

ROGUING IN SEED POTATO PRODUCTION IN INDIA: PRINCIPLES, PRACTICES AND PROSPECTS

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ABSTRACT: Roguing, the systematic removal of diseased, off-type, and volunteer plants, is a critical component of the Seed Plot Technique (SPT) for maintaining the health and genetic purity of seed potato. Potato is vegetatively propagated, pathogens particularly viruses accumulate rapidly over generations, resulting in seed degeneration and substantial yield losses. Effective roguing reduces primary inoculum sources, restricts secondary virus spread, delays degeneration, and ensures compliance with seed certification standard. Although roguing is labor-intensive and requires skilled personnel, it remains one of the most economical and reliable practices for sustaining seed health under Indian conditions. This review synthesizes principles, timing, operational steps, influencing factors, and precautionary measures associated with roguing in seed potato production. Emphasis is placed on its role within the Indian Seed Plot Technique, challenges arising from changing climate and vector dynamics, and the need for integration with modern diagnostic and digital tools. Strengthening roguing practices through training, supervision, and technology-assisted monitoring will be essential for sustaining seed potato productivity and profitability in India.

KEYWORDS: Seed Potato; Seed Plot Technique; Roguing; Seed Health; Seed Degeneration; Productivity

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the third most important food crop globally after wheat and rice, serving as a crucial source of calories and income for millions of farmers across the world. Its remarkable productivity per unit area and time has made it an indispensable component of food and nutritional security, particularly in developing countries (FAO, 2021). However, unlike most cereals, potato is vegetatively propagated through tubers, which facilitates the perpetuation and accumulation of viruses, viroids, bacteria, fungi and nematodes associated with seed tubers across successive generations. Among these, viruses are particularly important because systemic viral infections are readily

carried over through infected seed tubers and subsequently spread within crops by insect vectors. This progressive build-up of diseases, especially viral infections, results in seed degeneration, ultimately leading to substantial yield and quality losses (Forbes, 2020a; Lacomme *et al.*, 2017). In many developing potato-producing regions of South and Southeast Asia and sub-Saharan Africa, farmers rely substantially on farm-saved, locally exchanged or informally sourced seed, which may vary considerably in physiological and phytosanitary quality. Use of unhealthy seed tubers can result in poor crop establishment, increased disease incidence and substantial yield losses (Buckseth *et al.*, 2024). Because seed is one of the largest inputs in potato cultivation,

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maintaining healthy planting material is important for both crop productivity and farm profitability (Sadawarti *et al.*, 2023). The use of disease-free seed alone can improve productivity by 15-20% under field conditions (Naik and Buckseth, 2018). The degeneration of potato tubers is mainly due to viruses transmitted through seed tubers and insect vectors majorly aphids and white fly. The continuous presence of vectors throughout the growing season, coupled with the emergence of new pathogens like Potato yellow vein virus and Tobacco streak virus, has made disease management increasingly difficult (Lacomme *et al.*, 2017; Singh and Sharma, 2018). In India, this challenge was addressed through the development of the Seed Plot Technique (SPT) by the ICAR-Central Potato Research Institute (ICAR-CPRI), Shimla, in 1965. The SPT exploits the low-aphid period (October-January) in the Indo-Gangetic plains, incorporating timely dehauling, chemical vector control, and roguing to minimize disease spread (Sikka *et al.*, 1978; Sharma *et al.*, 2021). Within the Seed Plot Technique, timely removal of diseased, off-type and volunteer plants from the standing crop is one of the most important and cost-effective roguing practices for maintaining seed health and varietal purity. When executed properly and at the right crop stages, roguing substantially reduces the primary inoculum and restricts the secondary spread of viruses within and between seed generations. It complements chemical vector control and other cultural measures, forming an integral component of the integrated seed health management strategy in potato. However, its success depends heavily on the skill and vigilance of the roguing personnel and the distinct expression of disease symptoms, which can be obscured by mild or latent infections, environmental conditions, and mixed virus complexes (Singh and Sharma, 2018).

In recent years, the efficiency of roguing has been challenged by changing climatic conditions, extended vector activity, overlapping crop cycles, and the emergence of symptomless carriers. These developments have renewed interest in strengthening visual diagnosis with modern diagnostic tools, training programs, and digital phenotyping techniques to enhance accuracy and timeliness. Understanding the biological, operational, and environmental factors influencing roguing efficacy is thus essential for sustaining the health and productivity of India's seed potato system.

