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## Status of potato cyst nematodes, *Globodera* spp infection on potato at Kodaikanal hills of Tamil Nadu, India and yield loss estimation

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### Abstract

A study was conducted to assess the distribution of potato cyst nematodes (PCN), *Globodera rostochiensis* and *Globoera pallida* in potato (*Solanum tuberosum* L) fields of Kodaikanal hills, Tamil Nadu, India during 2014-2015. Soil and root samples were collected from 75 potato fields and examined for cyst infestation in soil or female infection in roots. Vulval cone of cysts were prepared and species was identified using appropriate taxonomic keys. Results showed that 36% of potato fields in Kodaikanal hills were infested with PCN. The mixed populations of *G. rostochiensis* and *G. pallida* was common in all positive fields. Infestation was high (60-90 cysts/ 200 cm<sup>3</sup> soil) at Poomparai and Gundupatti villages followed by moderate (30-60 cysts/200 cm<sup>3</sup> soil) at Poondi, Kookal, Mannavanur and Shenbananur villages. Low density (0-30 cysts/200 cm<sup>3</sup> soil) was observed at Pallangi and Kodaikanal villages. A field study was conducted to estimate the avoidable yield loss due to natural populations of PCN on potato. The 33.0 % tuber yield loss was observed due to natural populations of *G. rostochiensis* and *G. pallida*. Pot experiment was also conducted to confirm the yield loss estimation using challenge inoculated populations of *G. rostochiensis* and *G. pallida*. Results revealed that inoculum level of 10,000 eggs/pot could cause tuber yield loss of 53.4%. It is concluded that PCN control efforts are needed to increase yield and to check further spread in potato fields at Kodaikanal hills.

**Keywords:** Potato, *Globodera rostochiensis*, *Globodera pallida*, Kodaikanal, yield loss

### 1. Introduction

Potato (*Solanum tuberosum* L.) is the world's most important tuber crop that plays important role to meet food requirement of people in many countries. It is also used as an animal feed and to produce commercial starch products. It is cultivated over 25 countries in 19.09 million ha with a total production of 381.68 million tonnes. India is the second largest producer of potato and producing 46.4 million tonnes by cultivating in an area of 20.24 million ha [1-2]. Major constraints in potato production are insects, nematodes, fungus and other pathogens which accounts for nearly 37% yield loss throughout the world, of which nematodes alone contribute 23% share [3-4]. Primarily, the potato cyst nematodes (PCN) are important among 90 parasitic nematodes associated with the potato rhizosphere in India [5]. They are sedentary root endoparasites and feed on stele cells by forming typical multinucleate syncytia. It leads to stunted growth, early senescence, proliferation of lateral roots and partial or complete arrest of tuber formation [6-7]. After feeding, they rupture the root and protrude outside. Then they reproduce and deposit eggs inside body. The females having eggs become cyst after dead. The cysts can remain viable more than 10 years in absence of host plant. The golden cyst nematode, *Globodera rostochiensis* (Wollenweber) Behrens is relatively wide spread while white potato cyst nematode, *Globodera pallida* (Stone) Behrens is less prevalent. In India, PCNs are first reported during 1961 from Nilgiris and Kodaikanal hills of Tamil Nadu [8-9]. Since the seed tubers are the primary mode of spread for PCN, domestic quarantine was enforced in India to avoid the spread of PCN from Tamil Nadu. Nevertheless, PCN is later reported from Karnataka, Kerala and Himachal Pradesh [10-12]. PCN was found to occur in entire potato fields at Nilgiris hills, but most prevalent in six major potato growing localities of Nilgiri hills i.e. Adigaratty, Fern Hill, Kallahatty Nanjanad, Thummanahatty and Vijayanagaram [13-14]. However, there is no systematic information on the incidence of PCN and their yield loss potential in Kodaikanal hill regions. Hence, this study was conducted with the following objectives viz., 1) To study the distribution and intensity of PCN in potato at Kodaikanal hills, and 2) To estimate the avoidable yield loss due to challenge inoculated and natural populations of PCN in potato under pot and field conditions.

