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ACHIEVING HIGHER YIELD IN POTATO FARMING THROUGH TPS AND ARC METHOD

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One significant crop that can significantly improve food security is the potato. Potatoes can also improve nutritional security by addressing the issue of "hidden hunger" (the micronutrient shortage) due to their high nutritional value and capacity to create a significant amount of dry matter (Lal et al., 2023). After wheat, rice, and maize, potatoes (Solanum tuberosum *L.*) are the fourth-largest crop in the world. They are members of the Solanacea family. One of the most significant food crops in the world, potatoes are prized for their great nutritional value and productivity. Innovative methods like True Potato Seed (TPS) and the ARC (Apical Rooted Cutting) approach are revolutionising production systems by increasing output, lowering seed prices, and limiting disease transmission. Traditionally, potatoes are grown from seed tubers. In the latter part of the 1970s, the International Potato Center (abbreviated CIP, for Centro Internacional de la Papa) introduced true potato seed (TPS) as a substitute for growing potatoes from seed tubers. "True Potato Seed" (TPS), also known as sexual or botanical potato seed, is a radical substitute for seed tubers in the production of commercial potato crops. TPS has a number of benefits, including low planting material costs, less pathogen/pest transmission, ease of use, minimal storage and transportation costs, etc. In fact, TPS is devoid of almost all illnesses, including systemically transmitted viruses, with a few significant exceptions (such as potato spindle tuber viroid). A significant quantity of priceless potato stocks that are utilised as seed can be preserved for human consumption by employing TPS. The apical (top) shoot of disease-free mother plants is taken and rooted in a controlled nursery setting prior to being transplanted into the field using the Apical Rooted Cutting (ARC) technique.

Production of hybrid TPS

Planting of hybridization block: At 50 x 25 cm, entire tubers of desired parents or cut seed pieces (23–30g) are sown. Separate blocks of male and female lines should be planted under artificially extended photoperiods using high-density sodium vapour lamps with a power output of 100/250 W per 100 square meters. Five to six hours after sunset, from germination to berry setting, additional light is provided. Two to three batches of male lines should be planted two weeks earlier to provide a steady supply of pollen.

Hybridization: The female flower bunches are cut so that each cluster contains six to eight large buds. The right-stage blooms of the male parents are gathered in the morning, and the anthers are removed and stored overnight. If they are not needed immediately, they are stored in a refrigerator at 6–10°C.The next morning, extract the pollen by shaking the anthers in a nylon tea sieve. But it works better to utilise fresh pollen every day. Each receptive stigma should be pollinated twice by dipping it in pollen every eight hours.

Harvesting of berries and seed extraction: After 6-7 weeks of pollination, harvest the berries and let them ripen at room temperature until they are tender. Turn the berries into pulp by macerating them by hand or with a reverse screw juice extractor. To separate the seeds from the trash, treat the pulp with 10% HCl and stir for 20 minutes. To get rid of the acid, wash the seeds three or four times with water. To disinfect the seeds' surfaces, soak them in 0.05% sodium hypochlorite for ten minutes. To bring the moisture level down to 5–6%, dry the cleaned seeds in the shade and then expose them to the sun. Place the seeds in twin polythene bags and keep them in a refrigerator at or below 20 °C over calcium chloride as a desiccant.

Advantages of TPS

- TPS requirement for planting one hectare land cost 20 times less than the seed tubers.
- During pollination and fertilisation, a number of bacteria, fungi, viruses, and nematodes that infect seed tubers are filtered out. As a result, TPS eliminates illness and reduces the need for seed health checks.
- The TPS crop's segregating population has a multiline impact that improves protection against disease outbreaks.
- TPS can be stored at room temperature under dry conditions without the loss of viability for many years.
- Unlike seed tubers which are bulky, there is no transportation problem with TPS.

- A significant quantity of valuable potato stocks that are utilised as seed can be used as table potatoes by employing TPS. The nation will use six million tonnes of seed tubers by 2020, up from the current 3.1 million tonnes.
- Tuber seed production for present area under potato requires 40,000 ha land whereas for the production of TPS for the same area only 2000 ha land is required.
- Disease free potato tuber seed can be produced only in northern plains and north-western hills, whereas, TPS can be produced in most parts of the country.
- In tuber seed propagation varieties are likely to undergo pathological and physiological degeneration but in hybrid TPS the hybrid vigour is ensured.

Constraints in Adopting TPS Technology

Crops grown via TPS require more work, ongoing care, and are more vulnerable to weather-related disasters like drought, strong rainfall, and extreme heat than crops grown from seed tubers. Compared to the traditional potato crop grown from seed tubers, the TPS crop takes an additional 20 to 25 days to reach maturity. Adoption of this technology is also hampered by the limited selection of hybrid TPS populations. Since TPS is a segregating offspring, its yield is less consistent than that of the traditional potato crop, which lowers its market value.

