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Apical Rooted Cuttings: Bridging the Gap in Potato Seed Demand

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is globally recognized as a highly efficient food crop, capable of producing greater yields per unit area and time than many cereals and plays a pivotal role in food and nutritional security, particularly in developing countries; however, its productivity remains constrained by the limited availability of quality seed. It is evident that crop performance is fundamentally determined by the quality of planting material, while conventional tuber-based propagation systems remain inefficient due to low multiplication rates, high bulk and cost and progressive seed degeneration caused by the accumulation of pathogens over successive generations. This challenge is further intensified in tropical and subtropical regions, where access to certified seed is limited and transportation costs are high, compelling farmers to rely on farm-saved or locally sourced seed of inferior health and genetic quality.

In this context, Apical Rooted Cuttings (ARC) technology has emerged as a promising and scientifically robust alternative, utilizing disease-free apical meristems derived from tissue culture to enable rapid and large-scale multiplication of healthy planting material. Compared to traditional systems, ARC offers higher multiplication efficiency, improved phytosanitary status and greater flexibility in seed production and distribution. Its growing acceptance among researchers and farmers underscores its potential to transform seed systems by facilitating decentralized production and reducing dependence on long-distance supply chains, thereby contributing to sustainable and climate-resilient potato cultivation while effectively bridging the gap between seed demand and supply.

Concept and Scientific Basis of Apical Rooted Cuttings

Apical Rooted Cuttings are vegetative propagules derived from the apical meristem of tissue culture-raised potato plants. The apical meristem is relatively free from systemic pathogens, making it an ideal source of clean planting material. The ARC system exploits the physiological attributes of juvenility and high meristematic activity to achieve rapid multiplication. The process begins with the production of virus-free microplants through meristem culture under sterile conditions. These microplants are subsequently grown as mother plants under protected environments. Apical shoots are periodically excised and rooted in suitable substrates such as cocopeat or vermiculite. Once established, these rooted cuttings are transplanted into the field for tuber production. The ability to repeatedly harvest apical cuttings from a single mother plant significantly enhances multiplication efficiency, often achieving rates 20-40 times higher than conventional methods.

Methodology of ARC Production

1 Micropropagation - Disease-free plantlets are generated through tissue culture techniques using meristematic explants.

2 Mother Plant Establishment - Microplants are transferred to nursery trays or beds under controlled environmental conditions, ensuring optimal growth.

3 Cutting Harvesting - Apical shoots of 3–5 cm length is excised at regular intervals, typically every 10–15 days.

4 Rooting Phase - Cuttings are treated with rooting hormones (if required) and placed in inert media for root initiation.

5 Hardening and Transplantation - Rooted cuttings are acclimatized and transplanted into the field for seed tuber production and continuous multiplication and ensures uniform, high-quality planting material.

Advantages of Apical Rooted Cuttings (ARC) Technology

- **Rapid multiplication rate:** A single mother plant can generate a large number of cuttings in a short time, ensuring quick seed availability.
- **Disease-free planting material:** ARC originates from meristem-derived plants, reducing the risk of viral and systemic infections.
- **Reduced seed cost:** Eliminates the need for bulky seed tubers, lowering production, storage and transportation expenses.
- **Higher yield potential:** Healthy and uniform plants result in better crop stand and increased tuber yield.
- **Uniform crop growth:** Ensures consistency in plant vigor, maturity and tuber size, which is beneficial for market quality.
- **Efficient use of space:** Nursery-based multiplication allows high-density production in limited space.
- **Decentralized seed production:** Enables farmers, FPOs and small entrepreneurs to produce their own quality seed locally.
- **Reduced transportation burden:** Lightweight cuttings are easier and cheaper to transport compared to seed tubers.
- **Faster seed replacement:** Accelerates the seed renewal cycle, minimizing degeneration problems.
- **Adaptability to different regions:** Suitable for both tropical and subtropical conditions, especially in seed-deficit areas.
- **Lower storage requirements:** Unlike tubers, ARC does not require cold storage facilities, reducing infrastructure dependency.
- **Eco-friendly approach:** Minimizes the spread of soil- and tuber-borne diseases, contributing to sustainable agriculture.
- **Better input efficiency:** Healthy plants utilize nutrients and water more efficiently, improving overall productivity.
- **Entrepreneurial opportunities:** Promotes nursery enterprises and rural employment in seed production chains.
- **Compatibility with modern systems:** Can be integrated with technologies like aeroponics, hydroponics and protected cultivation.

Field Performance and Adoption of Apical Rooted Cuttings (ARC)

Field performance of Apical Rooted Cuttings (ARC) in potato has consistently demonstrated promising results across diverse agro-climatic conditions. ARC-derived plants establish quickly in the field, exhibiting vigorous early growth, uniform canopy development and improved plant stand compared to conventional seed tubers. Due to their origin from disease-free mother plants, these cuttings show significantly reduced incidence of viral diseases, resulting in healthier crops and enhanced physiological efficiency. Farm-level trials and adaptive research studies have indicated that ARC-based crops often produce comparable or even higher yields than traditional seed systems, particularly when proper agronomic practices are followed. The uniformity in plant population contributes to synchronized tuber development and better grading, which is advantageous for both seed and table potato markets.

Adoption of ARC technology is gradually expanding, especially in seed-deficit regions where access to quality planting material is limited. In India, progressive farmers, farmer-producer organizations (FPOs) and rural entrepreneurs are increasingly embracing this approach for localized seed production. Its relatively low requirement for bulky seed transport and its suitability for decentralized nurseries make it highly adaptable.

Challenges in ARC

- **Technical skill requirement:** Successful production of apical rooted cuttings (ARC) needs trained personnel for nursery management, cutting preparation and transplanting.
- **Dependence on controlled conditions:** Proper temperature, humidity and hygiene are essential; poor management can lead to high mortality of cuttings.
- **Initial investment:** Establishment of nurseries, shade nets and propagation units involves upfront costs that may limit small-scale adoption.
- **Limited awareness and extension support:** Many farmers are still unfamiliar with ARC technology and its benefits.
- **Logistics and scalability issues:** Ensuring timely supply of quality mother plants and maintaining uniform standards can be challenging at larger scales.

Future Prospects

- **Scaling and integration:** Apical Rooted Cuttings (ARC) can be integrated with advanced systems like aeroponics and protected cultivation to enable year-round, high-efficiency seed production.
- **Decentralized seed systems:** Wider adoption of ARC will promote localized, farmer-led seed enterprises, reducing dependence on long-distance seed supply chains.
- **Sustainable intensification:** ARC technology holds strong potential to support climate-resilient, cost-effective potato cultivation with improved productivity and seed quality.

CONCLUSION

Apical Rooted Cuttings represent a transformative innovation in potato seed production. By overcoming the limitations of conventional systems, ARC provides a scalable, efficient and economically viable solution to the persistent challenge of seed scarcity. Apical Rooted Cuttings offer a practical and scalable solution to the long-standing shortage of quality seed in potato cultivation. By enabling rapid multiplication of disease-free planting material, this technology can enhance productivity, reduce costs and strengthen farmer livelihoods. Its wider adoption holds the key to a more resilient and sustainable potato seed system.