Rec. zool. Surv. India: Vol. 117(4)/ 376-382, 2017
DOI: 10.26515/rzsi/v117/i4/2017/121402

ISSN (Online) : (Applied for)
ISSN (Print) : 0375-1511

Population fluctuation of soil inhabiting Nematodes in relation to soil temperature and moisture at Guava Orchard in West Bengal, India

Debabrata Sen*

Zoological Survey of India, M- Block, New Alipore, Kolkata - 700 053, West Bengal, India; debabrata.zsi@gmail.com

Abstract

Soil edaphic factors like temperature and moisture are important for the community composition of nematodes. Those were considered to assess their effects upon the population of soil nematodes. The present work was carried out in a guava (Psidium guajava L.) orchard at Shalipur (West), Baruipur block of South 24-Parganas for three consecutive years. The results revealed that the maximum populations of nematodes were observed during monsoon with a population of 4169/250gm of soil in the month of July. During monsoon low soil temperature (30.10C – 31.80C) and high soil moisture (20% - 26%) in the month of July were also observed. The minimum population (204/250gm of soil) of soil nematodes was observed during pre- and post-monsoon with a wide range of low to high soil temperature (180C - 340C) and low soil moisture (10% - 13%). This reveals a direct effect of these two climatic factors of soil on the population of soil nematodes which has been established by correlation and regression analysis.

Keywords: Correlation, Moisture, Population fluctuation, Soil Nematode, Temperature

Introduction

The nematodes are very primitive and the most diversified group among invertebrate pseudocoelomate metazoans. The Phytonematodes cause significant yield loss to the agricultural and horticultural crops. They inhibit root growth, growth of plants in general and are thus responsible for massive loss in production of crops. They are overlooked mainly due to their minute body, hidden nature and due to lack of awareness in common people and farmers. Dasgupta (1998) provided detail information about the yield losses of agricultural and horticultural crops due to nematode infestation in India as well as globally. Estimated overall average annual yield loss of the world's major crops due to the damage by the soil and plant-parasitic nematodes is 12.3% (Sasser and Freckman, 1987). Moreover, Nematodes play very important role like decomposition, mineralization and nutrient cycling in soil micro-habitat. Therefore, they may have a significant role in soil ecosystem.

The present study was conducted in a guava orchard situated at Shalipur (West), Baruipur block of Baruipur subdivision (geographical position 22°22.64¤ North and 88°25.696¤ East), where guava is produced most widely and extensively as a cash crop. The study was carried out for thirty-six consecutive months from May, 2004 to April, 2007. Monthly population of soil nematodes and soil temperature and moisture were recorded to observe the effect of these two climatic factors on nematode population in general. Neher (2001) observed the role of soil free-living and plant-parasitic nematodes in maintaining soil health and opined that nematode communities may be used as bio-indicators of soil condition because it is related with nitrogen cycling and decomposition. In this context soil temperature and moisture were considered to assess their effects upon the population of soil nematodes in the present communication.

Soil factors and climatic conditions are the important determining factors for the community composition of nematodes (Griffiths *et al.*, 2003). Temperature and moisture have direct bearing in controlling the activity and metabolism of animal community, so that those were considered to assess their impact upon the soil nematodes because climatic factors significantly determines the

* *Author for correspondence*

Article Received on: 28.07.2016

Accepted on: 02.02.2018

distribution and diversity of organisms. Soil nematodes inhabit the capillary water in soil particles and they depend on soil moisture for protection against desiccation because of their soft and delicate bodies. Increase in soil moisture is considered for better growth of soil microbial and fungal biomass, which in turn provides more resources for soil fauna like free living fungal-feeing nematodes (Liu *et al.,* 2009). Song *et al.* (2016) suggested that addition of water significantly increases soil nematode abundance.

Many workers observed the activity of nematodes in different ranges of temperatures (Croll, 1970; Wallace, 1973). Influence of soil temperature was studied by Ferris (1970). Kamra and Sharma (2000) reported the nematode distribution in India depending upon the soil temperature. Many works have been done on the effect of atmospheric conditions and soil temperature and moisture on *Hoplolaimus indicus* around the roots of guava (Sharma and Kumar, 1989), on *Ditylenchus destructor* isolated from ground nut (Waele and Wilken, 1990) and on *Helicotylenchus* in guava orchard (Sen *et al.,* 2008). Bakonyi *et al.* (2007) suggested that Community diversity and multivariate structure of the nematode community are more sensitive to minute changes in soil temperature and moisture.

