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Pest Risk Assessment Studies on Potato Cyst Nematode, *Globodera rostochiensis* under North India Conditions

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ABSTRACT: Studies on potato cyst nematode, *Globodera rostochiensis* were conducted at two locations to ascertain, (i) the chances of its establishment post introduction at relatively lower altitudes (lower than 2000 m AMSL) and (ii) number of generations under north Indian conditions. The first experiment involved pot culture studies using artificially inoculated/naturally infested soil. The nematode did not develop on potato cv. Kufri Jyoti at lower altitude (1290 m AMSL) location of Palampur, Himachal Pradesh. The second experiment was conducted in naturally-infested field site at Nathatop, Jammu & Kashmir (2558 m AMSL). The nematode development was traced *in situ* through periodic observations on its life cycle stages. *G. rostochiensis* completed one generation (juvenile penetration to cyst containing eggs) in 40 days on potato cv. Kufri Girdhari (mean air temperature 11.88-14.7°C). The study signifies that nematode dissemination through seed material at locations below 2000 m AMSL may not be conducive for the establishment of *G. rostochiensis*.

Keywords: *Globodera rostochiensis*, Himachal Pradesh, Jammu & Kashmir, potato, potato cyst nematode.

INTRODUCTION

The potato cyst nematodes (PCN) (*Globodera rostochiensis* and *G. pallida*) are internationally quarantined nematode pests and cause losses up to 30 per cent in potato crop yield (Oerke *et al*., 1994). Under Indian conditions, the tuber yield loss estimates vary from 5 to 80 per cent (Krishna Prasad, 1996) in The Nilgiris (Tamil Nadu), PCN are considered for loss assessment of Rs. 127.04 million annually (Kumar, *et al*., 2020).

In India, PCN were known to be restricted in about 4000 ha of The Nilgiri, Palani and Kodaikanal hills in Tamil Nadu with some adjoining areas of Kerala and Karnataka (Krishna Prasad; 1996) till recently. Since the first report of PCN in north India (Himachal Pradesh) (Ganguly, *et al*., 2010), surveys conducted under the aegis of ICAR-All India Coordinated Research Project on Nematodes revealed the occurrence of PCN not only from several districts of Himachal Pradesh, but Uttarakhand and Jammu & Kashmir as well (Chandel *et al*., 2020). Government Potato Seed Multiplication Farms (PSMFs) in these states have been identified as hot spots of PCN that also serve as epicenters of nematode dissemination to the nearby farmers' fields (Chandel *et al*., 2020).

The seed potato is usually contaminated with soil clods harbouring viable cysts of PCN that are disseminated mainly through PSMFs/other organizations to various places located at different altitudes. It was interesting to observe from the survey data of these three states in north India that viable cysts of PCN usually were not recorded below 2000 m AMSL; empty cysts recorded in such locations *albeit* are indicative of introductions (Chandel *et al*., 2020). PCN is known to complete only one generation in The Nilgiris (Tamil Nadu), whereas at lower altitudes, *G. pallida* is the predominant species that may complete even two generations (Krishna Prasad, 1992). The objectives of this study were (i) to assess the potential of PCN for establishment post introduction to new locations lower than 2000 m AMSL; and (ii) number of generations and life cycle development of PCN in pest risk analysis areas under north Indian conditions.

MATERIAL AND METHODS

The studies were carried out at two locations; (i) Palampur, Himachal Pradesh to assess the chances of establishment of PCN at lower altitude post-introduction, and (ii) naturally infested field at PSMF,

Department of Agriculture, Nathatop/Sanasar Union Territory of J&K, to generate information on the life cycle development and number of generations by PCN.

Experimental site I: Department of Entomology at CSK Himachal Pradesh Agricultural University, Palampur (N32.11, E76.23, altitude 1290 m AMSL).

In one set of pots, PCN-infested soil (predominantly *G. rostochiensis*) collected from seven locations (PSMFs) of Himachal Pradesh, was mixed thoroughly and filled in 2 kg capacity pots. In the second set of pots, steam-sterilized field soil was filled. In both the sets, potato tubers (cv. Kufri Jyoti) were sown in December (2016), March (2017) and September (2017) coinciding with the sowing periods of three crop seasons i.e., spring, summer and winter in Himachal Pradesh. In the second set, eggs and second-stage juveniles (J2) suspension of *G. rostochiensis* obtained by rupturing five cysts of PCN was inoculated in the rhizosphere of each plant seven days after sprouting. In both the sets, after 45 days of germination/sprouting, the roots were removed, washed and stained with 0.1% acid fuchsin (McBeth *et al*., 1941) and examined microscopically for the presence of nematode life stages. Besides, 100 cc of soil from each pot was processed by wet screening for the presence of cysts, if any.

