

Potato Cyst Nematodes – The Policy Paralysis

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ABSTRACT: PCN was intercepted in north India in the farm area of ICAR-Central Potato Research Institute (CPRI), Himachal Pradesh. CPRI being a nodal institution for the development of potato varieties/hybrids, a lot of germplasm and seed material exchange takes place between the institution and other Central/State Government agencies mandated to work on potato in the country. The basic seed produced at the farms of CPRI is multiplied at different Govt. Potato Seed Multiplication Farms (GPSMFs) of States/UTs, Departments of Agriculture Himachal Pradesh, Uttarakhand, and Jammu & Kashmir for further distribution to farmers in these and other states of the country. Considering the present scenario on the distribution of PCN in the three hilly states/UTs of North India, some general inferences can be drawn. (i) High populations of PCN were recorded at GPSMFs; this may be due to the continuous cropping of potato in these farms. Circumstantial evidence reveals the nematodes must have been introduced long ago, but due to non-specific above-ground symptoms and lack of awareness, they could not be detected earlier. (ii) GPSMFs may be contributing towards the dissemination of PCNs to farmers' fields, but the low populations in PCN-conducive areas could be due to discontinuous cultivation of potato crop. (iii) Populations of PCN at lower altitudes (<2000 m AMSL) may be *G. pallida*, wherever full cysts were encountered. The interception of empty cysts in such locations may be due to unfavourable temperatures for nematode development. The distribution pattern of PCNs in the northern hilly States/UTs in India vis-à-vis south India (the Nilgiris) shows contrasting patterns. While in the Nilgiris, most of the fields are infested, harbouring high cyst populations; the same is not valid in the north where such high populations are witnessed mostly in the GPSMFs. This leads to the assumption that PCN might have been introduced to the northern hilly states from the south much before the domestic quarantine regulations were enforced against them in 1971. However, independent and multiple introductions of seed potato (and PCN) from Europe is not ruled out. More intensive surveys are warranted to map the area for PCN completely. Further, similar geographies in the north-eastern parts of the country have not been surveyed so far for PCN and should be undertaken on priority.

Keywords: Golden nematode, Himachal Pradesh, Jammu & Kashmir, potato, The Nilgiris, Uttarakhand

Potato cyst nematode (PCN) includes two species viz., *Globodera rostochiensis* and *G. pallida*. Since its first interception in India in 1961 by Jones in the Nilgiri hills of Tamil Nadu, a flurry of activity commenced. These activities were governed by similar interceptions in the Europe and USA. The area of infestation was very small (around 4000 ha) and contiguous, therefore, efforts were made to restrict the nematode to this geography through the promulgation of domestic quarantine, besides other measures. However, after a gap of about 50 years, PCN was intercepted in a distant geography; this time in north India. Consequently, a fresh spell of activity is underway to tackle the further spread of this nematode. A debate has been going on since then to understand the

current state of affairs regarding its distribution in India; simultaneously, the development of management strategies is also underway.

This article discusses the global dissemination pattern of PCN, the present scenario in the Nilgiris, and an update on how possibly PCN could have been introduced in the north India hilly states in the backdrop of domestic quarantine regulations.

GLOBAL DISSEMINATION

It is accepted globally that PCN originated in the Andes mountains of south America (Primary distribution center), the home place of its host *i.e.*, potato. During