Neilsen (1949) suggested that in moist soil, nematodes remains constantly active, being inactive in the dry habitat. Mc Sorley (1997), Porazinska *et al.* (1998), Todd *et al.* (1999) observed positive correlation between increase in nematode population with rainfall or with increasing soil water. Bakonyi and Nagy (2000) opined that temperature is more important factor than water content of soil in changing the nematode community. Yeates (2002) suggested that nematodes are differentially affected by soil water content.

Material and Methods

Procedure of sampling of soil: Soil samples were collected for thirty-six consecutive months from May, 2004 to April, 2007. These were collected in the second week of every month in between 12.30 PM to 2.30 PM from a distance of about two to two and half feet from the trunk of guava tree. Five soil samples of 250gms each, composed of five cores of soil sampled to a depth of 0-20 cms were collected randomly.

Processing of soil samples and extraction of nematodes: The collected soil samples were processed by Cobb's sieving and decantation technique (Cobb, 1918) followed by modified Baermann funnel technique (Christie and Perry, 1951) for extraction of nematodes.

Counting of nematode population: The live specimens were taken for population counting. The nematodes of a particular sample with 3-4ml of water after extraction were taken in a 100ml measuring cylinder. To make it 100 ml, addition of clean water up to 100ml was done. Then it was made homogeneous by bubbling with the help of a dropper or by a pipette. 10ml of this water, containing homogeneously suspended nematodes, was taken in a counting dish by a graduated pipette. Counting of nematodes in the counting dish was done under a stereo zoom binocular microscope with the aid of a 4-digit "hand tally counter". The same process of counting was repeated thrice for each of the five samples. The process of calculation for each of the five samples was as follows:

Suppose, 10ml of homogeneous suspension contains x number of nematode.

1ml of homogeneous suspension contains x ⁄10 number of nematode.

100ml of homogeneous suspension contains 100x ⁄10 number of nematodes.

In this way, mean of nematode population for each of the five samples was calculated. After that the mean of total population of five samples for a particular month was finally calculated and were recorded for statistical analysis.

Estimation of soil moisture: Small amount of soils were collected and were kept in polythene bags to prevent the loss of moisture content. Initially 10gms of soil with moisture was taken and was kept at 105ºC in hot air oven until a constant weight is gained after loss of total moisture. The loss of weight of 10gms of soil in hot air oven is equal to the weight of its moisture content. Then from the difference of this weight, amount of soil moisture was calculated in percentage.

Estimation of soil temperature: Soil temperature was recorded every month from May, 2004 to April, 2007 from the guava orchard at the time of collecting soil samples between 12.30 PM to 2.30 PM with the help of a soil thermometer. The thermometer was pushed into the soil at least up to 10cm depth keeping there until a constant temperature was reached and the temperature was recorded.

Statistical analysis with the estimated data: Finally, the data obtained from the monthly population count of the nematodes with the estimated soil temperature and moisture from the guava orchard were subjected to appropriate statistical analysis, e.g., correlation and linear regression analysis, to observe the effect and relation between them.

Result

Population fluctuation of the nematodes in Shalipur (West) guava orchard: The most abundant population of nematodes occurred during the monsoon, in the months of June to August and the maximum population count of juveniles and adults was observed in the month of July among all thirty-six months of observations, the mean of total population being 4169.1/250gm of soil in July, 2004, 3559.2 in July, 2005 and 2204.8 in July 2006. At that period soil temperature and moisture were ranging between 30.1-31.8^{0}C and 20-26 % respectively. The minimum total population was recorded during pre- and post-monsoon, in the month of December, 2004, April, 2005, 2006 and in January, 2007, the mean of population being 398.9, 204.5, 242 and 476 respectively. In those months the soil temperature and moisture were 22.5^{0}C and 9.6%, 33-34^{0}C and 12.5-13%, 18^{0}C and 10% respectively. The fluctuation of nematode population is shown in Table 1, Figure 1 and that of soil temperature and moisture in Table 1, Figure 2.