Experimental site II: This field location (N33.094016, E75.265194, Altitude: 2558 m AMSL) at Nathatop (Jammu & Kashmir) was infested with *G. rostochiensis* having initial population of 333 cysts per 200 cc soil (278.7 eggs and J2 per cyst). The field was prepared as per normal agronomic practices. Approximately 100 potato seed tubers of cv. Kufri Girdhari were sown in the ridges. Three plants were removed randomly every 10^{th} day from the date of sowing till harvest of the crop (crop duration April 28, 2018 to September 9, 2018). The potato roots from experimental site were chopped into small pieces of approximately 1 cm in length, stained (McBeth *et al*., 1941) and examined microscopically to categorize them as J2, J3, J4, adult female/male, cysts etc. The time taken from penetration of J2 to appearance of cysts on roots with eggs was counted as the duration for one generation.

RESULT

Experimental I: No developmental stages of PCN were observed in both the sets of pots and in any of the seasons, i.e., spring, summer and winter. No cysts of PCN were recovered in the pot soil at the end of the experiment. It is, therefore, inferred that PCN does not develop under Palampur conditions.

Temperature is an important factor in the hatching of PCN eggs; the optimum hatching temperature in the field is 13.4° C (Table 1.), substantial emergence can be observed at 10°C (Franco *et al*., 1998) but hatching stops at >25° C (Kaczmarek *et al*., 2014). At Palampur, the weekly mean maximum, minimum and soil temperatures ranged between 11.63-21.07, 1.71-9.39 and 7.89-15.03ºC, respectively during spring crop (January-March). During summer crop (March-June), the respective temperatures ranged between 24.43-31.79, 11.71-19.11 and 21.36-27.32ºC; while for winter crop these ranged between 23.00-28.25, 8.91-17.29, and 18.08-26.12ºC, respectively. It is obvious that the temperature regimes prevalent at Palampur were not favourable for most part in all the three seasons for nematode hatching and development.

Table 1: Weekly mean temperature (°C) data during the study period at Palampur, Himachal Pradesh.

Period	Max.	Min.	Soil*	Period	Max.	Min.	Soil*	Period	Max.	Min.	Soil*
Spring crop				***Kharif* crop**				**Winter crop**			
Jan 01-Jan 07, 2017	17.34	6.20	10.53	Mar 25-Mar 31,2017	24.43	14.39	24.11	Sep 01-Sep 07, 2017	25.86	17.29	22.82
Jan 08-Jan 14, 2017	11.63	1.71	07.89	Apr 01-Apr 07, 2017	25.57	13.96	22.57	Sep 08-Sep 14, 2017	26.86	17.24	24.96
Jan 15-Jan 21, 2017	17.12	5.02	10.83	Apr 08-Apr 14,2017	25.42	11.71	21.36	Sep 15-Sep 21, 2017	28.25	15.00	26.12
Jan 22-Jan 28, 2017	16.24	7.38	10.14	Apr 15-Apr 21,2017	27.00	19.11	27.32	Sep 22-Sep 28, 2017	25.81	16.46	24.10
Jan 29-Feb 04, 2017	17.52	6.87	11.89	Apr 22-Apr 28,2017	28.30	12.93	25.34	Sep 29-Oct 05, 2017	27.00	15.56	24.20
Feb 05-Feb 11, 2017	17.10	6.31	12.11	Apr 29-May 05,2017	27.99	15.50	24.36	Oct 06-Oct 12, 2017	27.79	14.81	22.61
Feb 12-Feb 18, 2017	21.07	9.39	14.53	May 06-May 12,2017	31.79	18.07	26.86	Oct 13-Oct 19, 2017	27.41	13.28	22.56
Feb 19-Feb 25, 2017	19.13	7.29	13.96	May 13-May 19,2017	30.57	18.12	25.75	Oct 20-Oct 26, 2017	26.50	12.14	21.89
Feb 26-Mar 04, 2017	20.29	7.36	15.03	May 20-May 26,2017	30.29	17.78	25.22	Oct 27-Nov 02, 2017	23.00	10.60	20.54
Mar 05-Mar 11,2017	16.86	6.29	08.64	May 27-Jun 02,2017	28.90	16.36	24.43	Nov 03-Nov 09, 2017	23.53	08.91	18.08