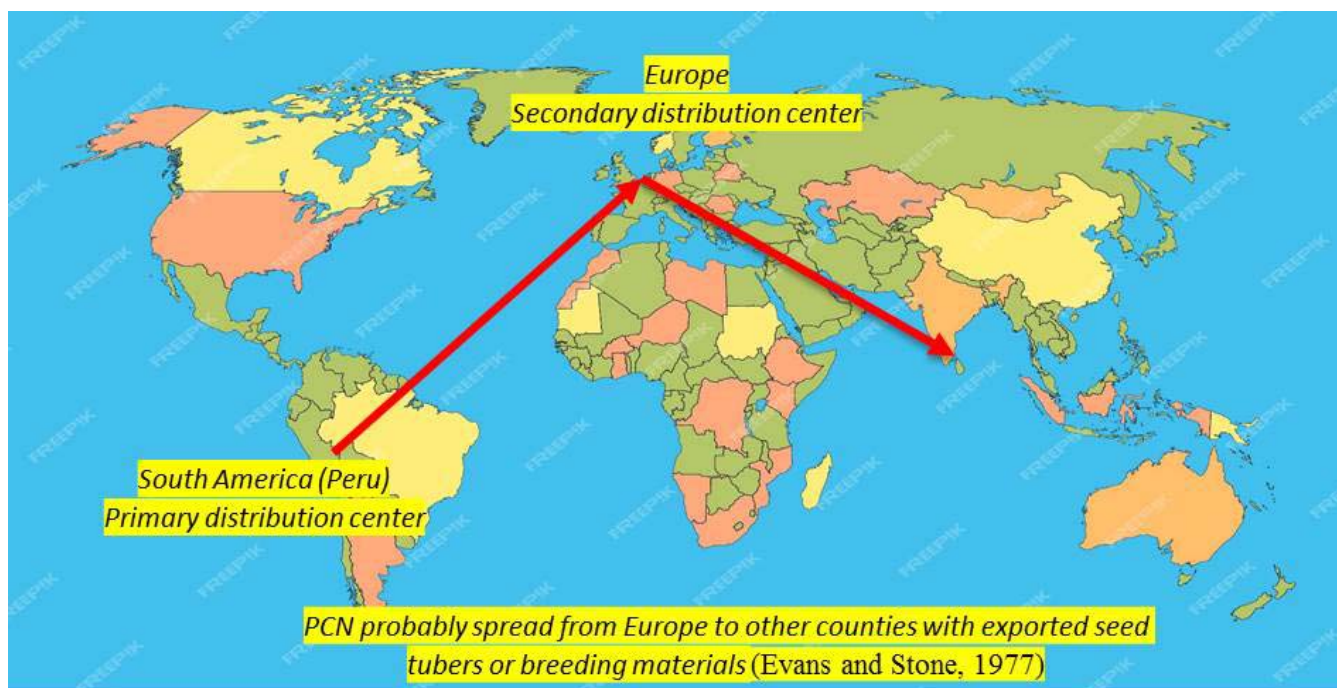


Fig. 1. Global dissemination routes of potato cyst nematode

1850s, PCN is believed to have been introduced into Europe along with the breeding material brought from Peru for developing resistant varieties against the late blight of potato. Europe is considered as the secondary distribution center since potato and PCN found their way to many countries from there, including India (Fig. 1).

INTRODUCTION TO INDIA - SCENARIO IN THE NILGIRIS

PCN was first intercepted in India in 1961 by F.G.W. Jones from Vijayanagaram farm, The Nilgiri hills, Ootacamund (Ooty), Tamil Nadu. It was revealed that PCN was probably introduced from Britain since these fields contained European weeds (Krishna Prasad, 1982). Further surveys in the region earmarked locations (about 4000 ha) within the Nilgiris. Subsequently, PCN was also intercepted in the adjoining Kodaikanal hills of Tamil Nadu, besides adjoining areas of Kerala and Karnataka. During 1964–65, an entire shipment of infected potato seed materials from Scotland and The Netherlands was

destroyed. In October 1968, a Golden Nematode Scheme jointly funded by ICAR and the Govt. of Tamil Nadu was launched. Under the aegis of this project, large-scale inspections of godowns and field-to-field surveys were conducted to earmark the PCN-infested areas.

A massive effort was initiated to restrict/eradicate PCN in the Nilgiris. In 1971, the Destructive Insect Pests Act, 1914 was amended by the Tamil Nadu Govt. Domestic quarantine was imposed in the Nilgiris whereby marketing of seed potatoes out of the Nilgiris was banned. During 1971–75, the Indo-German Nilgiris Development Project was rolled out. The project aimed to eradicate PCN through a massive and heavy chemical treatment that was made mandatory and free under TN Pest Act 1971.

Indo-German Nilgiris development project (1971–75)

Fensulfothion (Dasanit 10G) treatment was made mandatory in the PCN-infested fields under the Tamil

Nadu Pest Act, 1971. Very heavy doses of the nematicide were applied with an aim to eradicate PCN: first year - 30 kg a.i./ha, second year - 15 kg a.i./ha, and third year - 7.5 kg a.i./ha (see Table 1 for more details).

