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Chip-budding: A rapid and mass propagation technique for acid lime

Acid lime is predominantly propagated through seeds, which results in a prolonged juvenile phase and plants often not being true-to-type. To address these challenges, a comparative study on vegetative propagation methods, including cutting, patch-budding, I-budding, chip-budding, softwood grafting, and wedge grafting, was conducted at ICAR-CIAH, Bikaner during 2019–2025. Among these, chip-budding emerged as the most effective method for rapid and large-scale propagation of quality planting material, achieving over 80–90% success under both *in-situ* and *ex-situ* conditions. Chip-budded plants exhibited uniform growth, stronger canopy framework, and precocious bearing within two years. This method combines the benefits of grafting and rootstock influence, facilitating conservation of true-to-type germplasm and supporting crop breeding programs. Adoption of chip-budding is expected to enhance acid lime orchard development, increasing productivity, fruit quality, and profitability for growers.

Keywords: Acid lime, Canopy architecture, Precocious bearing, Rootstock, True-to-type plants, Vegetative propagation

ACID lime (*Citrus aurantifolia*) is an important citrus fruit grown commercially across India and it is a choice tree for kitchen garden. It is rich in vitamin C and antioxidants, which aid iron absorption. Its juice contains essential minerals such as potassium, calcium, and manganese, along with dietary fiber, supporting the immune system and promoting healthy skin. Consequently, lime fruit is in year-round demand due to its pleasant sour taste and nutritional benefits, offering considerable income potential for growers.

The experiment aimed to evaluate chip-budding as a viable alternative to vegetative and seed propagation methods for acid lime, given the limitations of conventional techniques such as patch/I-budding, layering, and seed propagation. Chip-budding was selected due to minimal bark damage and the ability to avoid thorn-related cavity problems seen in other methods. This technique allows precise bud placement and improved bud-to-rootstock contact, enhancing the likelihood of successful bud take and subsequent sprouting. Initial observations indicated higher bud success rates compared to patch-budding and I-budding, particularly during active growth periods under controlled nursery conditions. Healing of the bud union was more uniform and less prone to infection, as the method inherently avoids open wounds. Plants propagated through chip-budding demonstrated better vigor, uniformity, and early establishment, which are critical traits for commercial orchard development.

Adopting chip-budding on a wider scale can help overcome many challenges faced by acid lime growers, including long juvenile periods, disease susceptibility, and lack of uniformity in fruit quality. This technique can make acid lime cultivation more attractive to farmers by reducing the time to commercial yield and ensuring more consistent returns. Effective dissemination of this propagation method through training programs and extension services is essential to promote widespread adoption and fully realize its potential in transforming acid lime cultivation across India.

Methodology

The chip-budding method was standardised in acid lime on Rough lemon rootstock under both *In-situ* and *Ex-situ* conditions, conducted twice, once from the first week of March to the first week of April, and again from July to September. The following steps were followed to achieve the best results:

Selection of rootstock seedlings: Seeds were extracted from well-developed fruit of healthy rootstock plant during October to November and immediately sown, either directly into protrays (size: 36.5 × 23 × 10.5 cm; cell size at the top: 5 × 5 cm; depth: 5–6 cm) in the nursery, or into polybags (8 × 13 inches; 5 kg capacity). The rooting media was prepared by mixing 100 kg of soil with 400 g single superphosphate (SSP), 400 g muriate of potash (MOP), and 40 g zinc sulphate (21%), and then thoroughly mixed before being filled into the polybags or protrays. Seeds germinated within 20–25 days, and only vigorous seedlings were selected, avoiding zygotic and inferior ones. Nine- to ten-month-old seedlings with a height of

Table 1. Different propagation methods of acid lime *(Citrus aurantifolia)* based on technical and economic traits

Methods of propagation	Chip budding	Patch/I-budding	Cutting/layering	Seed
Success (%)	80-90	>40	40-60	>90
Worker skill requirement	Required skilled and efficient worker	Required skilled and efficient worker	Moderate skilled	Less skilled
Propagule requirement	Very low	High	High	Very low
Ready for transplanting after budding/sowing (months)	6-7	8-9	7-8	12-15
Genetic uniformity	High	High	High	Poor
Disease free potential	High	High	Medium	Low
Fruiting starts after transplanting (years)	<2	<2	<2	4-6
Commercial feasibility	High	High	Very low	Low
Remarks	Highly tolerant due to rootstock use; medium growth, longer orchard life, and high yield	Comparable to chip budding	Poor tolerance, short orchard life, and low yield	Poor stress tolerance, vigorous canopy growth, and late bearing

50–60 cm and a collar diameter of 7–8 mm are ideal for budding under nursery conditions. These seedlings can also be transplanted to the field at the desired spacing for *in-situ* budding. The budding process is the same for both *in-situ* and *ex-situ* conditions.

Selection of scion plants: Plant should be selected healthy, vigrous, high-yielding with quality fruits, identitical to the parant plant (true to type), and free from any dieases and pests.

