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Corresponding Author
Murlidhar Sadawarti
e-mail: murlidharsada@gmail.com

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Ensuring Healthy Seed Through Innovative Techniques of Seed Potato Production

Murlidhar Sadawarti[1], S. P. Singh[1], R. K. Singh[2], Tanuja Buckseth[2], Subhash Katare[1], Manoj Kumar[2], P. A. Khambalkar[3], Y. P. Singh[1], S. K. Sharma[1], S. K. Gupta[1], Surender Singh[1], and R. K. Samadhiya[1]

Abstract

Potato seed is accounting for 40-50% of the total cost of potato cultivation. The availability of quality seed of improved potato varieties in adequate quantities is the major constraint in enhancing productivity of the crop. Presently basic seed of potato in India is produced through conventional system i.e., through clonal selection, tuber indexing and stage-wise field multiplication of healthy indexed tubers in subsequent four generations. However, in hi-tech system, potato is seed produced through microplant, micro tubers, aeroponic mini tuber and apical rooted cutting which inturn will be multiplied under seed plot techniques. This technique enables large scale multiplication of healthy plants round the year which is not possible under conventional system and reduces the field exposure and thereby minimizing the accumulation of viruses in the seed stocks. In this article, we gave an overview of novel seed production methods in potato.

1. Introduction

Potato is grown in almost all the states in India under diverse agro-climatic conditions. In 2019-20, it was cultivated in an area of 2.05 million ha. India achieved production of 48.56 million ton with an average productivity of 24.0 ton/ha. About 90% of the total potato area is located in the sub- tropical plains, 6% in the hills and 4% in the plateau region of the peninsular India. Indo-Gangetic plains accounts for about 76% of the potato area. Nearly 87% of potato production in the country mainly cultivated as a winter crop from October until February-March. Although potato production is a very remunerative crop enterprise, yet its profitability is dented by the periodical gluts and price crashes. High yields of potato (*Solanum tuberosum* L.) mainly revolves around use of high-quality seed potatoes. Availability of disease free planting material is a critical input in augmenting potato production. Potato seed is the highest cost bearing input accounting for 40-50% of the total cost of its cultivation. Being a vegetatively propagated crop, seed quality and adoption of the Seed

Author's Address

[1]ICAR-Central Potato Research Station, Gwalior, Madhya Pradesh (474 006), India
[2]ICAR-Central Potato Research Institute, Shimla, Himachal Pradesh (171 001), India
[3]Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Madhya Pradesh (474 020), India

PlotTechnique (SPT) are critical for improvement of potato productivity and profitability.

Considering that, the country requires ~ 54 lakh tones of good quality potato seed every year for planting in an area of 2.05 million ha @ 2.5 ton/ha. Therefore, there is a deficit of ~ 49 lakh tones of good quality seed after adjusting the estimated certified seed being produced by the existing system. Though about ~12 lakh tonnes of seed potato are being sold every year by private growers in Punjab, western Uttar Pradesh, West Bengal, Haryana etc, there is no mechanism and infrastructure to assure quality of that seed. It is necessary to develop a national system to certify the quality of the seed being produced and supplied by the private seed growers.

2. Importance of Quality Seed in Potato

Since, potato is a vegetatively propagated plant, fungal, bacterial and especially viral diseases easily affect seed tubers. Viral diseases are mainly responsible for degeneration of seed tubers, which decrease their vigor as well as productivity. The availability of quality planting material of improved potato varieties in adequate quantities is the major constraints in enhancing productivity of the crop. Planting of degenerated tubers results in low yields. If they are planted in further generations, they reduced yield further showing 'degeneration' or salinity. Such salinity acts as a major constraint in producing disease free potatoes. Potato production is constrained by various factors which include availability of suitable varieties, agro- techniques, quality seed and storage infrastructure, but most important being the availability of quality seed as it has a direct bearing on crop yield. Potato seed is bulky in nature and the rate of multiplication is very limited (5-6 times) under Indian system which poses a unique challenge for seed production and availability. Since, the crop is multiplied vegetatively using tuber as seed; it gets degenerated very fast necessitating replacement after every four years.