Table 1. Quantities of nematicide used and area treated in the Nilgiris during 1970–75

Year	Area treated (ha)	Dasanit 10G used (kg)
1970–71	1120	3,28,518
1971–72	1400	2,23,639
1972–73	1564	1,99,425
1973–74	1227	1,11,246
1974–75	1874	Figures NA

The other provisions of the project mandated that the produce from the Nilgiris can be used for table purposes only, and cannot be used as seed potato.

There has been a gradual decline in the area under potato in the Nilgiris. From 10,000 ha in 1944–45, it reduced to 7,000 ha in 1985–86, 3,800 ha in 2008–09, and only 1,800 ha in 2014–15. Various reasons have been attributed to this; the main reasons being the late blight of potato and PCN, leading to the replacement of potato areas with tea plantations and carrot mainly.

Species and pathotypes in the Nilgiris

Further studies on the biology and ecology of PCN in the Nilgiris were mainly conducted by the regional stations of the Central Potato Research Institute, and the Tamil Nadu Agricultural University. In the Nilgiris, both species of PCN are prevalent in mixed populations. The current state of knowledge is summarized below.

- ***Globodera rostochiensis***: The yellow-coloured females (*vs* white in *G. pallida*), a prevalence of 43 per cent, preferred altitude is >2100 m AMSL, and three pathotypes (Ro1, Ro2, Ro5) have been recorded out of five.

- ***Globodera pallida***: More prevalent (57%), generally encountered at relatively lower altitudes (1550–2100 m AMSL), three pathotypes (Pa1, Pa2, Pa3) have been identified in the Nilgiris.

Means of spread and crop losses

Soil adhering to harvested tubers, farm implements, labourers' feet, gunny bags *etc.*, seed potatoes, and irrigation water are the major means of dissemination of PCN. Yield loss of up to 15 per cent even without the appearance of above-ground symptoms, and up to 90 per cent in severe infections have been assessed in the Nilgiris.

Current measures to manage PCNs in the Nilgiris

Enforcement of Domestic Quarantine against PCN, crop rotations with non-solanaceous vegetables such as beans/carrots *etc.*, application of carbofuran @ 2 kg a.i./ha in split application, growing resistant varieties (Kufri Swarna, Kufri Neelima, Kufri Sahyadri), and seed treatment with 2% NaOCl for 30 min, are being recommended for the management of PCN in the Nilgiris.

INTERCEPTION IN NORTH INDIA

The occurrence of PCN in the north Indian hilly state of Himachal Pradesh has been suspected since long, and the first authentic report was published by Ganguly *et al.* (2010) when they intercepted PCN from Potato Breeding Farms of Central Potato Research Institute located in Kufri, Shimla District of Himachal Pradesh. The potato fields at Lister House Farm and Main Farms were found to be heavily infested. Since then, AICRP (Nematodes) has been conducting surveys in Himachal Pradesh, Jammu & Kashmir, and Uttarakhand. Some startling facts have emerged from these surveys; the details have been published by Chandel *et al.* (2020). Interestingly, the major hot spots of PCN prevalence were the state-owned Government Potato Seed Multiplication Farms

(GPSMFs). The current status of the distribution of PCN in the three states is presented below.

Current status in Himachal Pradesh

Out of 11 GPSMFs across seven districts, PCN was intercepted in nine. Samples collected from GPSMFs in the Lahaul and Spiti districts were free from PCN (Fig. 2). From the farmers' fields, PCN cysts were found in seven locations, all in the Shimla district. PCNs were prevalent only in locations at elevations more than 1950 m AMSL. PCNs were not recorded from autumn or spring season crops grown in low and mid-hills of the Una (less than 500 m AMSL) district; perhaps PCNs do not establish in these areas due to relatively higher temperatures.



