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Novel Techniques for Increasing Seed Potato Productivity

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Abstract

Challenge before government seed producing agencies all over the world is providing high quality seed of potato at affordable price at right time. Currently largely seed potato is being produced by conventional system of seed potato production which has few bottlenecks like, low multiplication rate (1:6), high seed (tuber) rate, dynamic amassing of degenerative infections, perishability, massiveness and slower process of generating 100% healthy seed stock. Rapid multiplication techniques like aeroponic system of seed production has well integrated all over the world in seed production programme due to high seed multiplication rates (1: 20-80). New techniques like apical root cutting (ARC) and sprout cutting has the potential for large scale multiplication as they are rapid, cost effective and farmer's friendly. As ARC and sprout cuttings are promising technologies and their technical advancements have been or are being examined so that it can be integration in seed potato production system.

1. Introduction

Potato production in India has been increasing fast due to growing demand supported by technologies and innovations. Globally, India is the second-largest producer of potatoes accounting 11.3% of the area and 16.0% of production. In 2022–23, India produced 60.14 million tonnes from 2.3 mha area (Singh and Dutt, 2024). For this approx 5.4 million ton certified/ quality is required which is virtually impossible to produce such a huge quantity of seed by traditional methods. Moreover potato seed alone accounts for 40–50% of the total potato production cost (Buckseth et al., 2024).

Keywords:

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2. Challenges in Conventional Seed Potato System

Shortage of quality seed potatoes is a major and a key problem in developing nations. Only about 11% of the world's potato crop is grown from quality and certified seed. Due to this shortage, many a times the potato production often occurs or continue to occur with the degenerated seed material (Paul et al., 2022). In India, one noteworthy reason for low potato profitability is the utilization of low quality seed and at present the state and central seed offices of the nation can meet just 20–25% prerequisite of aggregate quality seeds. High yielding varieties and sound planting materials are prerequisites for sound seed potato production. Low multiplication rate, high seed (tuber) rate, dynamic amassing of degenerative infections, perishability, massiveness and slower process of generating 100% healthy seed stock are major bottlenecks in conventional system of seed potato production (Sadawarti et al, 2024). Breeder seed supplied by ICAR-CPRI is seldom multiplied in all three generations by the State Seed Producing Agencies maintaining the recommended procedures (Anonymous, 2021) and longer time which is equivalent to one cropping season approximately 4 months are the inherent issues in conventional seed potato production.

3. Desideratum of Rapid Multiplication Systems (RMT's)

Presently CPRI produces 72% breeder seed through conventional method and 28% through hitech system (Anonymous, 2022). To meet the present and increasing future demands of potato, the multiplication rate of seed potato needs to be higher and the whole process should need to be faster. Therefore, alternative methods of seed potato production are needed. Keeping in view, alternative methods should be rapid, low-cost and they must yield good quality seed potatoes which can fit well into the existing potato production system. It is, therefore, imperative to evolve a seed production system, encompassing the innovative techniques to improve the quality of seed and to reduce the field exposure, along with a robust system of certification and quality assurance of the seed produced and supplied by the private seed growers.

A paradigm shift in potato seed production methods has taken place globally and major potato producers of the world have shifted from conventional to the hi-tech

seed production system to improve the seed quality and enhance seed multiplication rate. Many RMT's have been developed in recent years for speedy potato multiplication (Buckseth et al, 2022), but the most common in developing countries are micro-propagation (plantlets and micro-tubers), cuttings (single-node, tuber sprout, axillary, leaf-bud, apical), aeroponics, and hydroponics (Schulte-Geldermann et al, 2022) which can be maintained indefinitely under controlled conditions and multiplied in artificial media under sterile conditions in the laboratory throughout the year irrespective of growing season, which has revolutionized seed production in potato world over. These hi-tech planting materials (designated as G0 or generation-0 seeds) multiplied in the insect proof screen /net house to produce the disease-free seed tubers known as the breeder seeds.

4. Benefit of Rapid Multiplication Systems (RMT's)

RMT's has several advantages *viz*, the faster introduction of new varieties, giving farmers quicker access to genetic gains, the quicker revitalization of popular varieties and lost seed stocks from a limited number of healthy propagules, fast bulking of foreign germplasm and the introduction of varieties into other regions or countries. Production of RMT's would reduce the land required for seed multiplication give smallholder farmers faster access to varieties that tolerate abiotic and biotic stresses. Hence RMT's contributed significantly to the increased supply of certified or high- quality seed in the region over the last decade. Hitech seed potato production also requires highly skilled technical staff and significant capital investment, which was a constant bottleneck. Attracting local private investment in RMT's while strengthening the capacity of the public sector and generating efficient public-private partnership (PPP) models has been a way to break the seed bottleneck which has been very much adapted in India by licensing aeroponic technology to private sectors, progressive seed potato growers and FPO's.