Production Procedure Involved in ARC

Cocopeat: perlite in a 2:1 ratio, aeroponics or fogponics, cocopeat mixture, coconut coir, and rockwool cubes are the rooting media required for the production of ARCs. IBA, NAA, and GA3 are the necessary hormones, and a balanced ratio of NPK, zinc, and boron is necessary for improved shoot growth and root development. ARC is a low-cost potato production innovation in which tissue-cultured microplants are sown in the nursery to create a mother bed. The mother plants regularly harvest the apical cutting with two leaves (2–3 cm) every 12–15 days to either replant in the mother bed for re-cutting or to plant in pot trays that include a **vermiculite:** perlite combination (1:1) and coco peat-perlite blend to promote roots. In forty-five days, one microplant yields eight rooted cuttings. For the development of first generation seeds, root cuttings that are 15 to 20 days old are planted in open fields or preparatory net buildings. Under controlled conditions, the mother plant's juvenile state may last longer and result in ARCs (Kumari, 2024 and NAAS, 2021).

Principle of Apical Rooted Cutting Technology

A rooted transplant made from tissue culture plants known as mother plants is called an apical rooted cutting (ARC). The technique's underlying idea is that the mother plant, which has simple, rounded juvenile leaves, can produce apical cuttings that have the potential to grow roots. As long as the mother plant is still in its juvenile stage and has not reached physiological maturity, which is indicated by the growth of compound leaves, vascularization, and tuberization, it can be used to produce ARC (VanderZaag *et al.*, 2021). Under controlled circumstances, the mother plant's juvenility can be preserved for an extended period of time, and it can continue to generate ARCs for many generations. In the field or greenhouse, the ARCs can be transplanted to create tiny tubers that are virus- and disease-free and comparable to nucleus seed (G0). As planting material for potato cultivation or seed production, the ARCs can be given to farmers or sold to seed businesses for the generation of seeds tuber.

Benefits of ARC

Compared to conventional method, ARCs' in potato has several benefits:

- With ARCs, higher multiplication rates—20–50 times per production cycle—are achieved.
- Because there is no dormancy, planting can be done between two and four weeks after rooted.
- As the plantlets are made from meristem-culture so they are free from any disease.
- Lesser requirement of labour with uniform spacing.
- This technique's affordability also makes it possible to incorporate new types from throughout the globe into the manufacturing chain.
- Mechanisation is used in ridge development to ensure healthy tuber growth and adequate soil aeration.
- By combining traditional and cutting-edge technology in ARCs, growers can produce seeds quickly, cutting down on the time needed to produce new plantlets.
- Greater adaptability because it can be more readily transferred from a lab to a greenhouse or field without causing any stress, which helps farmers produce potatoes without any issues.

- Because it produces high-quality seed at a low cost with rapid rates of multiplication and allows farmers to use both seed and ware potatoes, it can be a lucrative enterprise for small farms.
- Helpful for areas where seed production is negligible. (Buckseth *et al.*, 2022, Wauters *et al.*, 2022, Sadawarti *et al.*,2024, Chakraborty ,2026).

Constraints

- Mortality rate is high in planting material along with disease and pest succeptibility
- Inadequate storage and facility of warehousing
- Labour shortage in peak season
- Lack of quality planting material
- Lack of transport facility
- Lower price of potato produced through ARCs
- Lack of adequate technical information transfer to farmers' (Madhu and Basavaraj, 2025 and Moolimane *et al.*, 2025).

Suggestion to Farmers

Apical Rooted Cutting (ARC) and True Potato Seed (TPS) are two planting techniques that potato producers frequently select. Both approaches offer benefits, but the decision is based on output objectives, farm size, and budget. In TPS, potato plants are grown from botanical seeds. It is an inexpensive choice that is simple to move and store. Small and marginal farmers can benefit from this approach, particularly in areas where certified seed tubers are costly. TPS crops, however, may exhibit variance in tuber size and plant growth, necessitating cautious nursery management. Cuttings from tissue-cultured plants are used in the ARC technique. It yields consistent, disease-free crops with improved tuber size consistency and a larger potential yield. It is more appropriate for commercial farming for seed potato production, while having a greater initial cost than TPS.

For farmers aiming at higher yield and better market returns, the ARC method is generally more profitable. However, for those with limited investment capacity, TPS is a practical and economical alternative. The final choice should be based on available resources and production goals.

Conclusion

Innovative and scientific techniques like TPS and ARC can help grow potatoes with a higher yield. While the Apical Rooted Cutting technique increases productivity and multiplication, True Potato Seed technology lowers seed costs and disease transmission. These techniques can greatly boost farmers' productivity and profitability when paired with integrated pest control, nutrition management, and good agronomic practices. Apical root cuttings are less expensive per plant but offer all the advantages of plants grown in vitro. The apical root cutting-based techniques have also become more cost-effective because of their excellent tuberization potential. Therefore, the apical root cutting-based system becomes cost-effective for multipliers to sell high-quality seed and allows small farmers to participate in the production of potato seed because of the high productivity of rooted apical cuttings, the short time needed to produce disease-free and superior quality seed tubers, the high rate of multiplication, and the lower cost.TPS techniques are high-yielding, economical, and sustainable substitutes for traditional tuber-based propagation in the face of growing seed prices and disease issues. They have the potential to revolutionise potato production methods and improve global food security and farmer wealth if properly implemented.

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