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Original Research Article

Population Dynamics of Horizontal and Vertical Population of Root-Knot Nematode, *Meloidogyne incognita* under Protected Cultivation

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A B S T R A C T

Protected cultivation has become quite famous among farmers. Higher productivity and cultivation of crops during off season are the important benefits of this technology. However, the problem of root-knot nematode has flared up under protected conditions. Population dynamics of root-knot nematode, *Meloidogyne incognita* was observed for two years at flowering and harvesting time of cucumber crop under protected cultivation. At flowering and harvesting horizontal distribution of root-knot nematode was almost even in a bed of 30 m length at different distances (2, 4, 6, 8, 10 and so on up to 30 m). Whereas, vertical distribution of root-knot nematode was erratic at different depths (5, 10, 15, 20, 25, 30, 35 and 40 cm) at flowering as well as harvesting. At flowering and harvesting of cucumber, greatest densities of root-knot nematode was recorded at a depth of 25 cm followed by 20 and 15 cm and were at par with one another. Minimum population of root-knot nematode was recovered at 5 cm depth followed by 10 cm. Population of nematode was higher at the time of harvesting compared to flowering time. Seasonal fluctuations were also noticed as nematode population was higher in summer season during 2017 in contrast to winter season in 2018.

Keywords

Population dynamics, Soil sampling, cucumber, Root-knot nematode, Protected cultivation

Introduction

Protected cultivation of vegetables offer distinct advantage of quality, productivity and favorable market price to the growers. It increases their income in off season as compared to normal season. Off season cultivation is one of the most profitable technologies under Northern Plains of India. Cultivation of tomato, cucumber, capsicum, carnation and gerbera is done under protected cultivation (Nair and Swati, 2014). Under protected conditions crops are attacked by a number of pests and diseases including nematodes which hamper the growth of crops. Among the nematodes, root-knot nematode (*Meloidogyne incognita*) is the most damaging under polyhouse conditions, parasitizing almost all the polyhouses crops. Root-knot nematodes were first reported in 1855 by Berkeley, who observed them causing damage on cucumbers. About 2000 plants worldwide are susceptible to infection by root-knot nematode and they cause approximately 5% of global crop loss (Sasser, 1980). Above-ground symptoms of root-knot nematode includes stunting, yellowing and wilting of plants due to improper transportation of water and nutrients from roots to other plant parts. Galls formation on roots is a peculiar below-ground symptom of this nematode (Tisserat, 2006). This trial was carried out for two years in 2017 and 2018 in

a row, to know the population dynamics of root-knot nematode at the time of flowering and harvesting of cucumber crop in a polyhouse.

Materials and Methods

This trial was executed in a polyhouse of 28 m × 32 m (896 m^2) located at Horticulture Farm of Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan for two years in succession i.e. 2017 and 2018. Udaipur lies at the southern end of the Aravalli hills and 24.525049°N 73.677116°E with altitude of 598 meters above the sea level. It has a hot semi-arid climate and dominated by three main seasons, summer, monsoon and winter. The summer season runs from mid March to June and touches temperature ranging from 23 °C to 44 °C in the months of March to June. Winter begins in December and continues till February. The average day temperature during the season hovers around 25°C, while the minimum settles close to 8°C. Soils of Udaipur are known as brown soils as its color ranges from grayish brown to yellow brown and texture is sandy loam to clay loam. The beds of 30 m length, 1 m width and 30 cm raised above the ground level were prepared for experimental purpose. Prior to bed formation, basal dose of N:P:K (12:32:16) was broadcasted @ 50 kg/ha. Cucumber (cv. Mini Angel) was sown directly in the beds at 2-3 cm depth @ 1 seed per hill. Gap filling was done in case of no germination of seeds. Recommended package of practice was followed throughout the cropping season. Soil sampling was done at the time of flowering and harvesting from 4 beds raised up to 30 cm from the ground level at different depths i.e. 5, 10, 15, 20, 25, 30, 35 and 40 cm at different distances i.e. 2, 4, 6, 8 m and so on up to 30 m at the depth of 15-20 cm. Four replications were maintained in a completely randomized design. Samples were processed through Cobb's sieving and decanting technique, followed by Modified Baermann's Funnel Technique and observed under stereoscopic microscope. Observations were recorded on number of J2 of root-knot nematode present at different depths and at different distances in each sample at the time of flowering as well as harvesting.