Fig. 2. Distribution of potato cyst nematodes in Himachal Pradesh

Current status in Uttarakhand

Nine districts of Uttarakhand were surveyed to assess the prevalence of PCN. PCN was first reported from the Garhwal region of Uttarakhand viz., Chamoli, Pauri, Uttarkashi and Rudrapur districts. Three GPSMFs viz., Balati Farm, Tiksen Farm (Munshiyari, Pithoragarh) and Koti Farm Auli (Chamoli) were found to be heavily infested with PCN. PCN was not recorded in GPSMFs at Bhattka (Pithoragarh), Patwariya

(Almora), Kund and Dwari (Uttarkashi) and Khateda (Champawat) (Fig. 3). In Pithoragarh district, many farmers' fields also harboured full and empty PCN cysts. Most locations with full cysts were at > 2000 m AMSL, while those below this elevation contained only empty cysts. In Champawat district, no incidence of PCN was recorded and all the sampled locations were below 2000 m AMSL, except one at Devidhura Pati (2045 m AMSL) that contained full cysts. Four farmers' field locations in the Nainital district (all >2000 m AMSL) contained a few full and empty cysts.

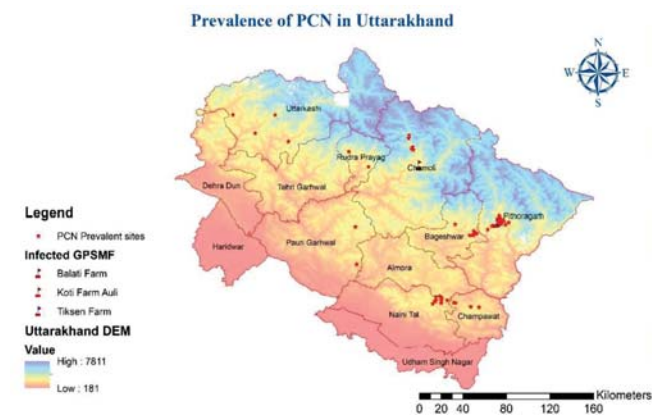


Fig. 3. Distribution of potato cyst nematodes in Uttarakhand

Current status in Jammu & Kashmir

In the Jammu division, a big and old GPSMF at Nathatop (Udhampur district) was heavily infested with PCN (Fig. 4). Another GPSMF located at Kandi Buddhal in Rajouri district of Jammu division also revealed the prevalence of PCNs. The Ishkunda and Narsingha farms at Gool in Ramban district also harboured *Globodera* cysts. Several samples collected from farmers' fields in the Jammu division contained cysts of PCN. In the Kashmir valley, only a limited survey could be conducted. Samples collected from GPSMF at Sedew in Shopian district revealed a 100 per cent frequency of occurrence of PCN. The samples collected from GPSMF and farmers' fields located in Baramulla district from the valley were free from PCNs.



Fig. 4. First interception of PCN in Jammu & Kashmir at Govt. Potato Seed Production Farm at Nathatop

Distribution and dissemination pattern of PCN in north India

Consolidating the information on the distribution of PCN in Himachal Pradesh, Uttarakhand, and Jammu & Kashmir reveals an interesting but worrisome scenario. The main epicentres apparently are Govt. farms, like Central Potato Research Institute, followed by GPSPFs. The consolidated map of the three states (Fig. 5) clearly

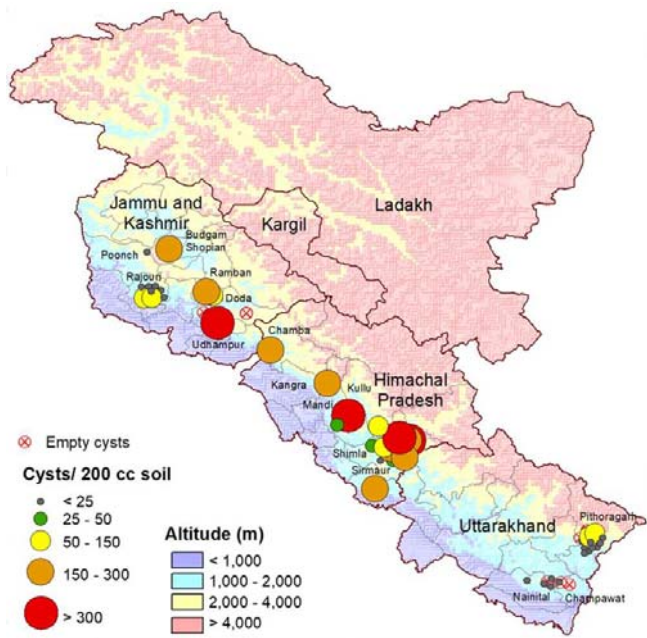


Fig. 5. Distribution of dissemination pattern of PCN in northern hilly states of India

reveals the clusters of high populations (GPSPF) encircled by low population locations (farmers’ fields). Several such clusters highlight the dissemination pattern of PCN (Fig. 6).

