

carefully monitor and control environmental parameters to create favourable conditions for root formation, shoot growth, and overall plant establishment.

7. **Regulatory Considerations:** In regions, regulatory requirements or restrictions may govern the propagation and distribution of vegetatively propagated plants, particularly for commercially important crops and endangered species. Growers should familiarise themselves with relevant regulations, obtain necessary permits or certifications, and adhere to best practices for plant quarantine and biosecurity to prevent the spread of invasive pests and diseases.
8. **Costs and Resources:** Vegetative propagation methods may require initial investment in equipment, materials, and infrastructure, particularly for commercial-scale operations or specialised techniques such as tissue culture. Additionally, on-going costs associated with maintenance, labour, and facility management should be considered when evaluating the feasibility and profitability of vegetative propagation.

Materials & Methods of Vegetative Propagation

These vegetative propagation methods offer growers various options for quickly and efficiently multiplying plants with desirable traits. Each method has its advantages and limitations, and the choice of method depends on factors such as the plant species, availability of materials, and desired outcomes.

1. Cuttings: Cuttings involve taking a portion of the stem, root, or leaf from a parent plant and encouraging it to develop roots and shoots to form a new plant. Cutting is a vegetative plant part that is severed from the parent plant to regenerate, thereby forming a new plant. Cutting with a sharp blade to reduce injury to the parent plant.

- **Stem Cutting:** Stem cutting is a common method of vegetative propagation, where a portion of a plant's stem is cut and encouraged to grow roots, eventually forming a new plant.

Procedure:

- A healthy, disease-free parent plant was selected. Plants should be free from diseases, pests, or any signs of stress.
- The best time to obtain stem cuttings is usually in the early morning for all seasons.
- Cutting from a young, actively growing stem ensures that it has several nodes.
- Remove any lower leaves to expose nodes, cut the stem to a length of 15-20 cm, and cut the stem in the upper part in a round shape and the lower part in a triangular shape.
- Treated with Bavistin fungicide (0.5-1% solution) for 2-3 hours to control fungal diseases.
- The lower side of the cutting was dipped in rooting hormone (Rootex) to promote root formation.
- Plants were cut in a suitable growing medium (vermiculite) and provided adequate moisture and warmth.
- Fill vermiculite into root trainers; vermiculite is a disease-free medium, with high water holding capacity.
- After 15 days, the plants started to initiate roots and shoots. After 60-90 days, they were transferred to a poly tube and kept in a shadow place, green net house, or poly house.

2. Air Layering: Layering is a propagation method suitable for trees with flexible branches. This technique involves inducing roots into a branch while it is still attached to the parent plant. Layering is a reliable method for propagating elite cultivars and maintaining genetic purity. Layering involves encouraging the development of roots on a stem that is still attached to the parent plant. Once roots have

formed, the stem is separated from the parent and planted as a new individual. The 2nd week of the month of June and the rainy season are suitable for air layering.

Medium preparation for air layering:

Dig a pit of 4*6*1 ft., and then cover it with a thick plastic sheet. The materials used to prepare the medium were soil (50%), cow dung (50%), NPK (1 kg), DAP (1 kg), and urea (1 kg). There were three layers of medium. All the required raw materials are divided into three layers according to the digging and requirements. Water was then covered with a plastic sheet. It was then left for 15-30 days, watered in between, and after 15-30 days, the medium was prepared. This medium has high water-holding capacity and nutrients for root initiation.

Procedure:

- A flexible, low-growing, healthy, disease-free stem was selected from the parent plant.
- A ring-like structure was made on the stem, the bark of the stem, which was 1 cm long, and a rooting hormone (Rootex) was applied around the ring.
- The wounded portion of the stem was tied to the rooting medium and covered with plastic and airtight twine tying while keeping the tip exposed.
- Encourage root development over a period of weeks or months. After 20-25 days, the roots are initiated.
- It takes 60-90 days for the roots to fully develop. The rooted portion was detached from the parent plant, pruned, and treated with an insecticide (cobra).
- The treated plants were transplanted into a 12x8 poly tube and kept in a shadow area, green net, or poly house according to the sessions.