Selection of budsticks: Green, triangular-shaped budsticks with pencli thickness (4-5 mm diameter), having swellen and healthy buds should be selected for budding. Triangular-shaped budsticks facilitate easier to detach buds along with the cambium campared to round-shaped budsticks.

Disinfection of grafting tools: Sterilize all grafting tools by spraying or dipping them in Chlorine bleach at 1.5% concentration, and keep them immersed for up to 30 seconds. Therafter, rinse thoroughly and wipe clean with tissue paper. Alternately, 70% Isopropyl alcohol can be used, which is effective in killing pathogens and is a better option than using no disinfectant at all.

Preparation for budding: First, remove all leaves and thorns from the lower part of the seedling, keeping only the top 5–6 leaves. This ensures better bud attachment and maintains a continuous food supply through photosynthesis. At a height of 18–20 cm from the base, on a pencil-thick stem (4–5 mm diameter), make a cut in the bark of the seedling in the shape of a chip in the internodal space until the cambium is exposed. Leave a small flap (2–3 mm) of loose bark at the bottom of the cut where the scion bud will be inserted. Simultaneously, remove all leaves from the scion budstick, selecting only swollen and mature buds. Retain the petiole and thorn (2.25–2.40 mm), trimming just above the bud. This helps in proper positioning of the bud onto the rootstock and avoids touching the cut surface, especially the exposed cambium, to prevent contamination or damage. Make the first cut into the wood 3–4 mm below the selected bud, followed by a second cut above the bud extending downward past the first cut, and finally detach the bud (length: 14–15 mm) along with a thin layer of cambium.

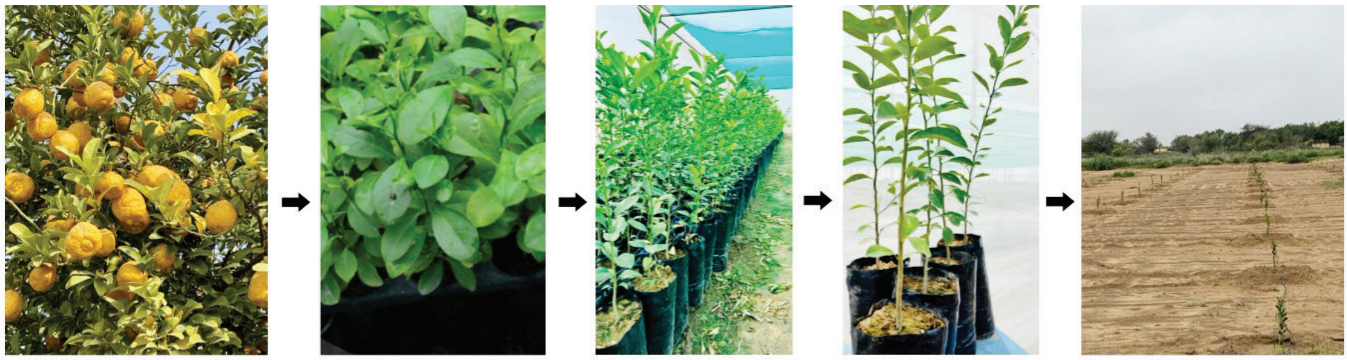
Inserting the chip bud into rootstock: Insert the chip bud into the flap of the rootstock seedling, ensuring that the bud is properly adjusted so that the cambium layers of both the bud and rootstock are in close contact at both the upper and lower cut edge.

Wrapping with tape or parafilm: After properly placing the chip bud into cut – rootstock, gently pull the tape and stretch it slightly wrapping first from the top to bottom and then in the opposite direction. By pulling the tape during complete wrapping of the bud, including the bud eye, cambium of the bud is pressed inward bringing cambium of the chip bud into better contact with the cambium of rootstock. This ensures a higher percentage of budding success.

Unwrapping tape/parafilm: Avoid watering for 4–5 days after the budding operation. Thereafter, provide proper watering directly to the root zone. The budding wound heals quickly due to the direct contact between the cambium layers. The tape or parafilm can be removed once the buds swell and begin to sprout, which usually occurs within approximately 20 days.

Heading back and disbudding: Head back the rootstock 3–4 cm above the bud graft when the scion has attained 4–5 cm in length. This practice breaks apical dominance and promotes faster growth of the scion shoot. Remove all lateral buds as they sprout by hand, taking care not to damage the scion shoot. Disbudding, or the removal of lateral buds from the rootstock seedling, further encourages robust and rapid growth of the scion shoot.

Training of scion shoots: When the scion shoot reaches a height of 12–15 cm, cut the main shoot 4–5 cm from the top. This heading-back promotes side branching. Among the sprouted side branches, retain only 4–5 well-spaced shoots in all directions to form a balanced, bush-like canopy, as acid lime naturally grows as a bush. Continue this training practice for 2–3 years to encourage the development of tertiary and quaternary branching. Remove dried, hanging, unwanted, or ground-touching branches promptly. A well-formed, bushy



Chip-budding propagation method steps for acid lime

canopy enhances both yield and fruit quality, as acid lime tends to bear more than 70% of its fruits in the lower and inner canopy.