Table 1. Month wise mean of population (adults and juveniles) of soil nematodes/250 gm of soil and estimated mean value of soil temperature (^{o}C) and moisture (%) in Shalipur (West) guava orchard

year	Month	Mean of Nematode Population	Temperature (oC)	Moisture (%)
2	May	1144.2	35	13.4
	Jun	1308.9	31	29.4
0	Jul	4169.1	30.1	21.2
	Aug	1546.7	30.1	20.4
0	Sep	768.7	31	28
	Oct	703.8	30	28.4
4	Nov	1057.6	24	9.6
	Dec	398.9	22.5	12
2	Jan	1047.6	19.5	15
	Feb	521.2	24	14
0	Mar	503.6	29	12
	Apr	204.5	34	13
0	May	918	36	12
	Jun	1029.3	32	25
5	Jul	3559.2	31	20
	Aug	1514.1	30	22
	Sep	805.6	30.5	26
	Oct	715	30	29
	Nov	984.8	24	9.8
	Dec	449.4	22	9
2	Jan	902	19	11
	Feb	548.3	24	12
0	Mar	513.5	30	12
	Apr	242	33	12.5
0	May	558.9	34	13.5
	Jun	860.5	33	22
6	Jul	2204.8	31.8	26
	Aug	1594.5	29.5	24
	Sep	925.3	30	28
	Oct	908.4	31	27
	Nov	901.2	24.5	10
	Dec	445.8	20	8.5
2	Jan	476	18	10
0	Feb	511.7	22	10
0	Mar	585.4	29	13
7	Apr	509	32	12

It was observed that the mean of total population of nematodes started growing from the month of May for the years under study and maintained high population growth up to the month of August, reaching its highest in the month of July. In the year 2004, the population started declining notably in September-October followed by an augment in November and in January. In 2005 and 2006 same type of population fluctuation was observed beside a higher population in January with an exception in January, 2007.

Correlation and Regression analyses of nematode population with soil temperature and moisture: In Shalipur (West) guava orchard, the nematode population was positively but least affected by soil temperature. The relationship can be represented by the following regression equation: $Y = 0.0012x + 27.031$ (correlation coefficient (r) = (+) 0.2006, $P > 0.10$). The population growth was positively correlated with the moisture content of the soil at a significant level. The relationship can be expressed by the following regression equation: $Y = 0.003x + 14.2$ (r = (+) 0.3483, $P < 0.05$). The regression analyses are shown in Figure 3.