3. Seed Plot Technique (SPT) for Seed Potato Production

In India, seed production is being done by well-developed seed plot technique. Growing seed potato crop during low aphid period with healthy seed from October to first week of January coupled with the use of insecticides, rouging and dehaulming in the last week of December or up to second week of January, was developed by the ICAR-CPRI, Shimla and is called as "Seed Plot Technique" (Figure 1). Quality seed production was possible under this technique in sub-tropical plains by advancing the date of planting from December end to first week of October. Due to seed plot technique, it became possible to grow healthy seed in the plains, consequently, the North Western plains emerged as important areas of high quality seed production. Seed produced in the plains is stored

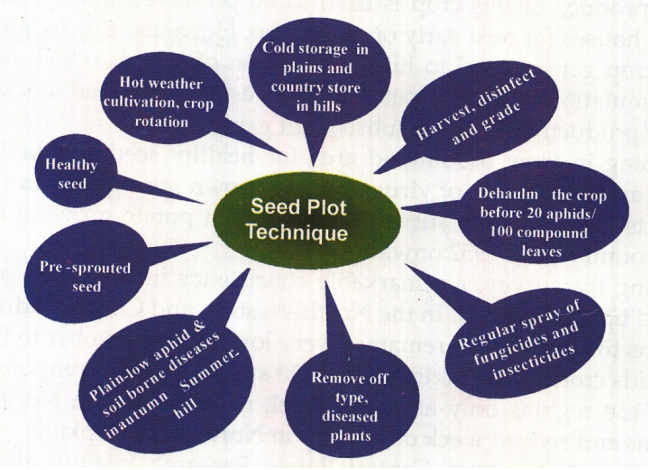

Figure 1: Components of seed plot technique in potato

in cold stores. During the storage, it becomes non-dormant and sprouts quickly when taken out of cold stores. Thus, it attains an ideal physiological stage for planting in the early or main crop in the plains.

4. Seed Production Systems

4.1. Conventional seed production system

Taking advantage of seed plot technique, a well organized strategy for production of breeder's seed was envisaged after 1970 through clonal selection and tuber indexing and stage-wise field multiplication of healthy indexed tubers in subsequent four generations (Figure 2). In this system, elite tubers are first individually indexed against PVX, PVS, PVM, PVA, PVY PLRV and PVY^{N} using ELISA. Tuber indexing is a process of testing the selected tubers for virus freedom by growing their eye plugs under net house/ glass house. Clonal selection is done from stage-I. The plants for virus freedom

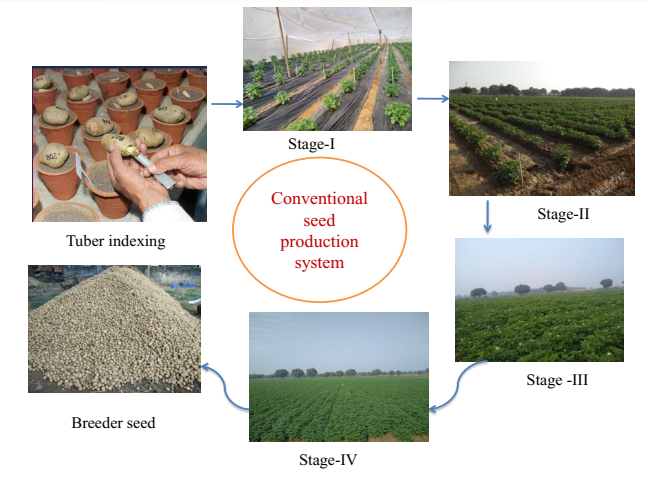

Figure 2. Seed potato production through conventional system

by ELISA are tested after 6 to 7 weeks planting or at 6 to 8 leaf stage as per the procedure. Even if any plant out of four eye plugs in a clone is found infected with virus during testing, all the counterpart indexed as well as their un-indexed sister counterpart tubers are to be rejected. The disease free tubers obtained during indexing are used for production of nucleus, breeder, foundation and certified seed. Stage –I clones are further multiplied in Stage-II, Stage –III and Stage IV with standard seed plot techniques. The produce of stage-IV is supplied as breeder seed. The conventional system although is very robust and easy to adopt but it has several limitations like,