Results and Discussions

Horizontal Distribution: At the time of flowering (45 days after sowing), maximum nematode population was noticed at a distance of 20 m in 2017 and pooled average of both years i.e. 499.00 and 394.50 J2 per 200 cc soil and at a distance of 16 m i.e. 296.00 J2 per 200 cc soil in 2018 in four beds of 30 m length, respectively (Figure 1). Distribution of root-knot nematode was non-significant at all distances i.e. 2, 4, 6 m and so on up to 30 m, at the depth of 25-30 cm in all four beds. At the time of harvesting, highest population of root-knot nematode was noticed at a distance of 14 m in 2017 and pooled average of both years i.e. 616.00 and 509.00 J2 per 200 cc soil and at a distance of 20 m i.e. 415.00 J2 per 200 cc soil in 2018 in four beds of 30 m length, respectively. Population fluctuation was non-significant at all distances in all four beds at the time of harvesting in 2017, 2018 as well as in pooled average of both years (Figure 2). Therefore, it was demonstrated that horizontal distribution of root-knot nematode at different distances in 30 m long bed under polyhouse condition was almost even at the time of flowering and harvesting of cucumber in individual years as well as in pooled average of both years (Figures 1 and 2).

Vertical Distribution: At the time of flowering (45 days after sowing), peak population of root-knot nematode per 200 cc soil was recovered at a depth of 25 cm (405.00, 219.25 and 312.12) followed by 20

cm (371.50, 210.00 and 290.75), 15 cm (354.00, 196.50 and 275.25), 30 cm (337.00, 112.25 and 224.62), 35 cm (92.00, 86.75 and 89.37) and 40 cm (39.50, 30.00 and 34.75) in 2017, 2018 and pooled average of both years, respectively. Nematode population was comparable with one another at 15, 20, 25 and 30 cm in individual years as well as in pooled average of both years. Minimum population of root-knot nematode per 200 cc soil was recovered at 5 cm depth (2.25, 4.00 and 3.12) followed by 10 cm depth (17.00, 10.50 and 13.75) in 2017, 2018 and pooled average of both years, respectively (Figure 3). At the time of harvesting, peak population of root-knot nematode per 200 cc soil was recovered at a depth of 25 cm (499.50, 290.25 and 394.87) followed by 20 cm (430.00, 273.75 and 351.87), 15 cm (416.00, 245.00 and 330.50), 30 cm (400.00, 174.50 and 287.25), 35 cm (88.00, 100.00 and 94.00) and 40 cm (50.50, 46.00 and 48.25) in 2017, 2018 and pooled average of both years, respectively. Nematode population was comparable with one another at 15, 20 and 25 cm in individual years as well as in pooled average of both years. Minimum population of root-knot nematode per 200 cc soil was recovered at 5 cm depth (6.25, 6.00 and 6.12) followed by 10 cm depth (10.75, 8.00 and 9.37) in 2017, 2018 and pooled average of both years, respectively (Figure 4).

At the time of flowering, horizontal population of root- knot nematode ranged between 450.00 to 499.00 J2 per 200 cc soil in 2017 and 228.00 to 296.00 J2 per 200 cc soil in 2018 (Figure 1). Whereas, population ranged between 560.00 to 616.00 J2 per 200 cc soil at the time of harvesting in 2017 and 350.0 to 415.00 J2 per 200 cc soil in 2018 (Figure 2). At the time of flowering, vertical population of root- knot nematode ranged between 2.25 to 405.00 J2 per 200 cc soil in 2017 and 4.00 to 219.20 J2 per 200 cc soil in 2018 (Figure 3). However, population ranged between 6.25 to 499.50 J2 per 200 cc soil in 2017 and 6.00 to 290.25 J2 per 200 cc soil in 2018 at the time of harvesting (Figure 4). Therefore, seasonal fluctuations were observed in horizontal and vertical population of root-knot nematode as nematode population was less in 2018 and more in 2017 (Figures 5 and 6). It is revealed from the Figures 5 and 6 that nematode population was more at the time of harvesting of cucumber than flowering.