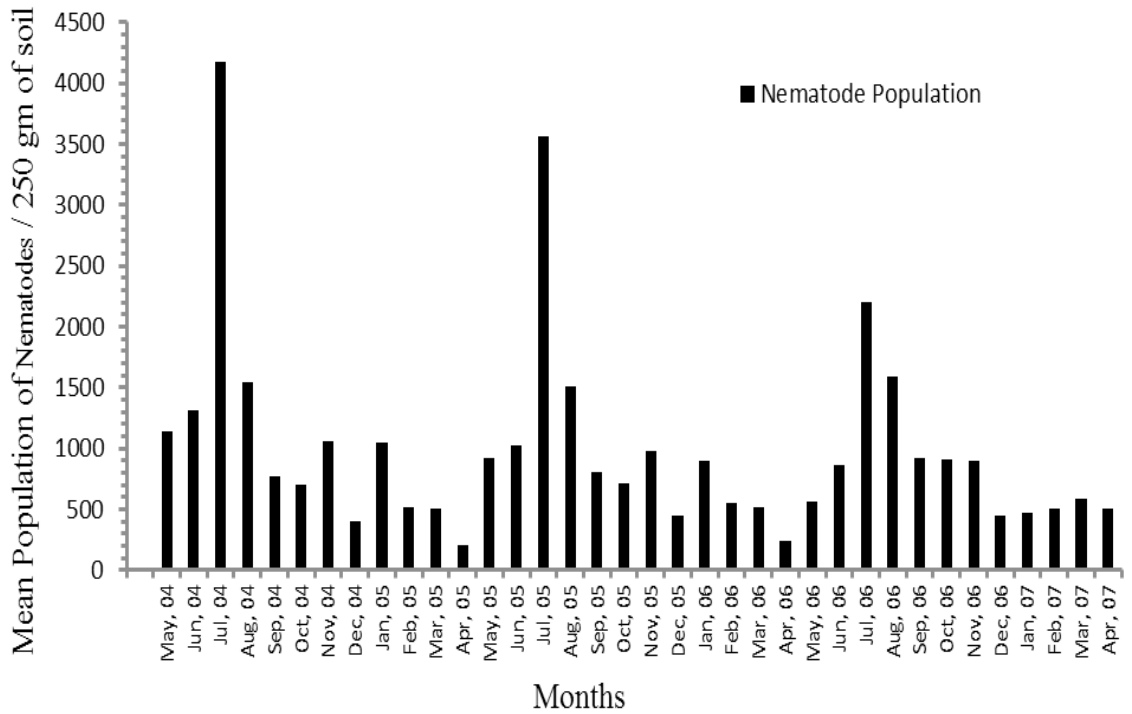

Figure 1. Graphical presentation of mean of total number (adults & juveniles) of soil nematodes and their monthly population fluctuations at Shalipur (West) guava orchard [Data shown in Table 1].

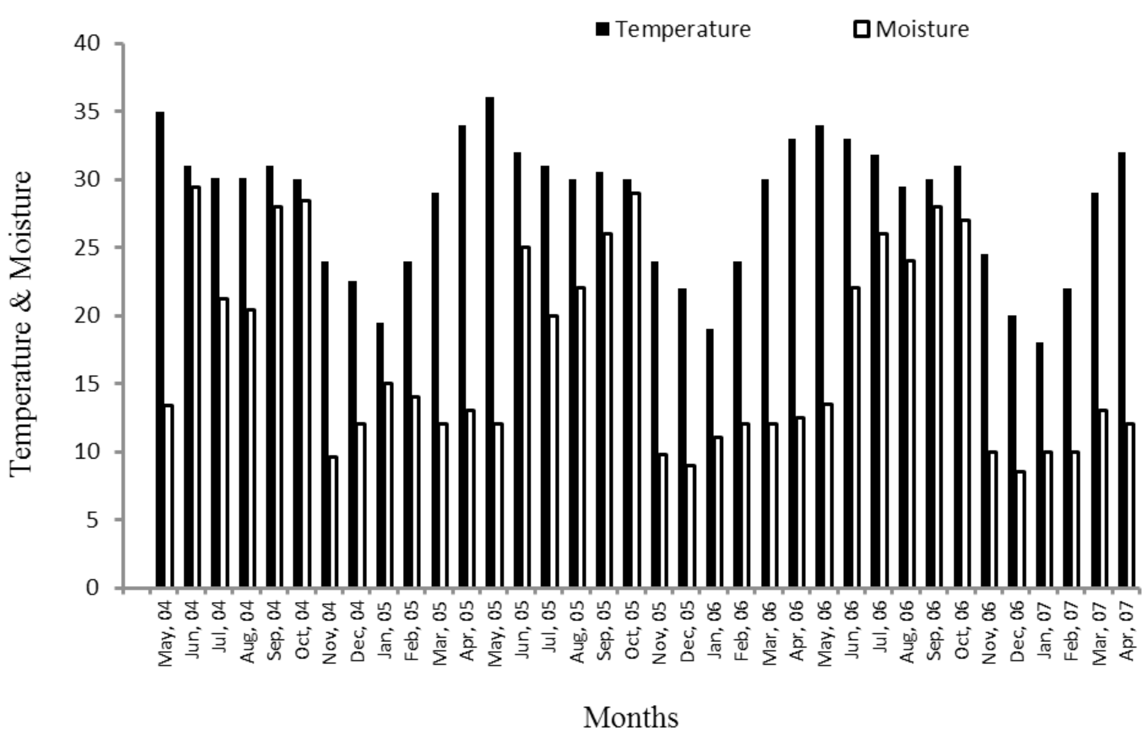

Figure 2. Graphical presentation of monthly soil temperature and moisture at Shalipur (West) guava orchard [Data shown in Table 1].