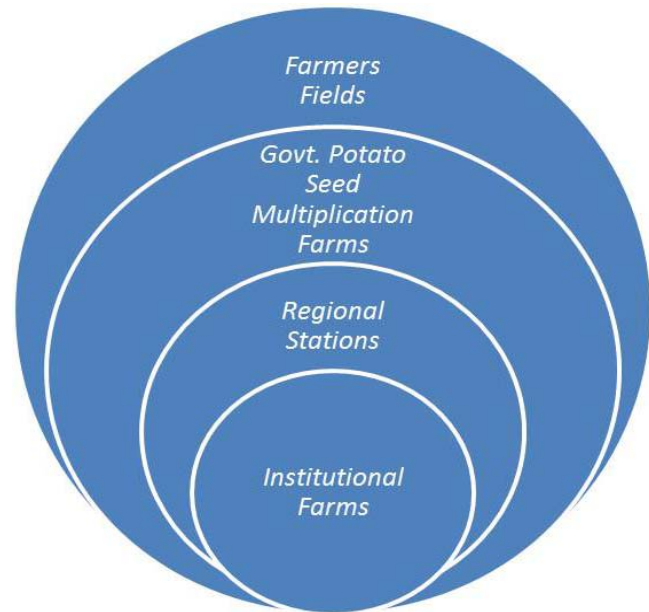


Fig. 6. Dissemination pattern of PCN in northern hilly states of India

To substantiate the dissemination pattern, it is worthwhile to mention here that the ICAR-CPRI has a well-established seed production system in which the institute produces about 3000 tonnes of breeders’ seed annually from about 521 ha farm area distributed over 15 units in the country at regional stations. The breeder’s seed is supplied to the State Department of Agriculture/ Horticulture for further multiplication in three stages as Foundation-I, Foundation-II, and Certified Seed.

The current scenario of PCN distribution in north India is still incomplete and more rigorous surveys are required to understand the situation holistically. There are several high-altitude locations in north eastern states having regional potato research stations that need to be investigated. However, some distinct patterns of PCN distribution have emerged in north and south India that are highlighted in Table 2.

Table 2. Distribution pattern of PCN in North vs South India

North India	South India
The geography of infested area is scattered over three states, the areas of infestation are discontinuous.	The geography of infested area is more or less uniform and clustered.
High populations of PCN are witnessed mostly in the GPSMFs. This may be due to monocropping of the mandated crop (potato).	The area under potato has reduced considerably, due to PCN problem partially, and replaced by other vegetables like carrot.
Incidences in farmers' fields are scanty and with low populations.	In the Nilgiris, most of the farmers' fields are infested harbouring high cyst populations.

Possible origins of PCN in north and south India

It is widely believed that PCN was introduced into India (read south India) from Britain about 200 years ago with contaminated potato seed material. This perception gains weight from the type of weeds prevalent in the area that are akin to the British weeds. The weed seeds also must have been part of the consignment, besides PCN. During British India, a lot of new plant introductions had taken place that included tea plantations, ornamentals, as well as potato, particularly among the hill stations within India. It is logical to believe therefore, that PCN could have been introduced into north India (Himachal Pradesh, Shimla being the summer capital of British) from south (The Nilgiri hills?) much before the domestic quarantine regulations were enforced against them in 1971. Homologies on the identity of populations from the two geographies through molecular tools can throw light on this.

Somvanshi (unpublished, *pers. comm.*) compared the PCN populations from different locations in the three north Indian states using microsatellite tools. They concluded that all the populations from these geographies are homologous, and therefore, might have the same source of origin. The study, however, lacked population from south India, and the question of homologies among north and south India remains elusive.