i) Low rate of multiplication

ii) Requires more number of disease free propagules in the initial stage

iii) Development of 100% healthy seed stock from infected material is slow and time taking

iv) Progressive accumulation of degenerative viral diseases in each field exposure and,

v) Many field multiplications of initial disease-free material (7 years).

To overcome these limitations Central Potato Research Institute is gradually shifting from conventional system of seed production to hi-tech seed production.

4.2. Hi-tech seed production system

Hi-tech potato seed production is based on tissue culture technique. This technique has revolutionized the seed potato production by enabling large scale multiplication of healthy plants round the year which also reduces field exposure and thereby minimizes the accumulation of viruses in the seed stocks. This system can be further sub-divided into three system *viz*. seed production based on (i) microplants (ii) micro-tubers and (iii) aeroponics (Figure 3).

4.2.1. Microplant-based seed production system

The mother tuber(s) of a known variety should be free from all viruses and seed-borne diseases. The mother plants raised from mother tubers should be tested by all possible methods for virus freedom before initiating in *in vitro* culture. These include, ELISA, ISEM, PCR, NASH etc. The virus-free stocks are multiplied through nodal cuttings on semisolid MS medium following the standard procedure up to 10-12 cycles. *In vitro* plantlets are then hardened for 8-10 days under appropriate conditions. The hardened plantlets should be removed from protrays along with peat moss and transplanted on nursery beds in mixture of soil, sand and FYM in rows at appropriate spacing under insect-proof net house conditions. Five per cent of the plants are tested by ELISA. The seed produced from the microplants is known as minitubers (G-0). Minitubers weighing >3 g are planted in Generation-1 in the field during next season. The produce of G-1 is further multiplied in the field for one more time (G-2). The G-2 produce is sold as breeder seed.

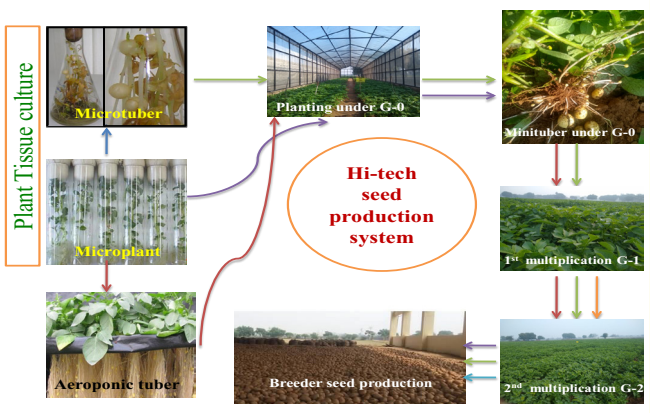

Figure 3: Seed production through hi tech systems

4.2.2. Microtuber-based seed production system

The microtubers are induced on the microplants in controlled conditions. For inducing the microtubers, 3-4 weeks old microplant shoot cutting are transferred into 250 ml conical/ erlenmeyer flasks or culture bottles containing 25-35 ml liquid medium. Cultures are then incubated at 25^{0}C and 16 hour photoperiod in the culture room. The medium is decanted and changed with tuber induction medium. The plants are then incubated in dark for 2-3 months for production of microtubers. The microtubers are hardened and used for raising seed crop under net house in G-0 (Figure 3) and further in G-1 and G-2 and G-2 supplied as breeder seed

4.2.3. Aeroponic based seed production system

In this system, the roots of the plant are grown in complete darkness in lightproof sealed box or container where the roots are intermittently supplied with nutrient solution in mist form. The nutrient solution is continuously re-circulated through the system and monitored and amended whenever necessary. The top portion of the plant is exposed to the open air and a light source. It prevents exposure of plantlets to unfavorable soil conditions and the minitubers harvested from this system will be free from soil-borne pathogens. Desired size of minitubers can be harvested sequentially which are further multiplied in G-0, G-1 and G-2 and G-2 supplied as breeder seed (Figure 3).