3. Grafting: Grafting involves joining two different plant parts (scion and rootstock) such that they grow together as a single plant. The scion typically provides desired characteristics, whereas the rootstock provides a strong root system. Grafting offers the advantage of preserving specific cultivars and improving disease resistance in trees. Different grafting techniques, such as cleft grafting, whip and tongue grafting, and approach grafting, are employed based on the characteristics of each species.

Procedure:

Selection of compatible plant varieties for scions and rootstocks. The rootstock was 1-2 years old. Take a scion 10-15 cm long and treat it with fungicide. Make matching cuts on the scion and rootstock, ensuring that they fit together snugly. Secure the graft union using grafting tape or other airtight materials. Protect the graft union from drying out and disease until the graft heals. After grafting, the plastic cover was placed on top for temperature maintenance and kept in a shadow area, green net, or poly house according to sessions. After 15 days, leaf-initiation was initiated and the plastic cover was removed. And after 45-60 days, the plastic tap was removed using fine objects and transplanted.

Results

Vegetative propagation through stem cutting

Stem cuttings were obtained from healthy parent plants and planted under controlled conditions. Success rate, growth, and overall plant health parameters were measured and recorded. Stem cuttings propagated in the mist chamber. Temperature and humidity in the mist chamber were regulated using an automated control system. The stem cuttings are listed in table.

Table no.1: Vegetative propagation through stem cuttings-

Name of plants	No. of stem cuttings	After 15-30 days Leaf and roots	After 30-60 days, developed	No. of successfully transplant
<i>Citrus limon</i>	200	2-4 leaf & roots	Root shoots	200
<i>Swietenia spp.</i>	450	2-4 leaf & roots	Root shoots	450
<i>Dalbergia sissoo</i>	300	Leaf & root	Root shoots	250
<i>Tectona grandis</i>	300	2 leaf & roots	Root shoots	380
<i>Boswellia serrata</i>	150	2-4 leaf & low roots	Root shoots	50
<i>Ficus religiosa</i>	250	4-6 leaf & roots	Root shoots	200

- ***Citrus limon***: All 200 cuttings developed 2-4 leaves and roots within 15-30 days and successfully produced root shoots within 30-60 days, resulting in a 100% transplantation rate.
- ***Swietenia spp.***: Out of 450 cuttings each developed 2-4 leaves and roots within the first 30 days, with all successfully forming root shoots 60 days after transplantation.
- ***Dalbergia sissoo***: Of the 300 cuttings, most developed leaves and roots within 15-30 days, with root shoots forming within 30-60 days. However, only 250 cuttings were transplanted successfully.
- ***Tectona grandis***: Initially, each of the 300 cuttings developed two leaves and roots within 15-30 days. After 60 days, root shoots developed, and 380 cuttings were successfully transplanted, indicating that some cuttings likely produced multiple shoots.
- ***Boswellia serrata***: This species shows slower development, with 2-4 leaves and low root development within 30 days. Only 50 of 150 cuttings were successfully transplanted.
- ***Ficus religiosa***: The cuttings showed robust growth, with 4-6 leaves and roots developing within 15-30 days and subsequent root shoots. Of 250 cuttings, 200 were successfully transplanted.

Stem cutting effectiveness (Figure 1) varies among the methods mentioned in the above table. ***Citrus limon***, ***Swietenia spp.***, and ***Ficus religiosa*** showed high success rates in leaf and root development and transplantation. ***Dalbergia sissoo*** and ***Tectona grandis*** also showed good success, but with some losses in the number of transplants. ***Boswellia serrata*** had the lowest success rate, indicating the need for improved techniques or alternative propagation methods for this species.



Fig.No.1: Stem cutting

Vegetative Propagation via Air Layering:

The air layering technique involves inducing roots in a branch while still attached to the parent plant. Layering involves encouraging the development of roots on a stem that is still attached to the parent plant. The air layering (Figure 3) plant results are listed below in the table.

