Apical Root Cutting in Potato for High-Quality Seedlings

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Potato (*Solanum tuberosum* (L.)) is one of the world's most vital staple crops, contributing significantly to global food security. Producing high-quality potato seedlings is a pivotal aspect of sustainable agriculture, directly influencing crop yield, quality, and disease resistance. Among the various methods of potato propagation, the utilization of apical root cuttings has gained prominence for its efficiency and reliability in producing robust seedlings.

Apical root cutting (ARC) involves carefully selecting and preparing specific portions of the root system, emphasizing the apical (terminal) regions. This method offers advantages in disease management, genetic preservation, and accelerated multiplication of desired potato varieties. As agricultural systems strive for increased efficiency and sustainability, understanding the intricacies of apical root cutting becomes crucial for farmers, researchers, and stakeholders in the potato industry.

ARC, a novel technique to produce quality seed potatoes, involves using tissue culture plantlets as mother plants, from which apical cuttings are produced. These cuttings are then rooted and transplanted to produce seed potatoes. This method can potentially transform potato seed systems due to its rapid and high multiplication rate [1, 2].

Rationale for Apical Root Cutting:

- **Disease Management:** Apical root cutting provides a unique advantage in disease management by allowing the production of seedlings in a controlled environment. Disease-free material can be selected, reducing the risk of carrying pathogens to the next generation [3].
- **Genetic Preservation:** The apical regions of the roots contain meristematic tissues with genetic information crucial for plant growth and development. By focusing on apical root cuttings, the desired genetic traits of the parent plant can be effectively preserved and propagated.
- **Accelerated Multiplication:** Apical root cutting enables the rapid multiplication of potato seedlings compared to traditional methods like seed propagation. This accelerated multiplication contributes to meeting the increasing demand for high-quality planting material.
- **Uniformity in Seedlings:** Through the careful selection and preparation of apical root cuttings, uniformity in seedlings can be achieved. This uniformity is essential for consistent crop development, maturation, and improved yield.
- **Resource Efficiency:** Apical root cutting minimizes resource requirements compared to traditional seed propagation methods, such as using true potato seeds. This approach optimizes resources and contributes to sustainable agricultural practices.
- **Adaptability to Tissue Culture Techniques:** Apical root cutting complements modern tissue culture techniques, allowing for seamless integration with advanced propagation methods. This adaptability facilitates the incorporation of biotechnological approaches in potato seedling production.

Methodology

There usually are two stages in rooted apical cuttings systems: production of cuttings in a lab and greenhouse, followed by sale to seed multipliers or potato farmers who plant the rooted cuttings to produce seed tubers [2]. Each cutting produces 7 to 10 tubers, multiplied further for a season or two, and the harvest is sold as seed [1]. The different steps in producing apical root cuttings are:

1. **Selection of Parent Plants**: Healthy and disease-free potato plants with desirable characteristics for the target crop must be chosen.
2. **Harvesting Apical Root Cuttings**: ARC is selected from the chosen parent plants. These

cuttings are ideally taken from the ends of healthy, disease-free roots.

- *Cutting Preparation*: Apical root sections are to be cut into pieces, each containing at least one bud (or "eye") and a portion of the root. Each cutting is around 2-4 inches long.
- *Disinfection*: Cuttings are treated to prevent the spread of diseases. Cuttings may be treated by dipping them in a fungicide solution or disinfectant.
- *Callus Formation*: They are allowed to form a callus by letting them air dry for a short period, which helps reduce the risk of rotting during planting.

3. **Planting in a Nursery Bed**: The treated cuttings are planted in a well-prepared nursery bed or seedling tray filled with a suitable growing medium. Make sure the eyes are facing upward.

- *Proper Spacing*: The cuttings are planted at appropriate distances to ensure good air circulation and prevent the spread of diseases. The spacing may vary depending on the specific potato variety.
- *Watering and Care*: Optimal moisture levels must be maintained in the nursery bed. Over-watering should be avoided to prevent water-logging, which can lead to diseases.
- *Fertilization*: A balanced fertilizer should be applied to promote healthy growth. The specific nutrient requirements may vary based on soil conditions and the type of growing medium used.
- *Weed Control*: The nursery bed is to be kept free from weeds that can compete with the potato seedlings for nutrients and water.
- *Disease and Pest Management*: The seedlings should be monitored regularly for signs of diseases and pests. Take appropriate measures, such as applying pesticides or organic controls, to manage any issues.
- *Hilling or Earthing Up*: As the seedlings grow, soil should be periodically added around the base of the plants to provide support and encourage the development of a robust root system.

4. **Transplanting**: Once the seedlings have reached a suitable size and are free from diseases, they can be transplanted to the main field for further growth and development.

- *Field Management*: Proper field management practices, including irrigation, fertilization, and pest control, should be implemented to ensure the continued health and productivity of the potato plants.
- *Adaptability*: The soil and environment in many parts of the eastern and southern regions are suitable for cultivating potato seed in the *rabi* season (October-March), and in some areas like Hassan in Karnataka and Koraput in Odisha, it can be grown in *kharif* season (July-October) also. Specifically, the northeastern states could be potato seed hubs supplying seeds to West Bengal, Odisha, and Bihar [1].