Figure.1 Horizontal distribution of root-knot nematode at flowering stage

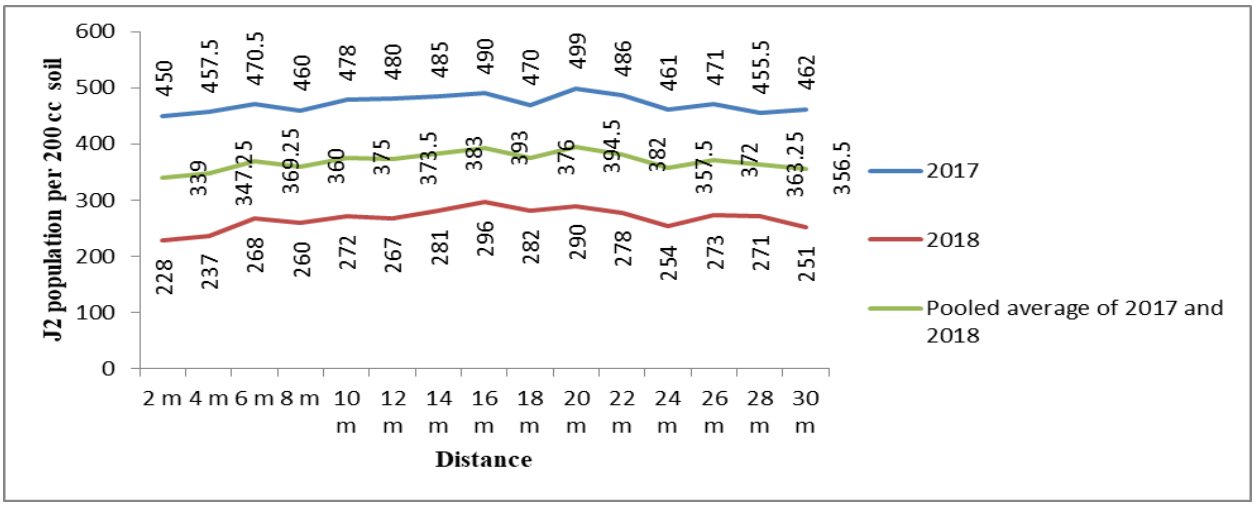


Figure.2 Horizontal distribution of root-knot nematode at harvesting stage

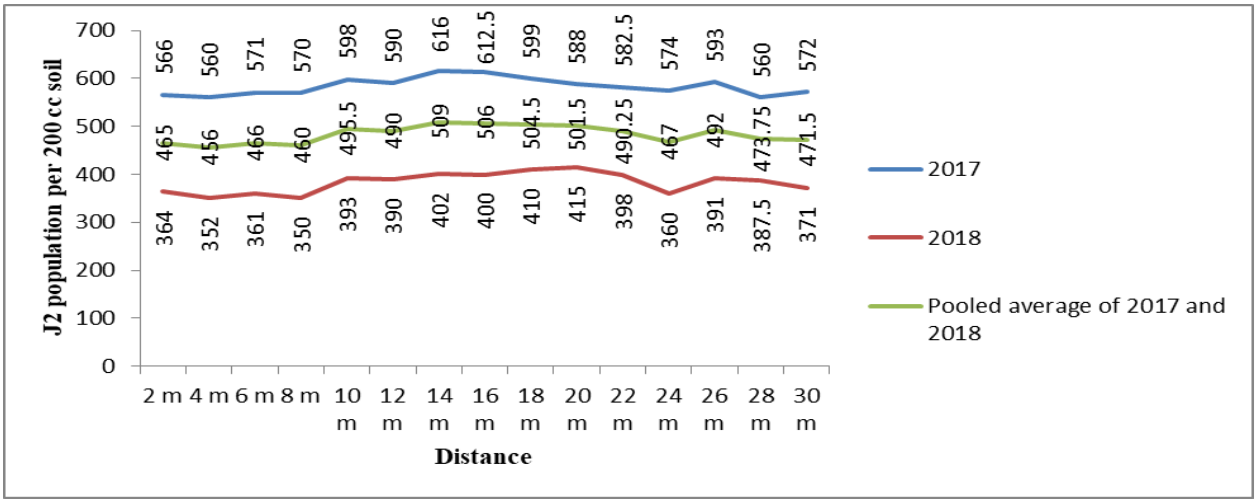


Figure.3 Vertical distribution of root-knot nematode at flowering stage