4.2.4. Apical root cutting (ARC): An emerging technology of quality seed potato production

Apical cuttings are an alternative to minitubers in current production seed systems for potato. Apical cuttings are rooted transplants produced in a glasshouse from tissue culture plantlets. In apical cuttings the tissue culture plantlets are used as mother plants in cocopeat for producing cuttings. In six weeks, one mother plant can be multiplied to produce

Figure 4: Seed production through apical root cutting

8 plants. These cuttings are transplanted on the seed bed and once rooted, are moved to net houses or open field for producing seed tubers. This technology works on lowering of apical dominance from plantlets by removing apical bud where the lowered IAA concentration allows the lateral buds to grow and produce new shoots. Once the apical dominance has been lifted from the plant, elongation and lateral growth is promoted and the lateral buds grow into new branches which are further used to increase the multiplication rate. Apical cuttings involve: i) Production of rooted cuttings (transplants) originating from tissue culture plantlets in the glasshouse. ii) Production of seed tubers in the field from transplants (Figure 4). ARC have the potential to transform potato seed systems through rapid and high rate of multiplication and will significantly contribute to reducing seed potato shortages.

Table 1: Comparison of conventional system and Hi-tech system seed production systems

Parameters	Conventional system of seed production	Hi-tech system of seed production
Type of multiplication	Seed potato production is mainly based on clonal selection of indexed tubers and its multiplication in subsequent stages in field.	This system is based on tissue culture. 100 % healthy material is used as seed source.
Procedure	Involves successive multiplication of nucleus seed tubers through super elite, elite tubers	Involves successive multiplication of pre-nuclear stock viz microplant, microtubers, aeroponic minitubers, seedlings.
Field exposure	Higher field exposure of 7-8 years	Reduces the field exposure and thereby minimizing the accumulation of viruses in the seed stocks
Uniformity	Uniformity is less	Large scale uniform production of clonal material in initial generation of potato
Speed of the multiplication	Slow	Fast
Seed multiplication rate	Multiplication rate in potato is low varying from 1:4 to 1:15 (one tuber yields 4 to 15 tubers) depending upon variety, agro- climatic conditions and crop management practices	Higher multiplication ratios (1:40–1: several thousand per year) (FAO, 2008)
Period	Time specific particularly in tropical and sub-tropical regions where potato is a winter crop	Not limited by the time of the year or weather particularly for pre-nuclear seed stock multiplication viz microplant, microtuber and aeroponic minituber.
Disease incidence/ degeneration of stock	Higher degeneration of seed stocks from one generation to another due to accumulation of bacteria, fungi, viruses and viroid's.	Degeneration of stock is less as due to less field exposure
Requirement of Land	Require more land due to bulkiness and more spacing in early seed multiplication	Require less land due small and uniform planting material and less spacing in early seed multiplication

Table 1: Continue...

Parameters	Conventional system of seed production	Hi-tech system of seed production
Cost	Usually tubers produced in conventional system are of large size and the whole seed tubers have to be planted for good quality crop. Therefore, the seed cost become high under conventional system due to high labor requirement	Initial establishment cost is very high which can be recovered after 3-4 crop seasons.
Benefit	In India presently 70 % seed production is done through conventional system which meets the seed requirement of the country on yearly basis	Clean seed tubers free from all diseases obtained in very less span of time.

5. Conclusion

High quality seed is of utmost important in potato production for higher yield potential. Basic seed production in India is currently being done by conventional and hi-tech system. A novel technique apical root cuttings (ARC) have the potential to transform potato seed systems through rapid and high rate of multiplication and can be integrated for augmenting seed potato demand in the country.

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