Table no.2: Vegetative propagation through Air layering-

Name of plants	No. of air layering's	After 15-30 days root initiation	After 30-60 day root initiation	No. of successfully transplant
<i>Litchi chinensis</i>	900	Moderate	Excellent	850
<i>Psidium guajava</i>	300	Moderate	Good	270
<i>Syzygium jambos</i>	50	Moderate	Good	45
<i>Mangifera indica</i>	1200	Moderate	Good	800
<i>Manilkara zapota</i>	150	No response	No response	0
<i>Elaeocarpus ganitrus</i>	30	Moderate	Excellent	30
<i>Citrus limon</i>	80	Moderate	Excellent	80

- ***Litchi chinensis***: Out of 900 air layers, moderate root initiation was observed within 15-30 days, progressing to excellent root development by 30-60 days. A large number of 850 air layers were successfully transplanted, indicating a high success rate.
- ***Psidium guajava***: Of the 300 Air layering's, moderate root initiation was noted within the first 30 days, with good root development by 60 days. A total of 270 air layers were successfully transplanted, indicating a high success rate.
- ***Syzygium jambos***: Moderate root initiation was observed in the 50 air layering within 15-30 days, with good root development by 60 days. A total of 45 layers were successfully transplanted.
- ***Mangifera indica***: Out of 1200 plants, air layering and moderate root initiation were observed within 15-30 days, progressing to good root development by 60 days. In total 800 air layers were successfully transplanted, indicating a fair success rate.
- ***Manilkara zapota***: None of the 150 air layers responded to root initiation, both within 15-30 days and 30-60 days, resulting in zero successful transplants.
- ***Elaeocarpus ganitrus***: Moderate root initiation was observed in all 30 air layers within 15-30 days, with excellent root development by 60 days. All 30 air layering procedures were successfully transplanted, indicating a 100% success rate.
- ***Citrus limon***: Of the 80 air layers, moderate root initiation was noted within 15-30 days, progressing to excellent root development by 60 days. All 80 air layers were successfully transplanted, indicating a high success rate.



Fig.No.2: Medium preparation for air layering



Fig.No.3: Air layering technique whole process

Vegetative propagation through Grafting

Grafting is a common vegetative propagation method that involves the union of two plant tissues to create a single plant. The mango grafting process is shown in figure 4.

- **Number of Grafts: 3000**
- **Successful Grafts: 2900**
- **Success Rate: 96.67%**

The high success rate of 96.67% indicates that grafting is an extremely effective method for vegetative propagation of mangoes. The success of 2900 out of 3000 grafts demonstrated the viability of this technique in producing a large number of healthy, genetically identical mango plants.

Factors Contributing to High Success:

- **Scion and Rootstock Selection:** Healthy and compatible scion and rootstock pairs.
- **Environmental Conditions:** Controlled conditions conducive to graft healing and growth.
- **Technique:** Skilled grafting ensures proper alignment and secure union of the scion and rootstock.





Fig.no. 4: Mango grafting technique whole stages

Discussion

These results indicate that the effectiveness of vegetative propagation methods varies significantly among different tree species. Grafting and budding are generally more effective for trees such as mangoes, lemons, and guava, which respond well to these methods. Layering is particularly effective for lychee and rudraksha, whereas cutting proved to be the best method for jamun. The high success rate of grafting should be widely adopted for mango propagation, and further research is needed to optimize cutting conditions and explore alternative propagation methods for species that show poor response, such as chiku. Improvements in hormone treatments, environmental controls, and cutting techniques may enhance success rates for species with moderate to good root initiation; and focus on optimizing cutting conditions and exploring other propagation methods for species with lower success rates. This could involve experiments with different substrates, humidity levels, and hormone treatments to improve root and leaf development and transplantation success.

Conclusion:

Vegetative propagation has great potential for producing quality planting stocks with superior phenotypic and genotypic characteristics in a very short span of time. This study acts as a guide for various vegetative propagation techniques and describes the role of plant growth regulators in speeding propagation techniques. Air layering is a commercial practice used in most countries for litchi propagation. Air layering is an effective propagation method for several species, including **litchi, guava, jamun, rudraksha, and lemons**, all of which show high success rates in root initiation and transplantation. Mangoes also showed good success, but with a lower transplantation rate. Chikku did not respond to air layering, indicating the need for alternative propagation methods for this species. The effectiveness of stem cutting varies between species. *Citrus limon*, *Swietenia spp.*, and *Ficus religiosa* showed high success rates in leaf and root development and transplantation. *Dalbergia sissoo* and *Tectona grandis* also showed good success, but with some losses in the number of transplants. *Boswellia serrata* showed the lowest success rate, indicating the need for improved techniques, and grafting is a highly effective propagation method for mangoes, with a success rate of 96.67%. This method ensures a high yield of healthy plants, making it the preferred technique for mango cultivation.

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