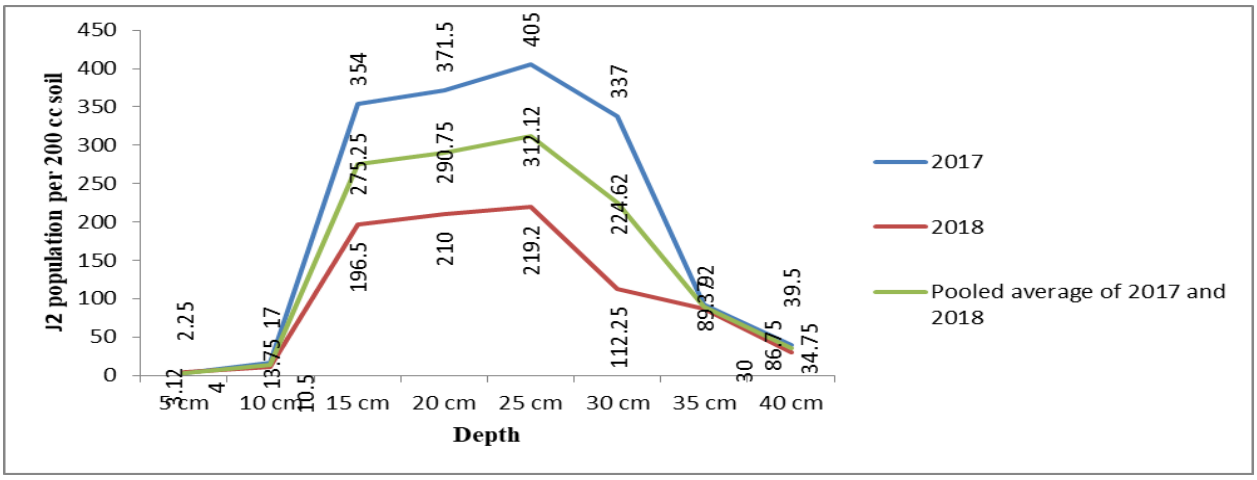


Figure.4 Vertical distribution of root-knot nematode at harvesting stage

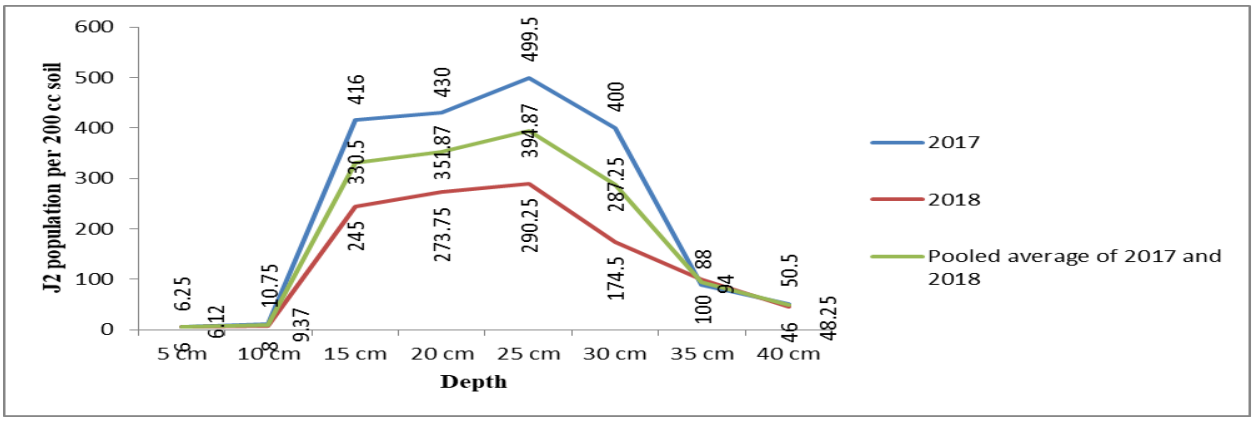


Figure.5 Horizontal distribution of root-knot nematode at flowering and harvesting stage (pooled average of 2017 and 2018)