Post-budding care and pest management

In the initial stages, lemon butterfly attacks are very common in acid lime due to its lush, soft green growth. Therefore, regular monitoring is essential. At the first sign of butterfly eggs on the abaxial surface of leaves, or the presence of larvae, apply a systemic insecticide such as lime Imidacloprid at 0.5 ml or Dimethoate at 1.0 ml per liter of water, preferably in the early morning.

Acid lime is highly sensitive to frost injury, which can cause complete damage up to the bud-union level.

Protect the plants by covering them with anti-frost cloth before the onset of winter, especially during the first three years. The entire plant, including the canopy and root zone, should be covered. In regions where temperatures drop below 4–5°C, plastic or straw mulching should also be used to provide additional insulation.

Ensure adequate irrigation during summer to support healthy plant growth. Employ drip irrigation two to three times per week, adjusting the frequency based on soil type and prevailing climatic conditions. Remove water sprouts and root suckers as soon as they are observed to maintain a proper canopy and healthy plants, as these sprouts and suckers are more prone to leaf minor and canker infection.

Additionally, manage citrus canker effectively by applying either Streptocycline at 100 PPM, or Bronopol at 0.5 g per liter of water, along with copper oxychloride (COC) at 3 g per liter. It is also important to control the primary vector of canker, the leaf miner. This can be managed by spraying Dimethoate at 1 ml per liter of water, applied three times at weekly intervals, particularly during periods of new vegetative growth in acid lime plants.

Highlights

- The key to the success of this technique is to align the chip bud (scion) cambium layer in perfect contact with the rootstock cambium layer at least at one point.
- Plants prepared using this method will boost acid lime orcharding by enabling fruiting 2–3 years earlier and reducing the cost of fruit cracking and canker management during the initial stage, compared to seedling orchards.
- Chlorine is hazardous. Wear safety gloves and immediately wash any exposed skin with soap or liquid handwash to avoid skin irritation or allergic reactions.

SUMMARY

The article highlights chip-budding as an efficient vegetative propagation technique for acid lime *(Citrus aurantifolia),* addressing limitations of seed propagation such as long juvenile phases and poor uniformity. Conducted at ICAR-CIAH, Bikaner, the study compared multiple methods, establishing Chip-budding as superior, achieving 80–90% success under both in-situ and ex-situ conditions. The technique ensures true-to-type plants, early fruiting within two years, uniform canopy growth, and enhanced disease resistance. Detailed guidelines on rootstock selection, bud preparation, insertion, aftercare, pest management, and training of scion shoots are provided. Chip-budding promises rapid, large-scale, high-quality plant production, improving productivity and profitability for growers.

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SUCCESS STORY

Geetha's Home to Home, Thrissur, Kerala

A woman, Smt Geetha Saleesh, entrepreneur from Thrissur, Kerala, being disabled never stopped her from achieving her goals. She started Geetha's Home to Home during the pandemic time of 2020. In her own brand developed a 'superfood supplement' Curcumeal using turmeric blended with other healthy ingredients. This product was the output of her two years research in turmeric value addition. During the course, she understood the value of high curcurmin turmeric varieties from ICAR-Indian Institute of Spice Research (IISR), Calicut and developed curcumeal using IISR Prathibha. Smt Geetha availed license for large scale cultivation of turmeric variety IISR Prathibha during July 2022. This opened a new door to the turmeric value chain in front of Geetha's Home to Home and the started cultivation of IISR Prathibha in 10 acres comprising 47 farmers fields in Thrissur and Pathanamthitta. Other than cucumeal, Smt Geetha launched two more products from turmeric 'First Drink' using turmeric and other spices such as black pepper and cinnamon and high curcumin Prathibha turmeric powder.

When Smt Geetha thought of expanding the turmeric cultivation in farmers' fields, the major problem was the price instability of turmeric seeds. This was resolved by executing the MoU with the farmers by assuring a 100% buy back at a higher price than the market, benefiting both the farmers and the business. In 2023-24, the firm expanded the cultivation of IISR Prathibha into 54 acres including 315 farmers of 6 districts in Kerala, viz. Thrissur, Palakkad, Kollam, Idukki, Ernakulam and Pathanamthitta, with all scientific expertise from ICAR-IISR. Regular visits and instructions on good agricultural practices and quality agri inputs developed by ICAR–IISR yielded quality produce and quality value added products from this. Currently the firm is associated with 305 farmers including FPOs and 150 women farmers in 6 districts.

Geetha's Home to Home organized training and education to ensure the quality of turmeric with group of farmers direct/online. Within one year the products have reached Kerala, Karnataka, Maharashtra, New Delhi, Jammu and Kashmir. The firm could employ 30 people in production and marketing sector. Smt Geetha Saleesh has participated in more than 35 expos to exhibit and introduce her products to the customers.

Smt Geetha Saleesh was selected for exhibiting the products during 95th ICAR foundation day cum technology day celebrated during 16-18 July 2023.