



Apical Rooted Stem Cuttings in Potato

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Article History

Received: 12.09.2025

Revised: 17.09.2025

Accepted: 22.09.2025

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the world's most important food crops, playing a vital role in global food security and income generation. A major constraint in potato production is the high cost and scarcity of clean seed tubers. Conventional seed potato systems rely on bulky tubers, which are expensive to transport and store, and are highly prone to degeneration due to viral and soil-borne diseases. These challenges limit farmers, especially in developing countries, from accessing quality planting material.

To overcome these bottlenecks, alternative propagation methods such as apical rooted cuttings (ARCs) have been developed. ARCs are juvenile apical shoots derived from disease-free mother plants, rooted under controlled nursery conditions, and transplanted into the field to produce seed tubers. Unlike traditional mini-tuber systems, ARCs are lightweight, rapidly multiplied, disease-free, and cost-effective. They also reduce the number of multiplication cycles required, thereby shortening the seed production chain.

This technique has gained global attention through initiatives by the International Potato Center (CIP) and national seed programs, showing promise in Africa, Asia, and Latin America. By maintaining juvenility in mother plants and optimizing rooting conditions (substrate, humidity, and hormone use), ARCs provide high rooting success and vigorous field establishment. As a result, apical-rooted cuttings are increasingly recognized as a transformative innovation for sustainable and affordable seed potato production.

1. Why apical rooted cuttings?

Traditional seed potato systems use tubers as planting material. ARCs use small, rooted shoot pieces (apical cuttings) produced from juvenile mother plants. Benefits include: much lower seed weight transported/stored, reduced risk of soil-borne diseases, rapid multiplication (several cutting generations per year), and lower input costs for smallholders — advantages reported and tested by CIP and partners in multiple countries.

2. Basic biology & principles

- **Juvenility and simple leaves:** Cuttings taken from juvenile (young apical) tissue with simple (not deeply lobed) leaves root and grow faster than cuttings from mature shoots. Maintaining mother plants in a juvenile state is therefore essential.
- **Rooting from stem tissues:** Potato stems can form adventitious roots when provided with moisture, aeration, a rooting medium, and (optionally) auxin treatment (e.g., IBA). Root initiation timing and root quality depend on explant age, hormone, substrate, and environment.

3. Overview of the ARC production chain

1. Produce virus-indexed plantlets (G0) in tissue culture or source very clean, juvenile mother plants.
2. Multiply to create mother plants (sub-mother) in the screenhouse (keep juvenile traits).
3. Take apical cuttings (1-3 nodes with apical meristem), root them in cubes/trays under mist.
4. Harden rooted cuttings and transplant to field as seeders — or use further multiplication cycles to generate more mother plants.

4. Detailed materials & methods (practical protocol)

4.1. Mother plant production (key points)

- **Start from true virus-indexed plantlets (G0)** from tissue culture or certified virus-free transplants. Keep them under controlled light (12–16 h), moderate fertilization and trimming to maintain juvenile simple leaves. Maintain a low node count per plant to favor apical shoot production.

4.2. Preparing apical cuttings

- **Timing:** Take cuttings from active, non-stressed mother plants early in the day. Younger apical shoots (2–3 weeks old after cutting back) root best.
- **Cut size:** 1 node (single-node) to 2–3 cm apical segments or 2–3 node cuttings including the apical meristem; leave 1–2 leaves (trim large leaves by half to reduce transpiration).
- **Sterility:** For best results, handle with clean tools and in a clean environment to reduce contamination and disease.

4.3. Rooting medium and containers

- **Substrate:** Use well-drained, aerated substrates: peat-based mixes, coir-peat, perlite mixes, or 3×3 cm propagation cubes

as used in several ARC protocols. Avoid heavy soils that hold too much water.

- **Containers:** Trays with individual small cells or substrate cubes that support single cuttings are common; they facilitate mechanized planting later.

4.4. Rooting environment

- **Mist/greenhouse:** High humidity (near saturation) and intermittent misting to keep leaves turgid while allowing some gas exchange produces the best rooting. Shade (30–50% reduction) and bright diffuse light encourage rooting without scorching. A temperature around 18–25 °C is generally suitable in temperate to tropical highland contexts.

4.5. Rooting hormones (auxins)

- IBA (indole-3-butyric acid) is widely used. Reported effective concentrations vary: many practical protocols use 50–1000 ppm depending on dipping method and cultivar; several studies found ~100–1000 ppm IBA improved rooting percentage and root number in potato cuttings (optimal varies with cultivar and explant age). Use quick basal dips (a few seconds to a few minutes) or quick treatments using powder formulations. Overdosing can cause callus without roots—run small trials per cultivar.