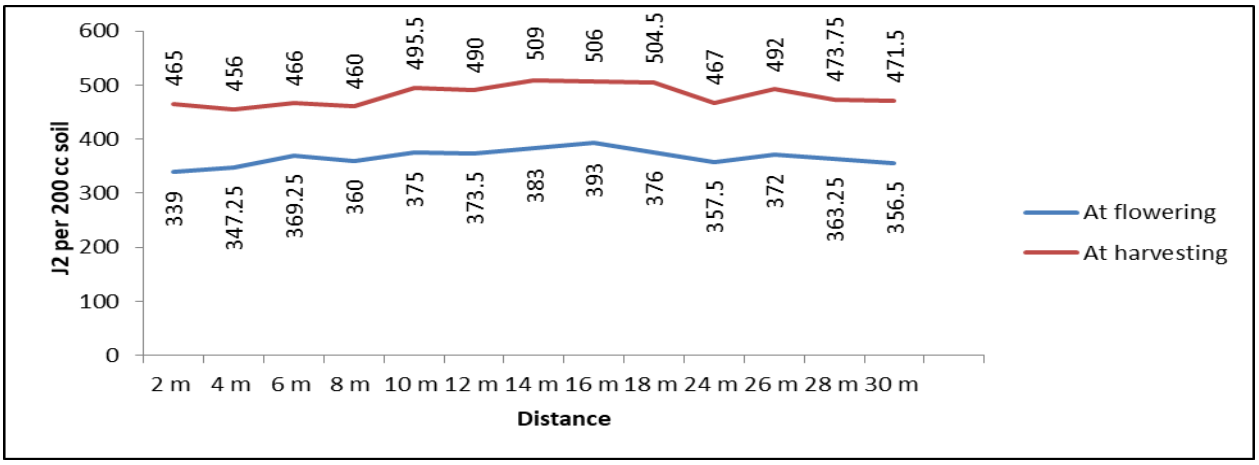
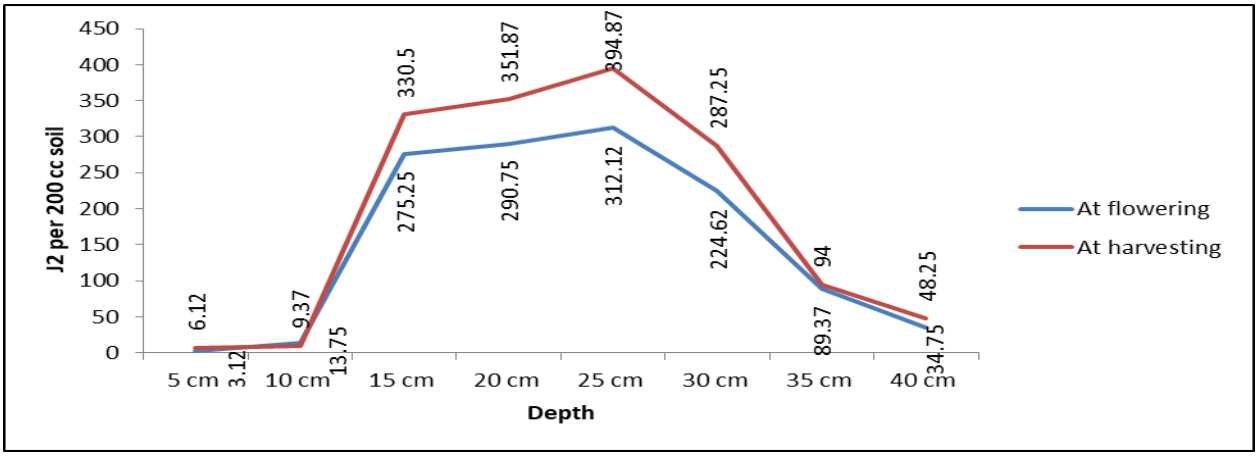


Figure.6 Vertical distribution of root-knot nematode at flowering and harvesting stage (pooled average of 2017 and 2018)



At flowering and harvesting nematode population was almost evenly distributed at 25-30 cm depth in a 30 m long bed at different distances i.e. 2, 4, 6 m and so on up to 30 m. Horizontal distribution of root-knot nematode was not significantly variable at different distances i.e. sampling of soil from different distances did not make any remarkable difference because of uniform distribution. Similar observation was recorded by Gao and Jianwen (1997) during study on distribution and fluctuation in the population of *Hirschmanniella oryzae* in rice fields. It was revealed from the research that horizontal distribution of *H. oryzae* was almost uniform within a rice field. On the contrary, fluctuation in the population of *M. incognita* in date-palm cv. Samani recorded during the year without any obvious peaks (Eisaa *et al.*, 2009).