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## 2. Materials and methods

### 2.1 Field survey

A survey was undertaken during 2014-2015 in potato fields at Kodaikanal hills of Tamil Nadu. Seventy-five fields were selected randomly from Shenbananur, Kodaikanal, Kookal, Gundupatti, Poomparai, Mannavanur, Poondi and Pallangi villages of Kodaikanal hills. Five plants from each field were uprooted, observed for the presence of golden or white colour adult females and counted per 2.5 cm root length. Soil samples collected from the same five plants were pooled to form a composite sample (2 kg). From the composite sample a sub-sample of 200 cm<sup>3</sup> was used for cyst extraction. Soil samples were dried and processed by Fenwick's floatation method [15]. The 60 mesh (250 µm) sieve used to collect the residue from Fenwick apparatus and residue were passed through filter paper fitted over a funnel. Then filter papers were dried and number of cysts were counted under a stereoscope microscope at 40x magnification. Ten cysts were randomly picked from each sample and vulvul cone were prepared on slides using glycerine jelly as mounting agent [16]. Species identity confirmed based on the morphometry (Cyst length (L) and width(W), L/W ratio, neck, cone, vulval slit and fenestra length, width of fenestra) using a Kozo Zoom 630 microscope equipped with Biowizard image analysis software [17].

### 2.2 Yield loss field study

A field trial was conducted to estimate the avoidable yield loss due to PCN in potato at Horticultural Research Station, Kodaikanal during the Kharif season 2014 (July 2014-September 2014). The field was naturally infested with mixed populations of *G. rostochiensis* and *G. pallida*. The potato cv. Kufri Jothi seed tubers were used for field trial. The experiment was laid out in paired *t*-test design with twelve replications. The treatments consisted of carbofuran 3 G @ 2 kg a.i./ha and untreated control. The individual plot size was 3 x 5 m<sup>2</sup>. Each plot was separated by raised bunds leaving 0.5 m space between each bund. Carbofuran was mixed with sand and applied in the soil before sowing. Seeds were sown at 60 x 30 cm spacing. Standard agronomic practices for potato cultivation were followed for raising the crop [18].

The population density of cyst in soil from each plot was determined before sowing and harvest. Each sample comprising of 10 random cores collected at a depth of 15-20 cm and pooled together into a composite sample. A sub-sample of 200 cm<sup>3</sup> from each composite sample was processed by Fenwick's floatation method [15]. The population of PCN cysts was counted under a stereoscope microscope at 40x magnification. Plant height was measured at 90 DAP from five plants per plot in a 'X' pattern. Plants were harvested in 120 days after sowing and tuber yield recorded from all plots. Yield was expressed in tonne (t) per ha. Five plants from each plot were collected and observations on number of tubers/plant was recorded. Also female population number per 2.5 cm root length was recorded using a stereo zoom microscope [19].

### 2.3 Yield loss pot study

A pot study was conducted to estimate the avoidable yield loss due to PCN in potato at Horticultural Research Station, Kodaikanal during June 2015- August 2016 under artificial inoculated conditions. The mixed population of *G. rostochiensis* and *G. pallida* cysts used in this study were isolated from potato plants collected at Shenbaganur village and pure cultures were maintained on potato cv. Kufri Jothi