However, specific mention is being made of an article by Singh *et al.* (2019), “*Seed potato (Solanum*

tuberosum) production systems in India: A chronological outlook”. This article reveals several facts (presented in quotes) that can be correlated with the introduction and dissemination of PCN in India. For example,

- “Potato was introduced in India for the first time in the 17th century by the Portuguese merchants; it was successfully established in gardens of Karnataka and Surat by 1675”.
 - o However, considering the geography of these places, PCN is unlikely to be established even if it were introduced.
- “Potato was introduced in the Shimla hills in 1828, followed by its introduction in the Nilgiri hills in 1830”.
 - o This means both in the north and south India, PCN might have been introduced simultaneously but independently.
- “1935, Potato Breeding Institute in Shimla and two seed creation farms at Bhowali (Kumaon slopes, UP, now Uttarakhand) and Kufri (Shimla Hills) were established as part of Indian Agricultural Research Institute, Delhi”.
 - o PCN might have been introduced in these farms much before these were clubbed.
- “Vasudeva and Azad (1952) surveyed the various diseases affecting potatoes; Potato cyst nematode is

restricted to Nilgiri hills of South India. It was first detected in 1961 at Ootacamund and brisk execution of isolate estimates confined its further spread to other potato developing areas”.

- o Lack of trained nematologist might have eluded PCN during surveys in 1952.
- “In 1946–47, 1072 mounds of seed potatoes of three varieties- Arran Consue, Up-to-date and Kerrs pink were distributed to local farmers”.
- o Another potential introduction of PCN in north India.
- “The three units functioning independently were (i) Potato Breeding Station, Shimla, (ii) Seed Certification Station, Kufri, (iii) Potato Multiplication Station, Bhowali were now converged into CPRI. It has seven research stations situated at Jalandhar (Punjab), Patna (Bihar), Modipuram (Uttar Pradesh), Kufri (Himachal Pradesh), Gwalior (Madhya Pradesh), Shillong (Meghalaya) and Ootacamund (Tamil Nadu). Potato seed creation was confined to high slopes till mid-1960s”.
- o With the integration of three old farms, the exchange of potato germplasm with the research stations must be going on. PCN could be introduced in stations located in plains but could not establish because of unfavourable environmental conditions, whereas it was established in stations at high altitudes.
- “The administration of Himachal Pradesh developed a research scheme for producing disease-free seed tubers. This venture effectively delivered clones of ‘Up-to-Date’ which was imported from Northern Ireland”.
- o Another potential introduction of PCN in north India.

GOVERNMENT INITIATIVES TO CONTAIN PCN

The developments on the interceptions of PCN in the northern hilly states of India led to several measures initiated by the Ministry of Agriculture, Cooperation and Farmers’ Welfare (DAC&FW), Govt. of India, Horticulture Department of the respective states, and Central Potato Research Institute. First and foremost, the provisions of the Domestic quarantine against PCN were extended to Himachal Pradesh, Uttarakhand, and Jammu & Kashmir (besides Tamil Nadu), vide Gazette notification dated October 12, 2018. However, in consideration of the disease-free potato seed production in hydroponic systems in these states and to facilitate their movement to the plains, the ministry revised its previous notification and issued a fresh order dated November 2, 2018, restricting the movement of seed potato from only the districts/farms infested with PCN to the other states. However, in the latest development, the restrictions on the movement of seed potato from these states/districts/farms have been lifted (vide Gazette notification dated March 6, 2024), subject to the fulfilment of certain conditions. The details are reproduced in Fig. 7.

The DAC&FW constituted a committee of experts to suggest measures to contain PCN in northern states. The following recommendations were made by the committee.

Short-term measures

- Measures like fumigation to be taken at Central Potato Research Institute (CPRI) and GPSMFs. In this regard, the CPRI and State Government are to prepare a proposal which, *inter alia*, includes infested regions and their intensity. This proposal needs to be submitted to the Directorate of Plant Protection,

MINISTRY OF AGRICULTURE AND FARMERS WELFARE
(Department Of Agriculture and Farmers Welfare)
NOTIFICATION

New Delhi, the 6th March, 2024

S.O. 1482(E).—In exercise of the powers conferred by section 4A of the Destructive Insects and Pests Act, 1914 (2 of 1914), the Central Government hereby permitting the movement of potato seed tubers with special conditions* with effect from the date of publication of this notification, from the following districts of Uttarakhand, Himachal Pradesh and Jammu & Kashmir to all other states/ UT of India.

