

APICAL ROOTED CUTTING: A UNIQUE METHOD OF POTATO SEED PRODUCTION

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ABSTRACT

Potato cultivation plays a crucial role in sustaining India's rice-wheat cropping system amid climate change, ensuring farmers' income. However, the success of this strategy hinges on the availability of quality seed potatoes, a significant production cost. Conventional seed production methods fall short of meeting the demand for high-yield, disease-free seeds. Hi-tech alternatives like tissue culture and aeroponics, while effective, are prohibitively expensive. Addressing the need for an affordable solution, the Apical Rooted Cutting (ARC) seed production technology integrates benefits from conventional and hi-tech methods. This cost-effective approach facilitates the rapid production of superior, disease-free seed potatoes, presenting a viable solution to the country's prevailing seed scarcity issue.



INTRODUCTION

Potato is a very important crop, which can play a vital role in enhancing food security. Due to its high nutritional value and ability to produce considerable amount of dry matter, potato can also address the problem of “hidden hunger” (the issue of micronutrient deficiency) (Lal et al., 2023), thus enhancing nutritional security. It is thus aptly referred to as ‘king of vegetables’ and regarded as exceptional crop by the Food and Agriculture Organization (FAO) (Devaux et al., 2019). The potato can also play a major role in maintaining the sustainability of the rice-based cropping system, which is facing major alternations and threat in the current regime of climate change. Being a high yielding and labour-intensive crop, potato can help to maintain farmers income in the current scenario, particularly in a country like India which has surplus labour and limited capital (Pandey et al., 2016; Singh et al., 2016). But, the profitability of the potato-based cropping system depends upon the availability of quality seeds. Since potato is propagated through seed tubers, a good potato seed should be free from diseases and have high productivity. In India the cost of these type of seed is high and accounts for 40-50 percent of the total production. This limits the profitability of the potato-based cropping system and is the key deterrent for the small farmers to take up potato production.

CONVENTIONAL SEED PRODUCTION SYSTEM AND ITS LIMITATIONS

The leader in seed potato production in India is ICAR-CPRI and other agencies, which produce potato by conventional “seed plot technique” (Pandey et al., 2012). The potato production by this technique involves vegetative propagation of tuber with simultaneous indexing against all major viruses and subsequent clonal multiplication in four cycles for breeder seed production (Sadawarti et al., 2017; Singh et al., 2019). This technically demanding method has many limitations like low rate of multiplication, limitation in development of 100% healthy seed stock from infected material, progressive accumulation of degenerative viral diseases and several field multiplications of initial disease-free material. This makes the seed production programme labour intensive, time consuming and expensive; resulting in less adaptability (Chiipanthenga et al., 2012). Moreover, this system of seed production is prone to diseases and infestation which build up after several generations of seed propagation (Sadawarti et al., 2017). Also, the local cultivars are not prevalent in this seed production chain. As a result, only a limited organisations and large landholding farmers take up this daunting task of potato seed production, creating a huge scarcity of the seed potatoes in the country (VanderZaag et al., 2021). Therefore, there is an urgent need to revive the Potato sector through developing alternate decentralized seed production system which ensures good quality seeds at affordable prices to farmers (Singh et al., 2023). To alleviate this problem, hi-tech method of potato seed production involving tissue culture, aeroponics and others can be used. The farmers, particularly small holding farmers, can also be involved in participatory seed production chain to increase the seed production. But the major challenges in realising this task is the availability of a low-cost method for production of seed potatoes. Apical Rooted Cutting (ARC) based seed production systems can solve this problem. This technology is adequate for low-cost production of disease and virus free potato planting material (Vander Zaag and Escobar, 1990).

PRINCIPLE OF APICAL ROOTED CUTTING TECHNOLOGY

An apical rooted cutting (ARC) is a rooted transplant produced from tissue culture plants referred to as mother plants. The principle behind the technique is that the mother plant, which has simple rounded juvenile leaves, are capable of producing apical cutting which can develop roots. The mother plant can be used to produce ARC as long as it is in juvenile state and does not reach physiological maturity characterized by development of compound leaves, vascularization and tuberization (VanderZaag et al., 2021). The juvenility of the mother plant can be maintained for long time in controlled conditions and it can produce ARCs for many generations. The ARCs can be transplanted in the field/greenhouses, where they produce mini tubers/tubers which are disease and virus free and equivalent to Nucleus seed (G0).

The ARCs can be supplied to seed companies for tuber seed production or they can be supplied to the farmers as planting material for seed production or potato cultivation.

PROCEDURE OF APICAL ROOTED CUTTING TECHNOLOGY-BASED POTATO SEED PRODUCTION SYSTEM

The rooted apical cuttings-based seed production systems involve two major stages:

1. Production of apical rooted cuttings in a lab and greenhouse:

The purpose of using ARC based system for seed production is to produce disease-free planting material (Buckseth et al., 2019). So, to begin with, the pure cultures of potato are produced through *in vitro* methods. The clonal propagation of these cultures is done for mass multiplication of the disease-free plantlets (Fig. 1 A). These micro plants are then transferred to seedling trays having substrate mixture for acclimatization and hardening, to produce mother plant (Fig. 1 B). The mother plants are grown in controlled conditions (in controlled polyhouse or greenhouse) to maintain their juvenility. The apical portions (1.5-2.0 cm) of 10-15 days old mother plant are cut and planted in substrate mixture for the development of roots (Fig. 1 C-E). The mother plant is left to grow further and develop secondary branches. The cuttings are again made from 7-10 days old branches of the mother plant. The process can be repeated 5-6 times or till the juvenility of the mother plant is maintained. The apical cuttings planted in the substrate mixture develop roots after 10-15 days. The cuttings are allowed to grow for 15-20 days in controlled polyhouse or greenhouse. These rooted cuttings (Fig. 1 E) can then be transplanted in fields or net house for development of tubers/minitubers (Fig. 1 F-J).

