Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(5): 224-227

Received: 13-07-2021
Accepted: 15-08-2021

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Effect of carbofuran on population dynamics of nematodes associated to pea crop in North-Western Himalaya

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Abstract
Plant-parasitic nematodes (PPNs) are diverse and pose serious threat to the yield of various crops. Management practices for PPNs in field conditions largely rely on soil application of carbofuran. Carbofuran applied as prophylactic measure at the sowing time provides immediate solution to reduce the population density of nematodes however change in population density of nematodes after application of carbofuran over the crop cycle of pea crop is not known. A survey for community analysis conducted in year 2018-19 in pea crop at Hawalbagh research farm, ICAR-VPKAS, Almora, located in North Western Himalayan region in which genera *Pratylenchus* identified as most prominent group among different PPNs affecting pea crop. In order to manage the PPNs, carbofuran were applied with the dosage of 1 kg *a.i.*/ha at the time of sowing. Subsequently PPNs density was recorded at monthly interval considering the general life-cycle of PPNs completing in a month. Effect of carbofuran was evaluated on PPNs density for the entire cropping season of pea crop in the North Western Himalaya region. In this study we observed that application of carbofuran reduces the nematodes density initially but in the later phase the population increased significantly.

Keywords: plant parasitic nematodes, community analysis, carbofuran, pea and population density

Introduction
Nematodes are the most abundant metazoan on the earth with the estimated number a million species but known species are 27000 approximately (Ferris *et al.*, 2001, Hugot *et al.*, 2001) [13, 16]. Nematode use to carry out a wide range of functions from being nutrient recycling agent to parasite of human, animal and plants. Plant parasitic nematodes (PPNs) have become a most destructive biotic stress accounting for huge monetary loss with the tune of USD 173 billion annually across the globe (Elling *et al.*, 2013) [12]. In recent past the losses due to these tiny parasites in India has been estimated to be ₹102,039.79 million (US$1577 million) to various crops (Kumar *et al.*, 2020) [19].

Considering the immense losses inflicted by PPNs makes the management efforts mandatory to carry out on farm level into various crops. In order to minimize the losses and maximize the profit various management practices such as cultural, physical, biological and manipulation of genetic background of crops using conventional as well advanced biotechnological tools (Bridge, 1996; Siddiqui & Mahmood, 1999; Cobb, 1918; Sikora *et al.*, 2005; Nyarko *et al.*, 2015) [6, 23, 7, 8, 24, 14]. With the time various innovation and viable options have been developed to tackle the menace using integrated approach. Among the integrated approach, application of chemical particularly carbofuran (2, 3-dihydro-2, 2-dimethyl-7-benzofuranyl methyl carbamate) in soil has been widely used for management of nematode in different major crops (Shukla *et al.*, 1996, Jothi *et al.*, 2004, Arita *et al.*, 2020) [22, 17, 4]. Generally, the dosage of carbofuran are advised to be used as soil incorporation before raising nursery or growing crops in field conditions however their persistence effect on nematode abundance and population dynamics of different nematode group, over the period of crop season are not very well known. Therefore, it is necessary to investigate the efficacy of carbofuran application in soil on nematode fauna over the period of crop cycle. Pea crop has been reported to be frequently infected by different species of nematode including genera such as *Belonolaimus*, *Meloidogyne*, *Tylenchorhynchus*, *Ditylenchus*, *Hoplolaimus*, *Heterodera*, *Helicotylenchus*, *Paratylenchus* and *Pratylenchus* etc (Goodey *et al.*, 1965) [15].

Information related to abundance of major nematode associated to Pea crop in North Western Himalayan region is limited. In the present study we surveyed Pea crop for identification of associated nematode fauna grown at ICAR-VPKAS research farm hawalbagh, located in North Western Himalayan region and made an attempt to investigate the population dynamics of soil nematode at different time point interval in Pea crop post application of Carbofuran 3G @ 1 kg *a.i.*/ha across the crop season from sowing to harvesting.