Vertical distribution of root-knot nematode was variable at different depths. Comparable results were observed by McSorley and Dickson, 1990 that vertical distribution of root-knot nematode was erratic and showed

marked seasonal variation in sandy soil in maize. At flowering and harvesting of cucumber, greatest densities of root-knot nematode were recorded at a depth of 25 cm followed by 20 and 15 cm and were at par with one another. Plant parasitic nematodes survive on feeder roots and distribution of maximum nematodes at a depth of 15-25 cm reflects the presence of feeder roots of cucumber at this depth. Similar results were observed by Johnson and McKeen (1973) that highest population level of root-knot nematode was found in the top 30 cm of soil in tomato in a greenhouse. The activity and presence of plant parasitic nematodes are correlated to the distribution of the root system (Ingham *et al.,* 1985; Verschoor *et al.,* 2001; Eissa *et al.,* 2009). Related results were found by Wu and Shi, 2012 in tomato under protected cultivation that root-knot nematode predominantly distributed at 20-30 cm soil depths. Generally the major share of nematodes can be found in the upper 0-25 cm of the soil, i.e. in the area where the bulk of plant roots are located (Bezooijen, 2006).

Other workers also found this kind of results that distribution of nematodes appeared to be correlated with the distribution of feeder roots of crops (Maqbool and Hashmi, 1985 for *Quinisulcius solani* on potato; Youssef, 1990 for rice root nematode; Youssef and Eissa, 1994 for root-knot nematode on date-palm; Eissa *et al.,* 2003 on banana; Wesemael and Moens, 2008 for *M. chitwoodi* in carrot and potato). Nematodes move and occur vertically in soils toward plant roots, but distance moved is dependent on species, soil temperature, soil type and soil moisture (Coleman and Wall, 2015). In deserts, nematodes are associated with plant roots to depths of 15 m (Freckman and Virginia, 1989) and the nematode *Halicephalus mephisto* was recently recovered from soils 3 km deep (Borgonie *et al.,* 2011).

Nematode population started declining at 30, 35 and 40 cm depth. Corresponding results were recorded by David and Wall, 2015 that population of nematodes in soil generally decreases with increasing depth, as many soil nematodes are largely concentrated in the rhizosphere. Seasonal fluctuation was observed in nematode densities as nematode population was lower in 2018 during September to December, though, more nematode densities were recorded in year 2017 during April to August. Temperature is an important factor in growth, development and reproduction of root-knot nematode. However, with the approach of winter season, nematode multiplication gets arrested (Walia and Bajaj, 2014). Similar results were obtained by Fayzia *et al.,* (2018) that nematode population increased during spring to summer from March to September. The maximum population fluctuation of root-knot nematode observed in summer in July and August on cucumber and decreased in autumn from November to reach minimum in winter in January and February in two seasons. Second-stage juvenile densities of *M. chitwoodi* after potato declined through winter and increased slightly as soil temperature increased in the spring (Pinkerton *et al.,* 1991; Noling and Becker, 1994).

The results revealed that the maximum horizontal and vertical population of nematode was recorded at harvesting stage followed by flowering stage. Similar results were found by Chandel, 2017; Askary *et al.,* 2018 that population of all the nematodes increased gradually in soil with the passage of time and advancement in growth stage of crop. Been *et al.,* 2002 observed in a potato field that as the time after harvest increases, the number of juveniles of root-knot nematode in soil decrease and detection becomes more difficult. Based on the results from the present work, it is ascertained that

soil sampling should be done immediately after harvesting. Samples taken soon after harvest gave the highest detection for root-knot nematode.

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