ROGUING

Roguing is a vital field operation in seed potato production systems, designed to maintain both genetic purity and phytosanitary quality of the crop. It involves the systematic inspection and removal of diseased, off-type, or volunteer plants from seed potato fields to prevent pathogen spread and ensure that only healthy plants contribute to the next generation of seed tubers (Sadawarti *et al.*, 2023; Forbes, 2020). Since potato (*Solanum tuberosum* L.) is vegetatively propagated, it is particularly prone to the accumulation of pathogens especially viruses over successive generations, resulting in seed degeneration (Lacomme *et al.*, 2017). Roguing interrupts this cycle by eliminating visible sources of infection before viruses can be transmitted to healthy plants.

In most potato-growing regions, particularly in developing countries, farmers depend on farm-saved or informally exchanged seed due to high costs or limited availability of certified seed (NAAS, 2021; Venkataslam *et al.*, 2017). Even when healthy seed is planted, crops remain vulnerable to infection by viruliferous insect vectors such as aphids (*Myzus persicae*), whiteflies (*Bemisia tabaci*), and leafhoppers, which transmit

viruses including Potato virus Y (PVY), Potato leafroll virus (PLRV), and Potato virus X (PVX) during the growing season (Singh and Sharma, 2018). These infections persist in tubers and can cause severe degeneration and yield losses in subsequent generations if infected plants are not promptly removed (Forbes, 2020a). Roguing operations are carried out at multiple crop stages before flowering, during full canopy development, and prior to haulm destruction to eliminate infected or off-type plants before they contaminate the seed lot. Removed plants are destroyed or buried deeply to prevent further infection (Sadawarti *et al.*, 2023).

The success of roguing depends on accurate visual identification of diseased or abnormal plants. Virus-infected plants may show symptoms on different parts of the plant. On leaves, symptoms commonly include mosaic, mottling, chlorotic patches, vein clearing, curling, crinkling and deformation. At the whole-plant level, infected plants may exhibit stunting, reduced vigour, shortened internodes, abnormal architecture and premature senescence. Depending on the virus and cultivar, symptoms may be mild, severe or completely absent (Singh and Sharma, 2018). Symptoms should, however, be interpreted carefully because nutrient deficiencies, herbicide injury, insect damage, drought, frost and other abiotic stresses may produce symptoms resembling viral infection (Fig. 1). However, mild or latent infections, such as those caused by Potato virus S (PVS) or mixed virus complexes, may exhibit subtle or no visible symptoms, complicating visual diagnosis (Lacomme *et al.*, 2017). Therefore, roguing should be conducted when the crop is healthy, weed-free, and actively growing so that symptoms are clearly expressed (Singh *et al.*, 2019).

For effective disease management, roguing should begin early and be repeated at



Fig. 1. Symptomatic potato plants exhibiting different types of foliar abnormalities; (a) herbicide injury characterized by chlorotic streaks and leaf distortion; (b) nutrient deficiency symptoms showing generalized chlorosis; (c) mild mosaic with light green mottling; (d) leaf curling with distortion and reduced leaf expansion; (e) mottling with irregular chlorotic patches; and (f) severe mosaic showing pronounced chlorosis, leaf crinkling, and deformation.

appropriate crop stages, with particular emphasis on completing critical seed-health operations before aphid populations reach damaging levels. Under the Indian Seed Plot Technique, a population of approximately 20 aphids per 100 compound leaves has traditionally been used as a critical level for initiating haulm termination, although vector pressure should be monitored locally because aphid abundance varies with region and season (Sikka *et al.*, 1978). Certain modern diagnostic tools, such as enzyme-linked immunosorbent assay (ELISA), immunostrip-based assays and polymerase chain reaction (PCR), can be used for the detection of virus infections in symptomless or doubtful plants. These tools can complement the traditional roguing system by supporting confirmation of suspected infections and improving the accuracy of seed-health assessment (Forbes, 2020; Singh and Sharma, 2018). Integration of these diagnostic tools with systematic roguing enhances the production of virus-

free, genetically pure seed stocks and sustains long-term productivity of potato seed systems (Naik and Buckseth, 2018).

