Indian Farming 75 (07): 41-43; July 2025

Converging innovations for resilient

seed potato production in the northeast

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Potato is a key crop in India, with the North Eastern Region (NER) offering significant potential for its cultivation due to favourable climatic conditions. However, potato farming in the NER is constrained by poor access to quality seed tubers, high costs, and reliance on long-distance transport, which leads to disease accumulation and reduced seed viability. To address these challenges, innovative seed production technologies such as micro-propagation, aeroponics, and apical rooted cuttings (ARC) are being promoted in the region. Micropropagation forms the basis for producing virus-free, genetically uniform planting material. These microplants are used in aeroponics systems to produce high-quality minitubers efficiently in controlled environments. In parallel, ARC technology provides a low-cost, decentralized method suited to smallholders, enabling the production of quality seed tubers at village level. The integration of aeroponics and ARC creates a complementary and scalable seed system that enhances local seed availability and reduces dependency on external sources, thereby enhancing the sustainability and productivity of potato farming in the NER.

Keywords: Aeroponic, ARC, Micropropagation, Potato, Seed

POTATO (*Solanum tuberosum* L.), the world's fourth most important food crop, plays a critical role in India's food and nutritional security. Among the country's diverse agro-ecological zones, the North Eastern Region (NER) holds considerable potential for potato cultivation due to its favourable climate. Despite this, potato farming in the region remains largely rainfed and faces significant challenges related to the untimely availability of quality seed tubers, which can account for 40–50% of the total cost of production.

Traditional seed systems in the NER often rely on seed tubers sourced from distant regions, which not only escalates production costs but also leads to quality deterioration due to disease accumulation from successive vegetative propagation. The logistical burden of transporting bulky seed tubers across hilly terrain further compromises seed viability and accessibility.

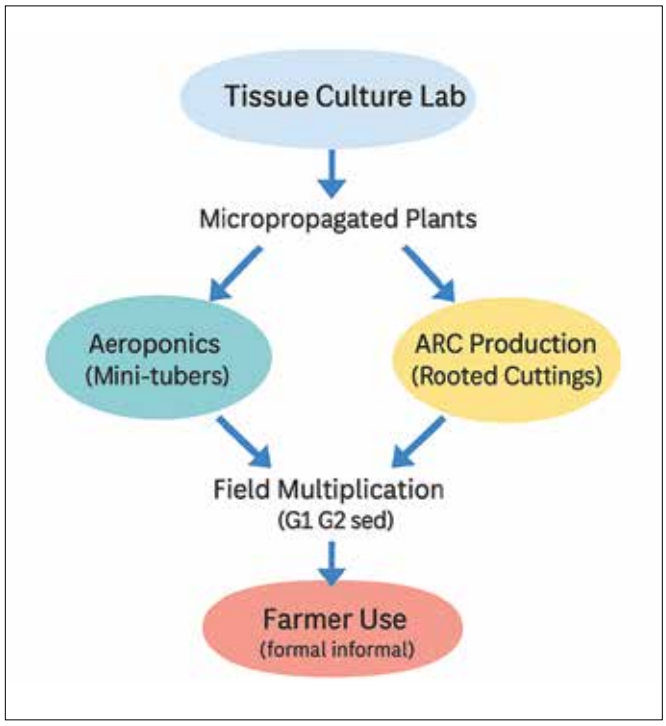
To address these challenges, innovative technologies such as micropropagation, aeroponics, and apical rooted cuttings (ARC) have emerged as transformative solutions. These methods facilitate the rapid and large-scale production of disease-free seed potato, significantly lowering input costs. This article explores how the convergence of these technologies customized for the unique conditions of the NER is contributing to a resilient, decentralized, and inclusive seed ecosystem.

Micropropagation: Foundation of clean planting material

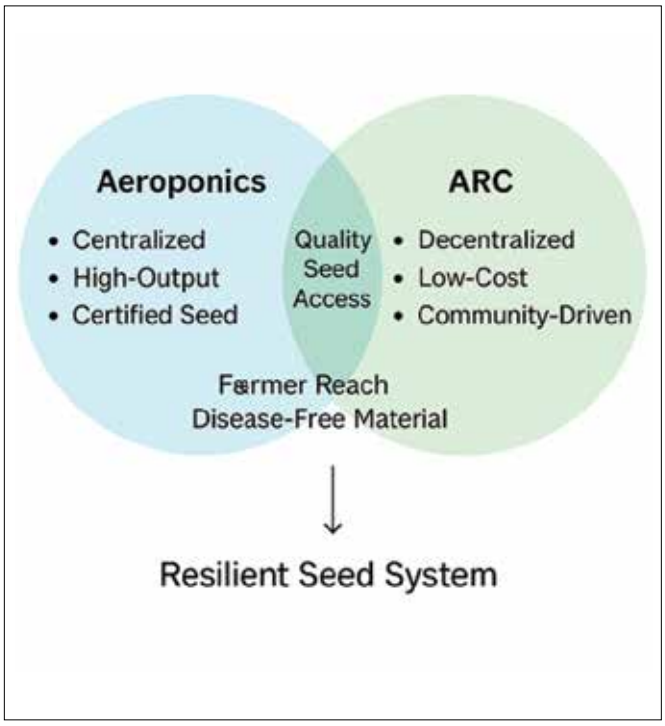
The foundation of both aeroponics and ARC-based seed systems lies in tissue culture-based micropropagation. This is a sterile, high-precision method for multiplying genetically uniform, disease-free planting material. In this process, virus-free mother plants are maintained under controlled laboratory conditions. Nodal explants, typically single nodes with a leaf, are excised and cultured in nutrient-rich media. This environment allows the generation of thousands of high-vigour microplants with identical genetic makeup. Prior to their use in seed production, these microplants are screened using diagnostic tools such as ELISA (Enzyme-Linked Immunosorbent Assay) or PCR (Polymerase Chain Reaction) to confirm they are free from major potato viruses like PVY, PVS, PLRV, and PSTVd. These validated microplants form the cornerstone of clean seed production systems, ensuring traceability, uniformity, and reliability throughout the chain.