[20]. The cysts were extracted from soils of pure culture first by Cobb's sieving and decanting method [21]. The residue containing cysts collected from the 60 mesh (250 µm) was crushed by a mechanical cyst crusher to release eggs and the macerated suspension was poured through 625 mesh (20 µm). Then the residue collected was processed by centrifugal floatation technique to separate eggs [22]. Eggs were counted by viewing under a stereo zoom microscope (Kozo Zoom 645) at a magnification of 40x and used as inoculum for pot study. The treatments consisted of carbofuran 3 G @ 2 kg a.i./ha and untreated control replicated twelve times. Five kg soil capacity clay pots containing autoclaved pot mixture soil (sand: red earth: farmyard manure – 2:1:1) considered as one replicate. Carbofuran treatment was done before sowing. The one seed tuber of potato cv. Kufri Jothi was sown in each pot. Then mixed eggs of *G. rostochiensis* and *G. pallida* @ 10,000/pot was inoculated in all pots. The plants were maintained in glass house and irrigated once in a day. Plants were fertilized with 20-20-20 (N-P-K) fertilizer at 0.1 % concentration at twenty days intervals. No pest or disease was recorded during the study. The plants were carefully uprooted at 110 days after inoculation. Soil of 200 cm<sup>3</sup> was taken and used for cyst estimation. The cyst extracted and counted as described earlier. The females per 2.5 cm were counted as explained earlier.

The data collected from both yield loss studies were analyzed and compared by *t*-test following Panse and Sukhatme [23].

## 3. Results and discussion

### 3.1 Field survey

Among 75 potato fields surveyed, about 36 % of potato fields in Kodaikanal hills were infected with PCN. In all the fields, mixed population of *G. rostochiensis* and *G. pallida* were observed. The PCN was found in all the villages surveyed at Kodaikanal (Table 1). The incidence rate was 60% in Gundupati and Poomparai villages and 50% in poondi. In other villages occurrence ranges from 20-40%. The PCN population density varied from 0 to 130 cysts/ 200 cm<sup>3</sup> soil with an average of 38.9. The mean population density was high (60-90 cysts/200 cm<sup>3</sup> soil) at Poomparai and Gundupatti followed by moderate (30-60 cysts/200 cm<sup>3</sup> soil) at Poondi, Kookal, Mannavanur and Shenbananur villages. The population density was low (0-30 cysts/200 cm<sup>3</sup> soil) at Pallangi and Kodaikanal (Fig. 1). The lowest (2.3) number of females/ 2.5 cm length root was observed at Pallangi and the highest (7.5) at Poomparai. Jones (1961) first reported *G. rostochiensis* from Nilgiris and Kodaikanal hills [8]. Later, Prasad (1996) showed that *G. rostochiensis* and *G. pallida* occurred as mixed population in almost all potato-growing areas at Nilgiris hills [13]. This is the first detailed report of PCN incidence and their intensity status of potato fields in Kodaikanal hills. Our results i.e existence of mixed populations of *G. rostochiensis* and *G. pallida* in all surveyed places is similar to the findings of Prasad (1996) who reported the same trend in Nilgiris potato fields too [13].

### 3.2 Yield loss field study

Results of field study showed that carbofuran application significantly reduced cyst population in soil and PCN infection on roots at harvest compared to the un-treated control (Table 2). Carbofuran 3G treatment resulted in a reduction of cyst density by 87.3 % in soil and female populations by 87.7 % in roots. The carbofuran treated plants were 37.1 taller than untreated plants. The number of tubers was also significantly more (19.3) in carbofuran treatment