Importance of Roguing in Healthy Seed Potato Production

The health status of seed potato plants is the cornerstone of a sustainable and productive potato seed system. Since potatoes are propagated vegetatively through tubers, systemic infections particularly those caused by viruses can be perpetuated from one generation to the next (Hooker, 1980; Salazar, 1996). Once infected seed tubers are planted, the resulting plants become primary sources of inoculum, initiating a disease cycle that accelerates the process of seed degeneration (Thomas-Sharma *et al.*, 2016). Degeneration is characterized by a progressive decline in yield and quality due to the accumulation of pathogens over successive generations (Singh *et al.*, 2020). Without proper control, viral and other systemic diseases can spread rapidly within a few seasons through insect vectors, mechanical contact, or volunteer plants, leading to significant economic losses (Radcliffe & Ragsdale, 2002; International Potato Center, 2022). The intensity of roguing is particularly high in early-generation seed stages (e.g., pre-breeder and breeder seed), where maintaining genetic and pathological purity is crucial. However, at the farmer level, roguing is often neglected due to the perceived loss of plant population and consequent yield reduction (Khurana *et al.*, 2005). Therefore, roguing not only maintains genetic and phytosanitary purity but also ensures higher net returns through improved tuber quality and market value.

Role and Training of Roguers

Effective roguing depends largely on the skill, vigilance, and consistency of personnel performing the operation. Roguers (Fig. 2)



Fig. 2. Roguers performing roguing to maintain seed health

must be well trained to accurately recognize disease symptoms, varietal deviations, and abnormal plant growth under field conditions (Hossain *et al.*, 2015). Training programs organized by research institutions and extension agencies, including ICAR-Central Potato Research Institute, are essential for improving disease recognition and operational efficiency. To minimize mechanical transmission of pathogens, roguers should use appropriate protective gear such as smooth rain pants, rubber boots, disposable gloves, and disinfectant sprays for tool sanitation (Food and Agriculture Organization, 2010). Roguing should preferably be conducted under the supervision of an experienced field inspector to ensure uniform standards in seed health management (International Potato Center, 2022).

Identification and Classification of Rogue Plants

Accurate identification of rogue plants requires familiarity with disease symptoms and varietal characteristics (Figure 3). Roguing should be performed when the crop is healthy, well irrigated, and free from stress, as nutrient deficiency or environmental injury can mask disease symptoms (Venkataslam *et al.*, 2017). Morning hours or periods of diffused light



Fig. 3. Classification of Rogue Plants

are preferred, as bright sunlight or dew may obscure mosaic or chlorotic patterns. Diseased plants, mother and daughter tubers along with their stolon's should be completely removed during the tuber initiation stage to prevent further spread (Salazar, 1996). Rogue plants are broadly classified into three categories (FAO, 2010):

1. Volunteer plants arising from tubers left in the soil from previous crops, often emerging earlier than the main crop and acting as primary sources of infection or varietal admixture (Khurana *et al.*, 2005; Thomas-Sharma *et al.*, 2016).
2. Atypical or off-type plants differing in morphology or phenology from the target variety, identifiable by variations in leaf shape, pigmentation, stem color, or flowering, particularly at 45-50 days after planting.
3. Diseased plants exhibiting viral (mosaic, leaf curl, crinkling), bacterial (wilt, blackleg), or fungal (early or late blight) symptoms (Hooker, 1980).

Timing and Frequency of Roguing in Seed Potato Production

Timely and systematic roguing is essential for maintaining seed potato health and varietal purity. Infected plants act as

foci for disease dissemination, particularly for aphid-transmitted viruses spread by *Myzus persicae* and *Aphis gossypii* (Radcliffe & Ragsdale, 2002). Delayed removal of diseased plants, often practiced to avoid yield loss, undermines roguing objectives by allowing secondary spread of infection (Khurana *et al.*, 2005). Field inspection should begin approximately two weeks after crop emergence, when systemic disease symptoms become visible (Salazar, 1996). Roguing must include removal of both above-ground parts and underground seed tubers prevent resprouting from infected tubers (Singh *et al.*, 2019). Disease symptoms are most clearly expressed under moderate light conditions, typically during early morning or late afternoon. Roguing is best conducted between 9:00-11:00 AM or 3:00-5:00 PM, with roguers moving opposite to the sun to enhance symptom visibility (CPRI, 2018).

Under Indian conditions, three rounds of roguing are recommended for seed production (Sadawarti *et al.*, 2023; Singh *et al.*, 2019):

1. First roguing (40-45 days after planting): Removal of visibly diseased, weak, or off-type plants before canopy closure. In hill regions, where crop duration is longer, roguing is typically carried out at 45-50, 70-75, and 85-90 days after planting.
2. Second roguing (55-60 days after planting): Conducted during peak vegetative growth when viral symptoms are most distinct.
3. Third roguing (70-75 days after planting): Performed prior to dehauling to eliminate late-infected plants that may serve as inoculum sources.