Aeroponics: Efficient and controlled mini-tubers production

Aeroponics is a modern, soil-less cultivation technique where micro-plants are planted on top of the growth chamber, and the developing root zone inside the chamber is fogged with nutrient solution



A fully growing kiwifruit plantation in Sikkim



Aeroponics and ARC complementarity

periodically. This highly oxygenated root environment promotes vigorous plant growth and efficient nutrient uptake. The closed nature of the system minimizes contamination risk and enables year-round production in controlled conditions. In the context of seed potato production, aeroponics is capable of rapidly multiplying mini-tubers with uniform size and high health standards. A single micro-plant can yield 60–80 mini-tubers in a 90–100 day cycle. This method is also highly space-efficient and ideal for protected cultivation in NER, where maintaining seed purity and disease-free conditions is critical.

ARC technology: Decentralized and farmer-friendly

ARC (Apical Rooted Cuttings) is a low-cost, scalable technology tailored for decentralized seed production in remote and resource-limited areas such as the NEH region. It involves the sequential cutting of apical shoot tips, approximately 1.5–2 cm long with a node and a pair of true leaves from mother plants raised from tissue-cultured micro-plants. These shoot tips are rooted in pro-trays using soilless media like cocopeat under humid conditions in polyhouses or hardening chambers. Once rooted, they are transplanted into protected net houses or open fields at a spacing of 30 × 15 cm. Each rooted cutting produces 5–15 seed-grade tubers within 60–90 days, referred to as Generation-0 (G0). Under NEH condition, ARC allows staggered planting over a 7–8 months window, facilitating continuous production and efficient land use. It reduces reliance on seed imports, shortens multiplication cycles, and enables farmers, SHGs, and FPOs to become local seed producers. ARC has been widely demonstrated in NEH states through institutions like ICAR-CPRI, KVKs and SAUs.

Complementarity and convergence of aeroponics and ARC

While both systems originate from tissue culture microplants, aeroponics and ARC offer complementary advantages rather than serving as substitutes. Aeroponics is suited for centralized, high quality seed production under controlled environments. ARC, by contrast, is more accessible to small and mid-sized farmers, enabling localized, low-cost seed multiplication. The convergence of these technologies ensures efficiency, scalability, and inclusivity across the seed value chain ultimately contributing to a resilient and inclusive seed production network tailored for the NER.

Embedding technologies in formal and informal seed systems

In the formal seed system, aeroponics plays a vital role in producing high quality seed due to its controlled, pathogen-free environment. ARC-based systems, when developed from verified micro-plants and managed in protected conditions, can also be brought under certification, particularly for G0 and G1 seed classes. In the informal system, ARC has proven to be a transformative tool for community-led seed multiplication. SHGs, FPOs, and rural entrepreneurs can produce and distribute quality planting material without demanding certification processes. The system promotes seed self-sufficiency, enhances local livelihoods, and improves access to timely seed in remote hill regions.

Institutional and policy support

The advancement of aeroponics and ARC in NE India has been supported by a collaborative framework of institutions and government agencies. ICAR-CPRI, KVKs, and SAUs have contributed through research, training, and technology dissemination. The Meghalaya Basin Management Agency (MBMA) and

State Departments of Horticulture have supported infrastructure creation for net houses and nurseries. The Department of Horticulture, Government of Mizoram, has also adopted aeroponics to produce localized mini-tubers. These coordinated efforts are establishing a sustainable and region-specific seed system in the region.

Limitations and Research Gaps

Limited on-ground infrastructure for aeroponics: While aeroponics shows high potential in quality seed production, its adoption is constrained by initial setup costs, energy requirements, and technical expertise particularly in remote hill areas with unreliable power and limited skilled manpower.

Scalability of ARC technology: Although ARC is decentralized and farmer-friendly, the standardization of protocols for large-scale, uniform quality production across various microclimates in the NEH region is still a work in progress. In addition, variability in tuber output per rooted cutting can affect predictability and economic return.

Limited availability of virus-free mother plants: The entire system relies heavily on disease-free microplants as the starting point. Ensuring a consistent and decentralized supply of these validated mother plants remains a challenge, especially in the informal seed system.

Inadequate certification mechanisms for ARC: While aeroponics fits well into formal seed systems, ARC-based G0/G1 tubers often remain outside formal certification schemes. This lack of certification can hinder market acceptance and confidence among buyers.

Data deficiency on long-term performance: There is limited empirical data on the long-term field performance, yield stability, and economic viability of ARC-derived and aeroponically produced seed tubers under diverse NEH agro-climatic conditions.

SUMMARY

The north eastern region is on the threshold of a seed system transformation. Through the integration of high-tech (aeroponics) and low-cost (ARC) innovations, combined with institutional support, the region is building a resilient, decentralized, and inclusive seed production model. While aeroponics supports large-scale production of clean seed under controlled conditions, ARC offers a farmer-friendly and affordable way to multiply seed locally. Together, they create a flexible and efficient seed system suited to the region's needs. With continued support from research institutions, state departments, and community groups, these technologies can strengthen seed self-sufficiency, improve crop productivity, and support the livelihoods of farmers in the hill regions of northeast India.

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