5. Novel Rapid Techniques of Seed Potato Production

Aeroponic technology is well standardized around the world and in India and well integrated in seed potato system. Apical root cutting (ARC) and sprout cutting are emerging techniques which are farmers friendly when well standardized and popularized among farmers can

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help in augmenting seed potato production. Research is being undertaken by CPRI and all over the world for standardizing these techniques.

5.1. Aeroponic technique

Aeroponics is a more recent technology complemented by plant tissue culture promises a great potential to transform seed potato production in developing countries (for breaking the seed potato bottleneck. Aeroponic system can be a suitable system of producing potato pre-basic seed under temperate conditions, and its optimization may be considered as a strategic investment with the aim of promoting a more efficient and sustainable production of high quality potato minitubers and have been well established following an increased demand for more efficient high quality seed production methods. Aeroponic technique can reduce the number of steps for potato seed multiplication and improving plant health and quality of the first field production generation. Aeroponics uses a hydroponics growing system where the plant roots are suspended in a dark enclosed chamber and sprayed with a nutrient solution as a fine mist and is a new breakthrough in the effort toward fast multiplication of seed potato types G0 in supporting agricultural development programs in commercialized seed systems. This system facilitates round the year production and adoption of phytosanitary standards.

G0 aeroponic potato production provides better profit due to higher productivity; tubers are better and healthier, sterile and free from pests and diseases and can be planted at any time. Hence aeroponics system is a viable technological alternative for the potato minituber production component within a potato tuber seed system. Given the potential advantages of the aeroponics system, such as its good nutrition monitoring and fast seed production, capacity to improve seedling survival rates and growth, spacious area, constant air circulation and eco-friendly nature, this system has the potential to reform the potato production industry. Aeroponics has transformed seed potato production in India by providing high-quality seeds, albeit with specific planning requirements, operational costs and the need for standardized nutrient solutions.

5.1.1. Aeroponic method

In this system, microplants are planted on the top of the growth chamber, and the developing root zone inside the chamber is fogged with nutrient solution (Figure 1). Plant roots are grown suspended in a dark box that is closed

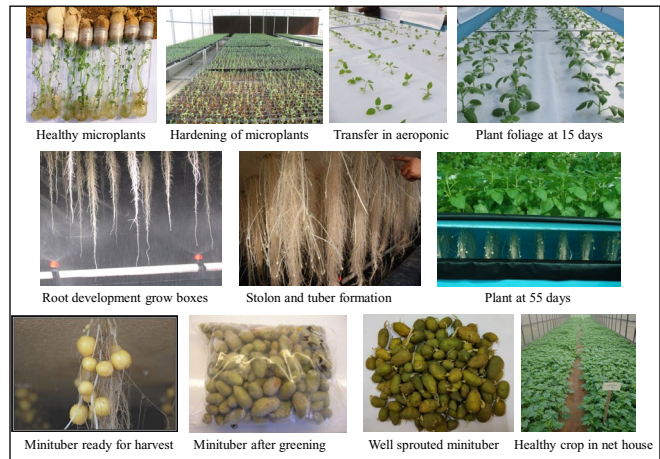


Figure 1: Aeroponic system of seed potato production

or semi-closed. Roots are sprayed with a nutrient-rich solution. The nutrients and improved aeration improve the growth of the root system. The chambers are installed inside an insect-proof nethouse. The aeroponic chamber has a removable opening at the top with holes for holding the potato plants. The front of the aeroponic chamber is set with pivots and can be opened to harvest mini-tubers of ideal size at different time intervals. Picking of tubers begins after 45–50 days of planting when they attain a size of 3–10 g. Picking of minitubers is done every week, and around 10–12 harvests are taken during the whole crop season of 4–5 months. Normally, 40–50 mini-tubers can be harvested from a single *in vitro* plant depending upon the variety as against 8–10 mini-tubers under the nethouse in nursery beds. The harvested minitubers are stored at 2–4°C to be utilized for planting in the next crop season.

5.2. Apical rooted cutting (ARC)

Apical cuttings are rooted transplants produced in a screenhouse from tissue culture plantlets. Rather than allowing tissue culture plantlets to mature and produce minitubers, cuttings are produced from the plantlets. Once rooted, the cuttings are transplanted into the field to produce seed tubers. A novel low-cost and farmer-friendly technology called Apical Rooted Cutting (ARC) has recently been standardized by CPRI, Shimla for hi-tech seed production in potato. The ARC involves raising *in vitro* plantlets in nursery and then transplanting of rooted-cuttings in glass/net-house (Buckseth et al, 2019). ARC can be used for production of quality planting material at low cost in seed deficit areas. The everlasting shortage of seed potatoes can also be partly

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overcome through ARC on account of its faster rate of multiplication. The apical rooted cutting (ARC) is a low-cost technology with simple steps that can be easily adopted by progressive farmers, farmer producer organizations (FPOs), and other small entrepreneurs in the potato production belts to produce quality seed at affordable prices. It can be profitable business for small land holders as has potential of significantly increasing quantity of quality seed as most productive and highly efficient low cost potato multiplication procedures (Wauters et al, 2022).