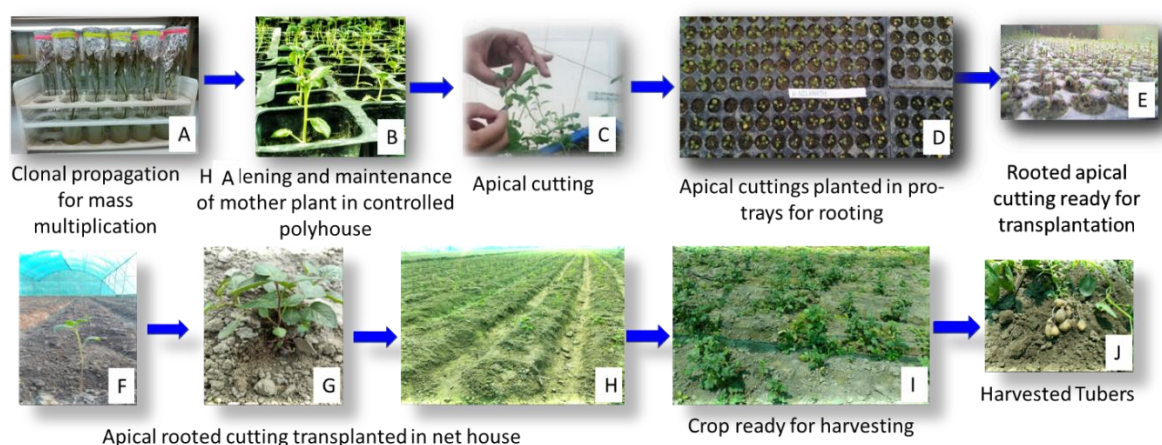


Fig. 1 Schematic Representation of Apical rooted cutting system

2. Distribution of ARCs to farmers and stakeholders for seed production:

The rooted apical cuttings developed in control conditions, act as seed and can be supplied to farmers or stakeholders. These cuttings are disease free and have high tuberization ability. Thus, they can be used by farmers either for seed production or potato tuber production. The first-generation tubers produced by this method is equivalent to nucleus seed (G0). These G0 seeds can be used as seed for production of tubers in controlled net house, which are equivalent to pre-breeder seed (G1). The G1 seed can be planted in open field to produce breeder seed (G2). The further multiplication of these seeds in open fields for three generation can lead to production of certified seeds. Hence, the farmers can use the ARC based system to produce certified seed in less time (Anjani et al., 2023).

ADVANTAGES OF ARC BASED SYSTEM OVER CONVENTIONAL SEED PRODUCTION SYSTEM

The ARC based system of potato seed production is a very unique system, which has the ability to revolutionize the potato seed production system in India, by enabling the smallholder farmers to participate in seed production. This is possible due to the many advantages of ARC based system over conventional seed production system. In the conventional system, the major challenge is the production of disease-free seed tubers. Since the rooted apical cuttings act as planting material for ARC based seed production systems and these cuttings are produced from tissue culture plants, they are free from any diseases or viruses. The input required for producing disease free seeds is thus minimal.

The second major challenge of the conventional system is low productivity and high cost. An apical rooted cutting has high productivity and has the ability to produce 10-25 or more seed tubers as compared to 5-10 seed tubers per minitubers. Also, one mother plant can be used to produce many ARCs as long as the juvenility is maintained. One microplant can produce six to eight rooted cuttings (Buckseth et al., 2022). Thus, the rate of multiplication is high in ARC based system and cost per plant is less, making it more economical. The cost-effective nature of this system also helps to introduce exotic, local landraces in the seed production chain (VanderZaag et al., 2021).

The third major challenge of conventional system is the time required to produce certified seeds. The tubers produced from apical cuttings can directly act as nucleus seeds. These can be multiplied using traditional cultivation methods to produce certified seeds in the fields. Thus, the time required to produce certified seeds is 4-5 years as opposed to 9-10 years in conventional method. The ARC based seed production technology thus combines the benefits of conventional as well hi-tech potato seed production system in addition to decreasing the cost and time, enabling small farmers to take up seed production (Buckseth et al., 2022).

CONCLUSION

Apical root cutting's have all the benefits of an *in vitro* produced plants but the cost per plant is less. Also due to their high tuberization ability, the apical root cutting based systems have become more economical. Thus, due to the high productivity of rooted apical cuttings, less time required to produce disease free and superior quality seed tubers, high rate of multiplication and less cost; the apical root cutting based system becomes economical for multipliers to sell quality seed and enables small farmers to participate in the potato seed production.

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