Operational Steps in Roguing

Roguing should commence as soon as infected or off-type plants are visible. Suspected plants must be carefully dug out using hand tools to remove the entire plant, including

the mother tuber, stolons, and newly formed tubers, as manual pulling may leave infected tissues in the soil (FAO, 2010; Singh *et al.*, 2019). Rogued plants should be immediately removed from the field and placed in sealed bags to prevent virus acquisition by aphids. Disposal should involve deep burial (~60 cm) or burning at designated sites away from seed plots to eliminate residual inoculum (FAO, 2010; Cortbaoui, 1984). Mechanical transmission is particularly relevant for viruses such as Potato virus X (PVX), Potato virus S (PVS), Potato virus M (PVM) and Potato virus Y (PVY), which can be transmitted through contact with infected plant sap. Mechanical spread may occur through handling, field operations, cutting implements and contact between plants. In contrast, viruses such as Potato leafroll virus (PLRV) are not considered mechanically transmitted and are primarily managed through control of their insect vectors. Therefore, sanitation of hands, tools and equipment is particularly important where mechanically transmissible viruses are present (Sharma *et al.*, 2021).

Factors Affecting the Roguing Process

The effectiveness of roguing is strongly influenced by crop, environmental, and operational conditions, which collectively determine symptom visibility and removal efficiency. Several agronomic and environmental factors influence the accuracy and efficiency of roguing in seed potato fields. Proper management of these factors is essential for effective identification and removal of diseased or off-type plants and for maintaining the genetic and phytosanitary purity of seed crops.

Crop Uniformity: Uniform crop growth facilitates the detection of diseased, off-type and abnormal plants because deviations in plant vigour, colour, architecture and phenology become easier to recognize.

Uniformity begins with the use of healthy and properly graded seed tubers of appropriate physiological age. Good land preparation, uniform planting depth and spacing, proper earthing-up, balanced nutrient management, timely irrigation, effective weed management and appropriate pest and disease control also contribute to uniform crop establishment and growth. Uneven emergence or excessive variation in plant vigour can make visual identification of rogue plants difficult and may result in missed infections (Sharma *et al.*, 2021; Khurana and Pandey, 2008)

Moisture Conditions: Adequate soil moisture enhances symptom expression, making leaf mosaic, curling, or chlorosis more apparent. Excessively dry conditions cause leaves to droop, wilting of the plants, masking characteristic viral symptoms.

Light Conditions: Diffused light, such as during early morning hours or cloudy weather, provides optimal conditions for detecting subtle foliar color variations (FAO, 2010). Direct sunlight creates shadows that may obscure symptoms. Roguers should preferably work with their backs to the sun so that their shadow falls on the plants, improving visual clarity.

Wind: Strong winds cause constant leaf movement, making it difficult to observe mild distortions or discoloration. Roguing should therefore be conducted during calm weather conditions (Sharma *et al.*, 2021).

Dirt, Residues, and Foliage Damage: Soil particles, pesticide residues, or dust on foliage can obscure disease symptoms and lead to misidentification. Roguing should be avoided immediately after spraying or earthing-up until foliage is clean (Khurana and Pandey, 2008). Similarly, mechanical injury, insect feeding, or phytotoxic effects may mimic disease symptoms, requiring trained personnel to distinguish abiotic stress from true infections.

Weed Infestation: Weeds hinder visual inspection and contribute to non-uniform crop growth. They may also serve as alternate hosts for insect vectors, increasing disease risk (Spooner *et al.*, 2014). Timely weeding and judicious herbicide use are therefore essential for accurate roguing.

Collectively, these factors underscore the importance of conducting roguing under optimal field conditions to maximize accuracy and operational efficiency.

Precautionary Measures for Effective Roguing

Effective roguing requires technical expertise, proper timing, and strict adherence to phytosanitary precautions to prevent vector-borne and contact transmission of viral diseases (Sharma *et al.*, 2021).