5. Example protocol (step-by-step, farmer-friendly)

1. **Mother plants:** Maintain mother plants in a screenhouse; cut back older shoots so new juvenile apical shoots emerge. (2–6 weeks to produce cutting stock).
2. **Cutting:** Cut apical 1–2 node segment with apical bud; trim large leaves by half.
3. **Hormone (optional):** Dip basal end in 100–500 ppm IBA solution for 2–10 seconds (or use commercial powder at recommended rate). (Test with and without hormone; many growers root well without hormone when other conditions are optimal.)
4. **Planting:** Insert cuttings into substrate cubes or trays so the basal node is in firm contact with the substrate.
5. **Rooting environment:** Place trays under shade and automated misting (30 s every 10–20 min initially). Maintain high humidity; avoid stagnant water.
6. **Rooting time:** Roots typically appear in 7–21 days, depending on temperature, cultivar, and hormone.

7. **Hardening:** Gradually reduce humidity over 7–14 days to acclimatize seedlings (open vents, reduce mist frequency).
8. **Transplant:** Field transplant at recommended spacing (e.g., plant with some

stem below soil line as in ARC recommendations: 2–3 cm of stem below soil). Follow local fertilizer and pest management practices.

6. Tables

Table 1 — Typical rooting responses reported (illustrative)

Parameter	Typical range/example
Time to root initiation	7–21 days.
Rooting percentage (well-managed)	70–95% (depends on cultivar & environment).
IBA concentration used in studies	50–1000 ppm (many reports around 100–500 ppm effective).
Recommended temperature	18–25 °C (warmer speeds rooting, but watch moisture).

Table 2 — Example spacing and field planting (from ARC guidelines)

Stage	Example spacing or figures
Nursery cell size	3 × 3 cm cubes commonly used for ARCs.
Field planting density (example)	3 rows/bed: ~20 cm between rows and 25 cm between plants (varies by system).
Multiplication cycle	Complete cycle from G0 to field-ready cuttings: ~4–6 months depending on system.

7. Hardening, field establishment & yield considerations

- Harden cuttings slowly by reducing mist and increasing ventilation over 1–2 weeks. Hardened ARCs establish quickly in the field and can produce comparable yields to tuber-planted seed when planted at the right time and density. Field management (fertility, hilling, pest control) follows standard potato recommendations.

8. Economics & scaling

- ARCs reduce the need to transport bulky tubers; initial investments are in a small screenhouse, propagation trays and misting system. CIP and partners report ARCs can markedly reduce seed costs for smallholders and enable faster distribution of clean seed. However, scaling requires reliable supply of disease-free starting material (tissue culture plantlets or G0 plants) and training.

9. Common problems & troubleshooting

- **Poor rooting:** Check explant age (too old), substrate oxygenation, mist frequency, and hormone treatment. Try a small trial varying IBA (e.g., 0, 100, 500 ppm) and record results.
- **Fungal rot/damping off:** Reduce irrigation duration, improve airflow, use clean substrate, and treat mother plants to reduce pathogen load.

- **Leaf drop/wilting:** Ensure high humidity during rooting; trim leaves to reduce transpiration while roots are forming.
- **Low multiplication rate per TC plant:** Keep mother plants juvenile and limit the number of cuttings taken per mother at once; allow recovery to re-shoot.

10. Varietal differences

Different potato cultivars show variable rooting vigor and rooting percentage from apical cuttings. It is essential to run small-scale trials for new cultivars to optimize cutting size, hormone concentration and nursery conditions.

11. Case studies/evidence (summary)

- CIP and collaborators piloted ARCs in Asia and Africa and reported successful multiplication, cost savings and adoption benefits in several smallholder contexts. Detailed protocols and grower-tested guidance are available from CIP and national partners.

12. Practical checklist for a first ARC nursery (starter kit)

- Certified G0 plantlets or virus-free mother plants
- Propagation trays / 3×3 cm substrate cubes
- Rooting substrate (coir/peat/perlite mix)
- Misting or fogging system (timer) and shade net (30–50%)
- IBA powder or solution (50–1000 ppm stock) for trials

- Clean pruners, labels, benches and hand tools
- Record book for tracking rooting % by batch/cultivar

food and nutritional security for farming communities that rely heavily on potato cultivation.

CONCLUSION

Apical-rooted cuttings are emerging as an efficient and sustainable technology in potato seed production, addressing many of the limitations associated with conventional tuber-based systems. By propagating potatoes through juvenile apical shoots derived from virus-free mother plants, this method ensures high-quality planting material that is free from soil-borne pathogens and viral infections. The technique also enables rapid multiplication and significantly reduces the cost of seed, which is often the most expensive input in potato farming. With proper nursery management that includes maintaining the juvenility of mother plants, using well-aerated rooting substrates, providing adequate humidity, and applying suitable concentrations of rooting hormones such as indole-3-butyric acid, farmers can achieve high rooting success and vigorous field establishment. Apical rooted cuttings have already demonstrated their potential in improving yields and profitability in many countries where the International Potato Center and national agricultural programs have promoted them. Their successful integration into local seed systems can shorten the multiplication cycle, improve the availability of clean seed, and ultimately enhance

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