Material and Methods

Field survey and soil sample collection

The survey for nematode was conducted in pea crop in the year 2018-19 at hawalbagh research farm of ICAR-VPKAS, Almora (figure 1). Soil sample were collected at the depth of 15-20 cm with hand shovel in zig-zag pattern for the preceding crop as well last year pea grown soil of the same field. Representative soils of field were collected from the root zone of crops and were pooled together in a polythene bag (200 g) and labelled properly. Subsequently the soil sample was carried to laboratory and place overnight at room temperature. The collected soil sample were analysed for its texture and nutrient status.

Extraction, identification and abundance study

Collected soil sample were washed and sieved through the recommended protocol of cob sieving and decanting (Cobb, 1918) [7, 8]. Residue collected at final sieve (325 µm) was subjected for modified Baerman funnel dish (Baermann, 1917) [5] to extract the nematode overnight. Extracted nematode was counted using telecounter on per ml basis and identified using morphological parameter under stereoscopic microscope (Magnus MSZ-Bi, Olympus) following the keys (Mai *et al.*, 1975, Ahmad, 1996, Ahmad and Jairajpuri, 2010) [20, 2, 3]. Community analysis using different parameters were calculated for different genera using the standard formulae (Norton, 1978) [21]. Soil sampling was performed every month post application of carbofuran until the plants were harvested.

Application of carbofuran and observation

The land site under study was well ploughed and leveled and divided into different blocks. The field was treated with granular formulation of carbofuran (Furadan®) @ 1 kg a.i. / ha before a day of sowing in first week of November in 2019. Observation of change in soil nematode density was taken each month post application of carbofuran from sowing to harvesting.

Result & Discussion

In the year of 2018-19 survey conducted in Pea crop grown at ICAR-VPKAS, Hawalbagh farm (Figure 1) revealed variety of nematodes including free living, parasites of plants and predatory nematodes in varying density (Table 1). The parameters of community analysis indicated abundance of nematodes with 100% and 16.66% absolute as well relative frequency in all 8 samples belonging to the different trophic group including plant parasitic nematodes genera such as *Pratylenchus*, *Hoplolaimus*, *Helicotylenchus* and *Tylenchorhynchus*, Mononchids as predatory and others free living groups. Analysis of population density (mean, relative and absolute density) of nematodes revealed the dominance of *Pratylenchus* followed by free living, *Helicotylenchus*, *Tylenchorhynchus*, *Hoplolaimus* and *Mononchids* (Table 1). Prominence value analysis showed the most prominence of nematode in following order *Pratylenchus*>free-living>*Helicotylenchus*>*Tylenchorhynchus*>*Hoplolaimus*>*Mononchids*. Considering the perspective of threat of economic damage in Pea crop we attempted to apply carbofuran as control measure for nematode management. In the initial period before application of carbofuran the population density of different group of nematodes recovered from soil was high (Figure 2) in pea crop. The population density recovered (nematode count/200 g soil) of different nematode group *i.e.* mononchids, free living and PPNs was found to be reduced post application of carbofuran. The highest reduction in nematode density was recorded in the month of December immediately after soil application of carbofuran. However, as the time progressed in the subsequent month population density of different nematode increased slowly and may reach at the threshold level in presence of suitable host and climate. Community analysis in Pea crop suggested the co-existence of diverse nematodes in the Himalayan ecosystem. The frequency, density and diversity of nematodes vary according to soil, ecological and host factors (Khatoon *et al.*, 2001) [18]. Presence of PPNs like *Pratylenchus*, *Hoplolaimus*, *Helicotylenchus* and *Tylenchorhynchus* suggest their role of parasitism to cause economic damage to the associated crop and free living and Mononchids might be playing role in improving soil health and predation of soil nematode respectively (Ferris *et al.*, 2001) [13]. Presence of highest density of *Pratylenchus* genera in Pea crop indicates their damage potential and need to for management intervention. It appears that the carbofuran treatment as prophylactic measure has affected the nematode population density by killing effectively in soil. The similar trend of reductions in nematode population due to carbofuran application has been observed by the several researchers (Disanzo, 1975, Da-Tadzadeh *et al.*, 1981, Crozzoli & Diego 1991, Adekunle & Fawole 2003) [11, 10, 9]. It suggests that application of carbofuran at sowing time is most effective to reduce nematode density for early stage however for more efficient control multiple dosage at various time point interval will increase the chances to combat the nematode problems. The reason behind increase in nematode density could be due to reduction in carbofuran toxicity in soil and loss due to several factors like leaching, detoxification etc. The result obtained in this work shows the trend of population dynamics of different nematodes after application of carbofuran in Pea crop in subsequent months. The recorded observation shows that carbofuran application at the sowing time is most effective to reduce the nematode density and can be used as potential option against PPNs control in Pea crop grown in NWH region. The reduction of free living nematodes as well predatory nematodes is serious concern as they performed several ecological services from nutrient recycling to predation of PPNs in soil.