1. **Skilled and Supervised Roguers:** Roguing should preferably be carried out under the supervision of an experienced seed production supervisor, plant pathologist, seed technologist or other trained technical personnel. In certified seed production, roguing should also be coordinated with the requirements of the designated seed certification authority and field inspection procedures. Roguing should be performed by trained personnel for the proper identification of diseased plants, volunteer plants, varietal off-types and plants showing symptoms caused by abiotic stresses that may resemble viral diseases (FAO, 2010).
2. **Integration with Vector Control:** Roguing should be synchronized with integrated pest management strategies. Insecticides recommended under the Seed Plot Technique should be applied two to three days before roguing to reduce vector activity (Khurana and Pandey, 2008).

3. **Minimizing Contact Transmission:** Roguers should avoid unnecessary contact with healthy plants and perform roguing before canopy closure to reduce mechanical virus spread (Sharma *et al.*, 2021).
4. **Sanitation and Field Operations:** Tools, hands, and footwear should be disinfected regularly. Intercultural operations should be mechanized where possible to reduce physical transmission of pathogens (FAO, 2009).
5. **Safe Disposal of Rogued Plants:** Infected plants and tubers must be removed from the field and destroyed by deep burial or burning to eliminate residual inoculum (Cortbaoui, 1984).
6. **Environmental Considerations:** Moderate soil moisture and calm weather are ideal for roguing. Extreme wetness, drought, or high winds reduce symptom visibility and operational efficiency (FAO, 2009).
7. **Early and Regular Roguing:** Early roguing soon after plant emergence is critical for preventing virus spread. The guiding principle remains: "When in doubt, take it out" (Sharma *et al.*, 2021).
8. **Field Allocation and Accountability:** Assigning specific field sections to individual roguers improves coverage, accountability, and efficiency (Khurana and Pandey, 2008).
9. **Role in Seed Quality Assurance:** Roguing is a cornerstone of the seed plot technique and plays a decisive role in maintaining varietal purity and seed health, ensuring compliance with certification standards and long-term seed system sustainability (Sharma *et al.*, 2021).

For ease of reference and to facilitate comparison across operational stages, the key elements of roguing in seed potato production are presented in Table 1. The table summarizes

Table 1. Roguing in seed potato production under the Seed Plot Technique

Aspects	Description
Purpose of roguing	Removal of diseased, off-type and volunteer plants to maintain genetic purity and phytosanitary quality
Rationale	Vegetative propagation leads to accumulation of systemic pathogens causing seed degeneration
Major target pathogen	Potato viruses (PVY, PLRV, PVX, PVS, PVA, PVM)
Key vectors	Aphids (major vectors); whiteflies and other sucking insects may contribute to virus transmission
Integration with SPT	Combined with low-aphid period cultivation, vector control and dehauling
Stages of roguing (plains)	40-45, 55-60 and 70-75 days after planting
Stages of roguing (hills)	45-50, 70-75 and 85-90 days after planting
Identification criteria	Mosaic, leaf curl, crinkling, chlorosis, stunting, off-type growth
Classification of rogues	Diseased plants, off-types and volunteer plants
Operational steps	Identification → uprooting → removal → destruction
Disposal method	Deep burial (>60 cm) or burning away from seed fields
Factors affecting efficiency	Crop uniformity, moisture, light, wind, weeds, foliage cleanliness
Precautionary measures	Skilled roguers, tool disinfection, synchronization with vector control
Diagnostic support	ELISA, immunostrips and PCR
Impact on seed quality	Reduced virus incidence, delayed degeneration, certification compliance
Future strengthening	Digital detection, mobile advisories, drone monitoring and training
Overall Impact	Healthier seed crop, reduced virus incidence and degeneration, improved crop performance, higher yield potential and better economic returns

the rationale, implementation framework, and expected outcomes of roguing within the Seed Plot Technique, emphasizing its role in controlling virus spread and delaying seed degeneration.

WAY FORWARD

Effective roguing reduces sources of inoculum, limits secondary virus spread, delays seed degeneration and supports compliance with seed certification standards. Although labour-intensive and dependent on skilled field personnel, roguing remains one of the most practical and economical approaches for maintaining seed health under Indian conditions. This review discusses the principles, timing, identification criteria, operational procedures, influencing factors and precautionary measures associated with roguing, with particular emphasis on its integration with the Indian Seed Plot Technique. The review also highlights the

emerging challenges posed by changing vector dynamics and climate variability and the opportunities for strengthening roguing through improved training, vector surveillance, modern diagnostics and digital technologies.

ACKNOWLEDGEMENT

We thank ICAR for financial and infrastructural support.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

ETHICAL STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors

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(MS Received : January 27, 2026; Accepted : September 10, 2026)