S.No.	State/District	Locality	Special Condition*			
Himachal Pradesh						
1.	Shimla	Khadralla	i) Decontamination of cyst-infested potato tubers with sodium hypochlorite (NaOCl) @ 2% for 30 minutes which removes all the cyst from the tuber surface and completely disintegrates them according to the protocol developed by ICAR-CPRI, Shimla. ii) Regular inspection, supervision of treatment and post treatment inspection to ensure the absence of nematodes. iii) Soil sampling and isolation of cyst nematodes for its absence/presence to prevent the entry, establishment, and spread of the Potato Cyst Nematode. iv) Submission of quarterly report to Directorate of Plant Protection, Quarantine and Storage, Faridabad for regular monitoring and assessment of the risk of Potato Cyst Nematode. v). The left over sodium hypochlorite solution should be disposed of scientifically to safeguard the environment and soil micro flora.			
		Umladwar				
		Sarapani				
		Kharapani				
		Tootupani				
		Hanstari Teer				
		Ponidhar				
		Deorighat				
		Kharapathar				
		Central Potato Research Station, Kufri				
		Central Potato Research Station, Fagu				
2.	Sirmour	Kheradhar				
		3.		Mandi	Phuladhar	
					4.	
		5.		Kullu		Chowai
6.	Kangra		Rajunda			
		Uttarakhand				
1.	Pithoragarh	Balati, Munshiyari				
		Tiksain, Munshiyari				
		Govt. Potato Farm, Balati				
		Govt. Potato Farm, Tiksain				
2.	Tehri	Rani Chauri, College of Forestry Farm				
		Horticulture Farm, Dhanaulti				
		Agriculture Farm, Dhanaulti				
3.	Chamoli	Govt. Potato Farm, Ramani				
4.	Almora	Patoria				
5.	Nainital	Malla Ramgarh Farm				
Jammu & Kashmir						
1.	Ramban	Natha top				
2.	Rajauri	Kandi Buddhal				
3.	Shopian	Sedew				
		Govt. Potato Seed Development Farm, Near Village Chhotipora, Sedew, Shopian				
4.	Jammu	Govt. Potato Seed Production Farm, Natha Top, Jammu				
		Potato Seed Development Farm, Kandi Buddhal				

[F. No. 8-144/2018-PP-II]

ASHISH KUMAR SRIVASTAVA, Jt. Secy.

Note : The principal notification was published in the Gazette of India, Extraordinary, Part II Section 3, Sub-section (ii) vide number S.O.5280 dated 12th October, 2018 and was last amended vide number S.O. 5642 dated 2.11.2018

Fig. 7. Gazette notification by Govt. of India regarding withdrawal of restrictions on the movement of potato seed in north India

Quarantine and Storage (DPPQ&S). The DPPQ&S, in turn, to conduct fumigation activities under their supervision in the infested regions. In this regard, the DPPQ&S will nominate a nodal officer and communicate the same to all three states.

- CPRI and GPSMFs to have facilities for washing potato seeds thoroughly to get rid of PCN cysts.
- The State Government is to provide samples to the nearest Nematology unit of the Agricultural University or CPRI for holistic analysis and mapping. In this regard, the AICRP will share standard sampling protocols with all three states.
- With an aim to restrict the movement of potato seeds, the Seeds Division (DAC&FW) issued advisories to all three states, asking them not to disseminate their potato seeds to other states.

Mid-term measures

- CPRI to ensure an adequate quantity of Kufri Swarna seed (PCN-resistant seed) to meet the needs of the states.
- CPRI to impart training to state agriculture functionaries of the three states on PCN and measures to curb it.
- The State Government is to investigate the viability of swapping potato farms with vegetable farms and implement it accordingly.

Long-term measures

- AICRP-N to undertake rigorous mapping of the areas infested with the problem of PCN (including in the northeast).
- Label claims on newly registered nematicide to be generated based on the efficacy studies.

CONCLUSION

The interception of PCN in north India has raised many concerns, particularly the presence of very high populations in the GPSMFs. Unknowingly though, but this chain of dissemination of PCN is apparently very worrisome. This needs to be addressed with all seriousness. While the research organizations have recommended suitable measures, the onus rests with the implementing agencies, *i.e.*, state govt. departments. The latest notification of March 6, 2024, is contrary to the earlier recommendations.

CONFLICT OF INTEREST

The author does not report any conflict of interest.

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