Table 1: Community analysis of nematode associated with Pea crop

Nematode	Mean Density	Relative density %	Absolute density %	Prominence value
Pratylenchus	113	37.293	56.5	5.65
Hoplolaimus	35	11.551	17.5	1.75
Helicotylenchus	42	13.861	21	2.1
Tylenchorhynchus	36	11.881	18	1.8
Mononchids	11	3.63	5.5	0.55
Free living	66	21.782	33	3.3

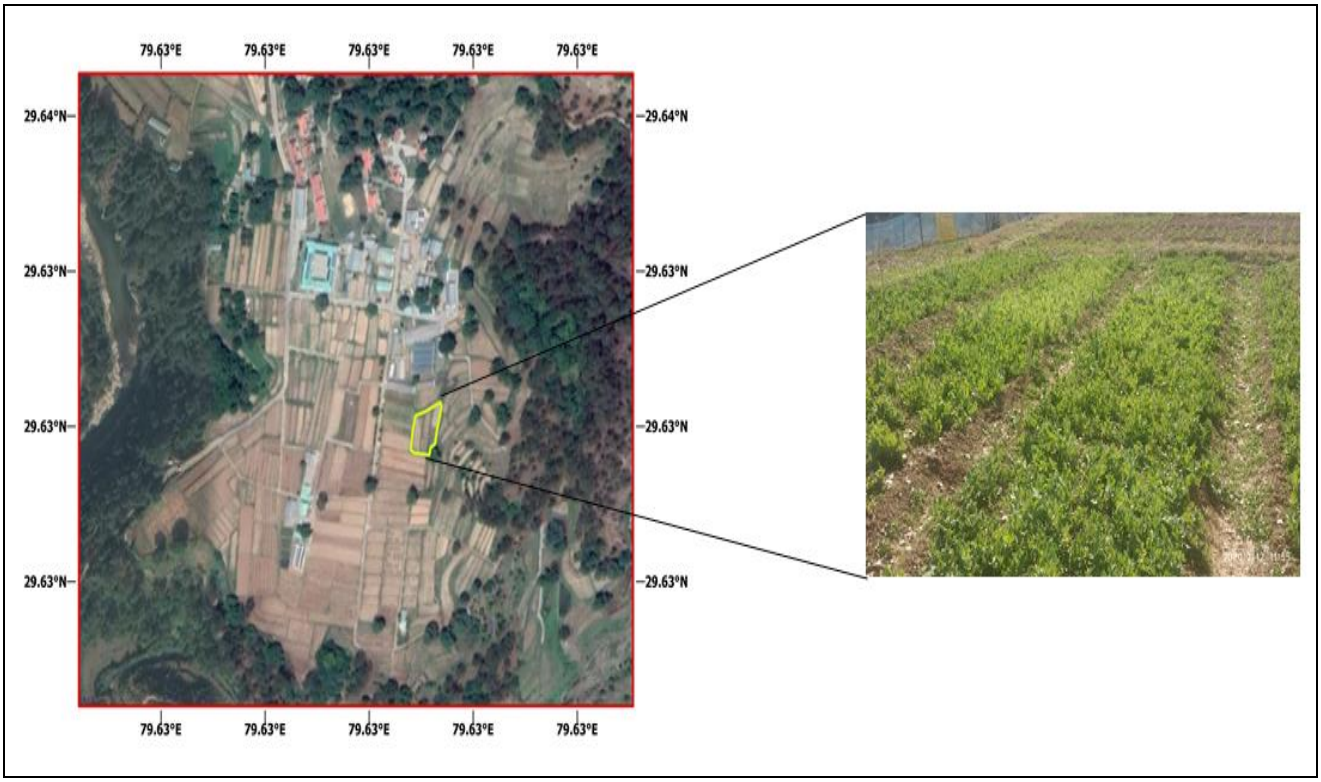

Fig 1: Study area of survey and carbofuran treatment

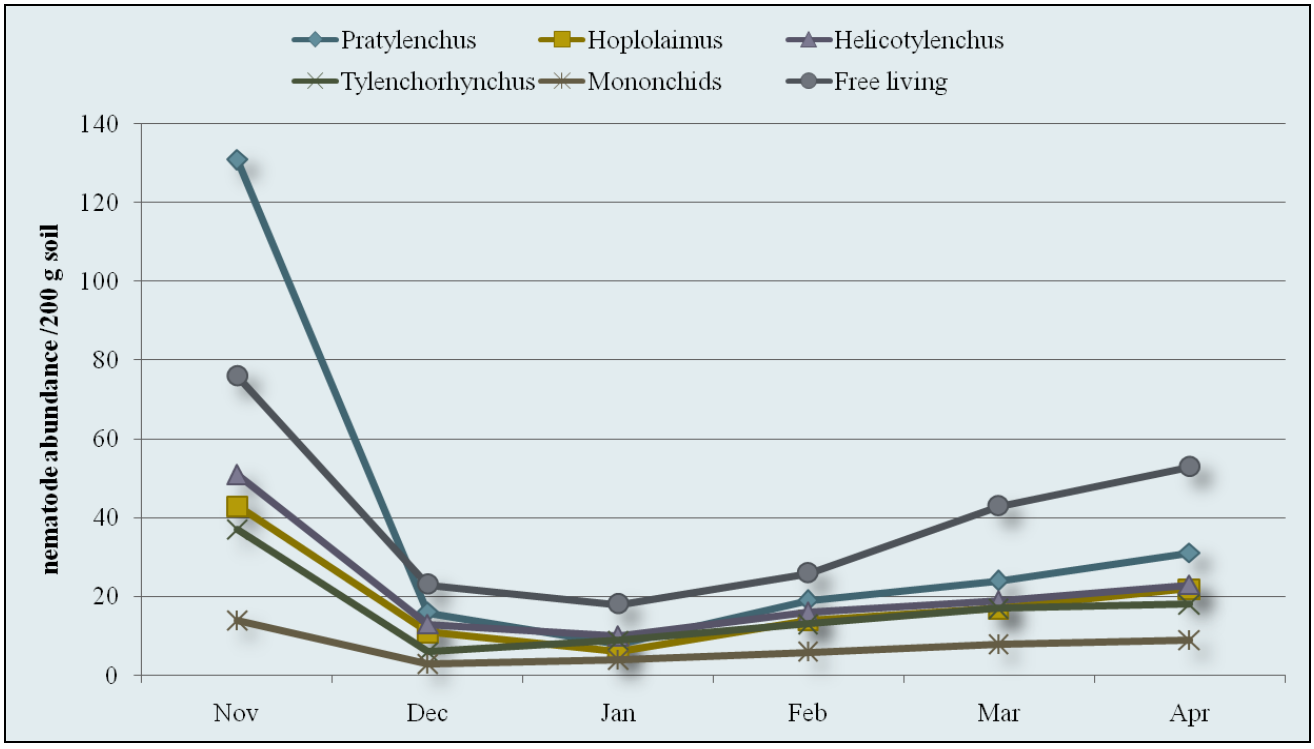

Fig 2: Change in population structure of nematode over the period after application of Carbofuran

Conclusion

Carbofuran has been proven to be the most effective nematicide against different nematodes in various crops. Application of carbofuran at the sowing time in Pea reduces nematode density initially but the population increases slowly across the growing period of Pea crop. This study indicates that the nematode population density under North Western Himalayan condition in the Pea crop significantly decreases after application of carbofuran and the positive change in population dynamics have been observed in the subsequent time period. Therefore, to obtain the best result of complete elimination of nematodes from Pea crop multiple dosage of carbofuran could be useful.

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