5.2.1. Apical rooted cutting method

In ARC, the healthy buffer stock of microplants acts as initial planting material (Figure 2) on nursery beds (400 microplants- m²). The first round of cutting starts after 15-20 days of planting of the mother stock. To follow the seed plot technique (*i.e.* growing potato seed crop under aphid-free period of the season) and to fit into the seed production window, only 3-4 cuttings are recommended in the north-western central plains of India. Thus, one microplant can produce 6-8 rooted cuttings. Around 7-10 days old rooted cuttings are planted under insect proof nethouse for tuber production. Batch wise pedigree of the cuttings is maintained so as even if any plant out of a cutting is found infected with a virus during testing, all the counterparts of the cutting/sister counterpart tubers can be rejected. Based on the available data, 7-10 tubers weighing 10-70 g can be harvested from a single cutting, thereby, achieving multiplication rate of more than 50 depending upon the variety. Rooted apical cuttings are transplanted right away in the field, thereby saving one generation, as mini-tubers are no longer needed. When

standard operating procedures are adhered to ensure seed health within the seed production timeframe, this method holds significant promise.

5.3. Sprout cutting

Sprout cutting is old traditional method which has been rejuvenated with the increasing demand of quality seed to produce virus free seed potato for quick multiplication of higher amount of quality seed potatoes within a short period of time. After cutting the sprouts, mother tubers are also used for the production of seed potatoes. Sprout cutting is highly effective to produce virus free seed potato without affecting the production capacity of the mother tubers. This effort might be highly sustainable for producing our own quality seed potatoes which ensures the supply of quality seed potatoes to the farmers in proper time. This might contribute to reducing price and minimizing the shortage of seed potatoes for potato cultivation by the farmers (Karim et al., 2010). For maintenance and multiplication of desirable seed material sprout cutting is important one among different rapid method of multiplication. Sprout planting can be an important advance in the production process of basic seed potatoes. Sprouts of seed potatoes of class G-0 can start point for national seed potato production.

5.4. Sprout cutting method

Disease-free tubers are the starting material for seed production. Scooping of apical eye plugs is done to break the apical dominance and this leads to multiple sprouting. In this technique, sprouts are repeatedly harvested from mother tuber. The multiplication



Figure 2: Apical rooted cutting production

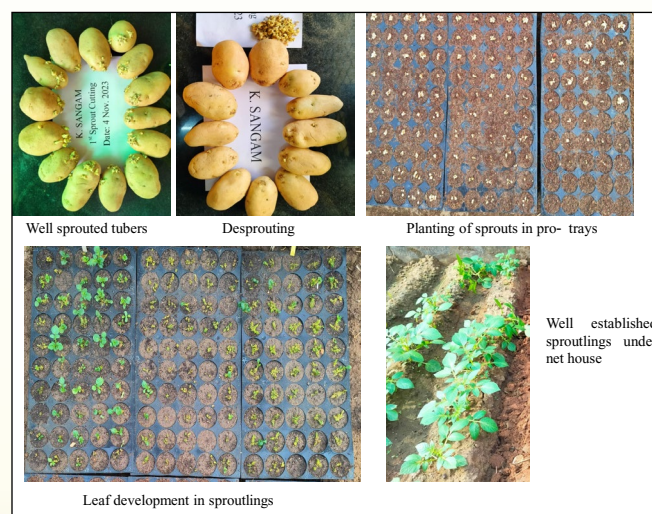


Figure 3: Sproutling production in seed potato production

potential can be enhanced by further cutting the sprouts into pieces (each having one or two nodes). The de sprouted mother tubers can also be used as normal seeds. Detached healthy sprouts are then planted in polythene bags/ protrays filled with soil: farmyard manure (1:1) mixture and are grown under the shade. Sproutlings are established, they are transplanted in the field (figure 3). Depending on cultivars, 3-4 harvesting of sprouts can be taken from a mother tuber at an interval of 15-20 days. Sprouts of potato tubers can effectively be used for propagation of potato, which is yet to be standardized. This method provides an efficient alternative for farmers and seed growers who may not have access to advanced technologies, ensuring a high multiplication rate and maintaining seed health.

6. Conclusion

Novel systems/ RM techniques offers higher and faster rate of multiplication, disease freedom under controlled conditions, cost effectiveness followed by reduced number of field exposures as compared to conventional seed potato system. Due to these numerous advantages, the novel/rapid multiplication system of seed potato production is finding favours among the seed potato entrepreneurs/farmers all over the world.

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