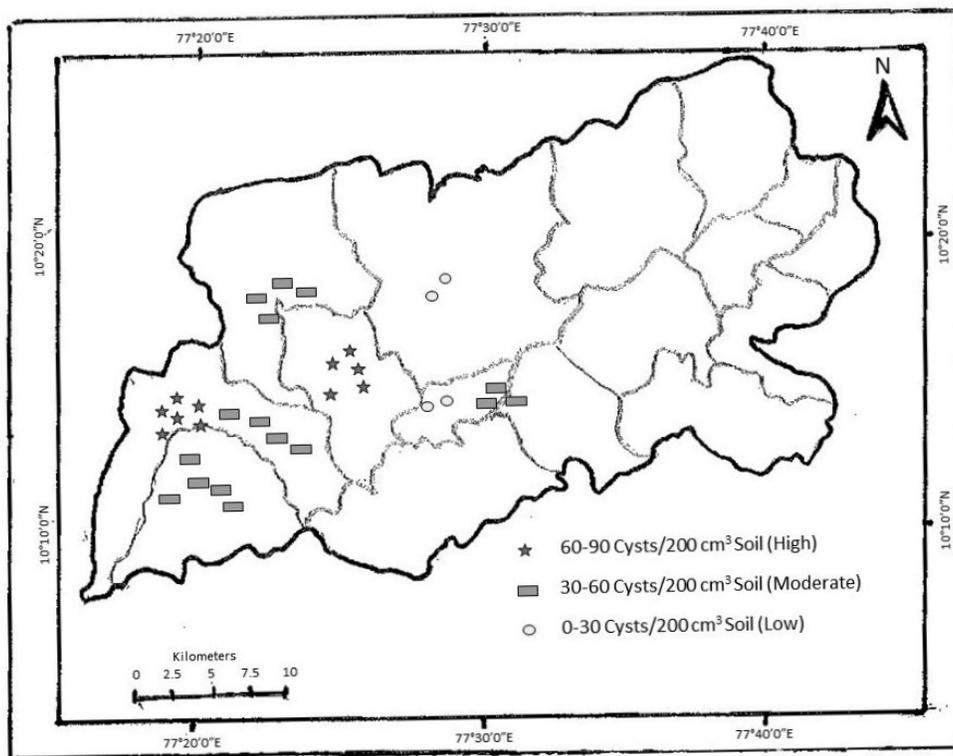
than un-treated control (10.1). The plots treated with carbofuran before sowing had a significant increased tuber yield when compared to the control. The yield loss due to PCN on potato estimated in the present study was 33.0 % tuber yield per ha. In Europe and North America, the yield loss due to PCN was reported as 9-100% [24, 25]. In India, up to 80% yield loss due to PCN was reported from Nilgiris hills, Tamil Nadu [26]. Yield loss reported in this study falls within the range of earlier reports. Trudgill (1986) proved that PCN decreases potato yield by reducing the effectiveness of root system which affect the leaf area duration, the amount of light intercepted by the plant canopy and efficiency of photosynthesis assimilation [27]. Elston *et al.* (1991) evidenced that the degree of yield loss due to PCN on potato varies primarily with initial nematod density, but also vary due to the secondary factors such as soil type, nutrient status and other cultivation practices [28]. Hence it is evident that population density of cyst and other environment factors prevail at Kodaikanal conditions are responsible for a 33.0 % yield loss in potato.

**3.3 Yield loss pot study**

The results of pot study were similar to field study. However, the extent of damage and yield loss was relatively higher in

pot studies (Table 3). Carbofuran 3G treatment resulted in a reduction of PCN Populations by 91.0 % in soil and 84.6 % in roots. The carbofuran treated plants were 43.2% taller than untreated plants. The number of tubers was also significantly more (7.3) in carbofuran treatment than un-treated control (3.1). The plants treated with carbofuran before sowing had significant increased root tuber yield when compared to the control. The yield loss due to challenge inoculated populations of PCN was estimated as 53.4% tuber yield per plant. Similar results was also reported by Brown and Sykes (1983) who observed more than 50% of yield loss on potato under artificial inoculated conditions in pot study [29]. The findings of Norshie *et al.* (2016) also in line with our results [30].

In conclusion, the potato cyst nematodes, *G. rostochiensis* and *G. pallida* occurred at moderate to high densities in many potato-growing villages of Kodaikanal hill regions. They can cause 33.0-53.4% loss in tubers that may pose serious threat to potato cultivation. Hence, there is an urgent need to formulate strategies not only for the management but also to check further spread of PCN in potato fields in Kodaikanal hills.