Following these steps carefully increases the chances of producing high-quality potato seedlings from apical root cuttings (**Figure 1**). Adjustments may be needed based on specific environmental conditions and potato varieties.

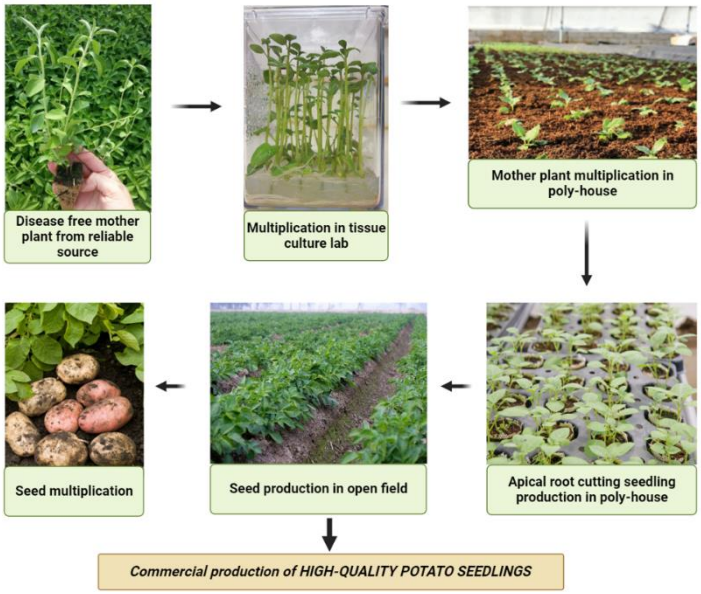

Figure 1: Illustration of different steps involved in producing high-quality potato seedlings through apical root cuttings.

Recent Advancements

ARC is effective in producing high-quality seedlings. Handayani *et al.* 2023 found that apical-

rooted cuttings from various potato varieties can produce tubers suitable for seed purposes [6]. Basavaraj *et al.* 2023 concluded that potato varieties Kufri Himalini and Kufri Jyoti apical rooted cuttings with 45 × 20 cm spacing showed optimal growth and leaf length for high-quality potato tuber production [7]. Nikmatullah *et al.* 2018 further demonstrated that these cuttings can be used for mass propagation of G1 seed tubers, with the best results obtained from cuttings derived from 2 to 3-week-old mother plants [8].

This technology was recently standardized for the first time at ICAR-Central Potato Research Institute Shimla, India. The remarkable results suggest that local growers can use the technology to produce quality planting material at low cost [1].

Comparison of apical root cutting and other methods of potato propagation

Apical root cutting (ARC) is a significant advancement in potato propagation, offering several advantages over traditional methods (**Table 1**). Hence, ARC is a promising alternative to traditional potato propagation methods, offering a cost-effective and speedy supply of clean starter material for the onward multiplication and bulking of early-generation seeds (EGS) [5]. Here is a comparison:

Conclusion

Apical root cutting is a transformative technique that has the potential to enhance the quality of seedlings significantly. It is a promising alternative to the current aeroponic seed production system. This method, which involves producing rooted transplants from tissue culture plantlets, offers a rapid and high multiplication rate. It offers a cost-effective and speedy supply of clean starter material for the onward multiplication and bulking of Early Generation Seeds (EGS), which results in high-quality seeds, equivalent to basic or certified seeds in seed certification systems. Adopting this technique could significantly contribute to reducing seed potato shortages, improving productivity, and lowering the cost of production.

With the rapid adoption of ARC by seed producers, smallholder farmers, and youths, the ARC revolution brings great excitement and promise of prosperity to remote, poor highland communities. Therefore, apical root cutting is a promising, speedy solution for producing quality seed potatoes, boosting food security.

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Table 1. Advantages of Apical Root Cutting (ARC) over conventional methods in the production of high-quality seedlings

Serial No.	Feature	Apical Root Cutting (ARC)	Conventional methods
1.	Rate of Multiplication	ARC has a faster regeneration potential and is true to type. A single shoot can yield 125 copies in just three months.	Traditional methods have a slower rate of multiplication.
2.	Cost-Effectiveness	The cost of an apical cutting is USD 0.10.	The cost of a mini tuber ranges from USD 0.15-0.30
3.	Quality of Seedlings	ARC from juvenile simple rounded leaf mother plants is a novel approach to transplanting and field cultivating seed potatoes.	It may not always produce high-quality seedlings.
4.	Adaptability	The technology was first developed in warmer climates at lower elevations less than 1,500 meters above mean sea level. However, it was gradually successfully developed in East Africa's cooler climates. It is well established in the highlands of Vietnam and the Philippines.	Traditional methods may not be as adaptable to different climates.
5.	Time Efficiency	Using cuttings as starter material for seed production takes one year less than mini tubers to produce commercial seed	It takes longer to produce commercial seeds.

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