Max = Maximum, Min = Minimum, *Mean data of morning and evening

Experimental site II: The J2 penetration in the growing tips of potato roots were recorded 20 days after planting when the average air temperature was 11.9° C (Table 2.). The J3 were found in the roots on 30th day of plant growth and after 10th day of J2 root penetration. On 40th day of plant growth and after 20th day of J2 root penetration, the J4 stage was observed. Young adult females and adult males in roots were recorded on 50th day of plant growth and 30th day after J2 root penetration. The highest population of young females was recorded after 30th day of J2 penetration (17th June) inside the roots. Adult females (white/yellow cysts) containing eggs were observed outside roots after 60 days of planting (27th June) and 40 days after J2 root penetration.

Table 2: Weekly mean temperature (°C) at Nathatop, Jammu & Kashmir.

Period	Maximum	Minimum
Apr 25-May 01, 2018	18.66	06.83
May 02-May 08, 2018	14.40	04.26
May 09-May 15, 2018	15.20	05.60
May 16-May 22, 2018	16.43	07.14
May 23-May 29, 2018	19.66	09.54
May 30-Jun 05, 2018	21.14	06.60
Jun 06-Jun 12, 2018	19.94	10.69
Jun 13-Jun 19, 2018	20.17	09.74
Jun 20-Jun 26, 2018	19.20	10.97
Jun 27-Jul 03, 2018	18.82	08.61
Jul 04-Jul 10, 2018	17.63	10.71
Jul 11-Jul 17, 2018	18.51	11.80
Jul 18-Jul 24, 2018	18.20	12.03
Jul 25-Jul 31, 2018	17.97	12.06
Aug 01-Aug 07, 2018	17.43	11.74
Aug 08-Aug 14, 2018	17.03	11.57
Aug 15-Aug 21, 2018	18.29	12.37
Aug 22-Aug 28, 2018	18.34	11.71
Aug 29-Sep 04, 2018	18.60	11.17
Sep 05-Sep 09, 2018	18.44	10.83

G. rostochiensis produced one generation during potato crop under the temperate climatic conditions of Nathatop (Jammu & Kashmir) on potato cv. Kufri Girdhari, at an average atmospheric temperature of 11.8-14.7°C. The life cycle was completed in 40 days (J2 penetration to the cysts containing eggs).

DISCUSSION

Experiment I: It has been hypothesized that PCN might have spread to north India from southern parts despite domestic quarantine regulations (Chandel *et al*., 2020). Further, within north India, government institutions/farms mandated for developing and testing potato crop germplasm, might have aided in the dissemination of PCN to different locations. The present studies clearly reveal that despite introduction, PCN is not likely to develop and establish in such locations that are below 2000 m AMSL (lower altitudes and plains). However, PCN is able to establish in the adjoining hilly areas of Jammu & Kashmir and Uttarakhand that are above 2000 m AMSL.

Experiment II: PCN hatching is strongly influenced by potato root diffusates (PRD) that attain peak activity when the potato crop is three weeks old (Rawsthorne and Brodie,1986). In the present study, the peak activity of PRD coincided with the penetration of J2 i.e., 20 days after germination of the potato crop.

G. rostochiensis has been reported to complete one generation only from across the world (Walia and Bajaj, 2014). In some conditions, however, a partial or complete second generation has also been observed within the growing season (Greco *et al*., 1988; Perez *et al*., 2009).

Under lab conditions at Ootacamund, The Nilgiris (Tamil Nadu, India), the J2 took 37-39 days during summer crop (April to July) and 40-42 days during autumn crop (September to December) to become cysts. Generally, one generation is completed in one crop season but there are evidences of second generation of *G. rostochiensis* being completed as it has a shorter dormancy period of 45-60 days (Krishna Prasad, 1992).

It is concluded from Experiment 1 and Experiment 2 that (i) despite dissemination through seed potatoes PCN is not likely to establish in new locations below 2000 m AMSL, and (ii) *G. rostochiensis* completes only one generation at Nathatop conditions in Jammu & Kashmir. Our results will provide insights into developing future management strategies.

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Conflict of Interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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