**Fig 1:** Distribution pattern of potato cyst nematodes in potato fields at Kodaikanal hill of Tamil Nadu

**Table 1:** Occurrence, intensity and infection of potato cyst nematodes on potato in different potato growing villages of Kodaikanal hills in Tamil Nadu

| Name of Place | No of fields surveyed | Percent Occurrence | Cyst/ 200 cm <sup>3</sup> soil |      | Number of females/2.5 cm root |      |
|---------------|-----------------------|--------------------|--------------------------------|------|-------------------------------|------|
|               |                       |                    | Range                          | Mean | Range                         | Mean |
| Shenbananur   | 10                    | 30.0               | 0-65                           | 38.3 | 0-7                           | 2.7  |
| Kodaikanal    | 10                    | 20.0               | 0-34                           | 26.7 | 0-6                           | 2.3  |
| Kookal        | 5                     | 40.0               | 0-72                           | 48.1 | 0-8                           | 5.0  |
| Gundupatti    | 10                    | 60.0               | 0-124                          | 76.0 | 0-13                          | 7.4  |
| Poomparai     | 10                    | 60.0               | 0-130                          | 84.6 | 0-14                          | 7.5  |
| Mannavanur    | 10                    | 40.0               | 0-86                           | 44.7 | 0-8                           | 5.5  |
| Poondi        | 10                    | 50.0               | 0-92                           | 58.3 | 0-9                           | 6.1  |
| Pallangi      | 10                    | 20.0               | 0-48                           | 28.4 | 0-5                           | 2.3  |

**Table 2:** Avoidable yield loss in potato cv. Kufri Jothi due to natural populations of potato cyst nematodes under field conditions

| Treatments                   | Initial cyst population in 200 cm <sup>3</sup> soil* | Final cyst population in 200 cm <sup>3</sup> soil* | Number of females/2.5 cm root* | Plant height (cm) | Number of tubers/plant | Tuber yield (t/ha) |
|------------------------------|--|--|--------------------------------|-------------------|------------------------|--------------------|
| Carbofuran 3 G @ 2 kg a.i/ha | 85.3   | 36.3 (87.3)  | 2.0 (87.7)                     | 67.3 (37.1)       | 19.3 (47.6)            | 20.31 (33.0)       |
| Untreated control            | 86.1   | 286.3  | 16.3                           | 42.3              | 10.1                   | 13.6               |
| t-value                      | 1.3  | 7.41**   | 8.08**                         | 9.21**            | 7.48**                 | 12.36**            |
| S.Ed                         | NS   | 36.1   | 1.2                            | 1.8               | 1.5                    | 1.81               |
| CD (5%)                      | NS   | 72.3   | 2.6                            | 3.8               | 2.8                    | 3.91               |

\*Mixed population of *Globodera rostochiensis* and *Globodera pallida*; \*\* - Highly significant (P=0.001); NS - Non-significant; Figures in the parenthesis are percent decrease or increase over untreated control.

**Table 3:** Avoidable yield loss in potato cv. Kufri Jothi due to artificial inoculated populations of potato cyst nematodes under pot condition

| Treatments                   | Final cyst population in 200 cm <sup>3</sup> soil | Number of females/2.5 cm root | Plant height (cm) | Number of tubers/plant | Tuber yield (g/pot) |
|------------------------------|---|-------------------------------|-------------------|------------------------|---------------------|
| Carbofuran 3 G @ 2 kg a.i/ha | 32.3 (91.0)                                       | 4.3 (84.6)                    | 69.1 (43.2)       | 7.3 (57.5)             | 606.5 (53.4)        |
| Untreated control            | 362.3   | 28.1                          | 31.2              | 3.1                    | 282.6               |
| t-value                      | 8.6**   | 9.3**                         | 10.4**            | 8.2**                  | 10.8**              |
| S.Ed                         | 20.6  | 1.3                           | 1.9               | 0.7                    | 15.1                |
| CD (5%)                      | 41.3  | 2.8                           | 4.2               | 1.2                    | 28.4                |

\*Mixed population of *Globodera rostochiensis* and *Globodera pallida*; \*\* - Highly significant (P=0.001); Figures in the parenthesis are percent decrease or increase over untreated control.

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