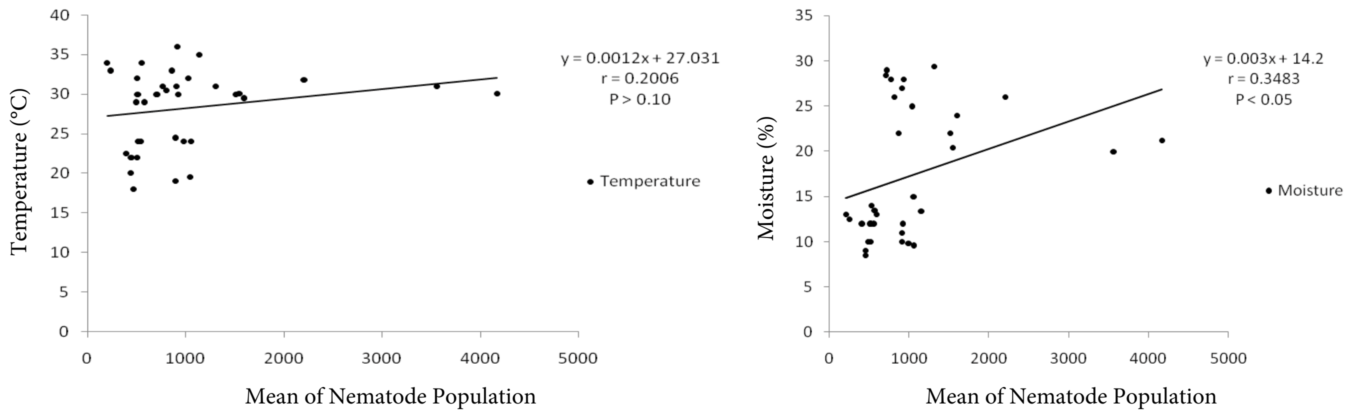

Figure 3. Linear regression of nematode population in relation with soil temperature and moisture (as mentioned on Y axis) in Shalipur (West) guava orchard (Data shown in Table 1).

Discussion

Although in Shalipur (west) guava orchard the population of nematodes fluctuated randomly (with rise or decline, whatever may be the case) all through the 36 months of study (Table 1; Figure 1), a close observation reveals that the maximum ascend of population occurred during the monsoon, more particularly, in the month of July. The reason behind this may be, due to their breeding season at that time, substantiated by the presence of huge numbers of juveniles. The monsoon in the area of study lasts from June to September generally. This increase was followed by gradual reduction (rather fluctuating in nature) in pre- and post-monsoon periods showing an insignificant peak of population during October-November indicating the population fluctuation being bimodal. This may be an evidence of their breeding twice a year. But this observation is not in consonance with the study of Das *et al.* (1984) who suggested one generation in a year in case of *Hirschmanniella gracilis*. Khan *et al.* (1980) and Chowdhury and Phukan (1990) observed the population decline of tylenchid nematodes from September onwards up to December, with an increase in population during summer months (March-July) attaining the highest peak in March, the fluctuation being unimodal. Jones (1980) reported the population increase of *Helicotylenchus multicinctus* during summer and decreasing during winter and suggested three generations in a year, regulated by temperature. He also observed the population peak in case of *Cephalenchus leptus,* the major one during the month of July in the sub-tropical environment, being consistent with the present study. Two nematode population peaks-one in October-November and second peak in July of *Hoplolaimus indicus* around the soil of guava in Allahabad, India evidenced in the work of Dwivedi *et al.* (1987) resembles close to the present findings. Many observers reported seasonal population fluctuation of nematodes concluding differently in regard of their maximum and minimum growth from various climatic conditions of tropics and sub-tropics which are either consistent or inconsistent with the present investigation, yet at least in one point they agree that the soil moisture, rainfall, temperature etc. have definite and significant influence in the growth of nematode population (Harris, 1979; Pinochet *et al.*, 1990; Deshmukh *et al.*, 1990; Azmi, 1995; Srivastava *et al.*, 2000; Rama and Dasgupta, 2000; Kumar, 2002, Sen *et al.*, 2008). Movement, development and survival of nematodes in soil are regulated by the interaction between soil porosity and water condition. As a possible reason behind the increase or decrease in population, it can be concluded that during pre- and post-monsoon periods the depletion of soil moisture is one of the significant limiting factors in the population growth of nematodes. During monsoon, the rainfall reduces temperature and an increase in soil moisture after summer, favours better built of nematode population. But it seems that this kind of fluctuation depends up on the local environmental and soil conditions. The factors responsible for this type of population changes may be better understood by studying overall changes in the soil environment, which are anticipated to have influence on the growth or decline of nematode population.

From the estimated mean values of soil factors (Table 1, Figure 2), this is evident that temperature remained highest in the pre-monsoon which slightly came down with the onset of monsoon but still remaining moderately high, rather optimum for the growth of nematodes. Soil moisture, although was significantly high in the rainy season (June to September); it was observed to be the highest in the post-monsoon due to delayed rains during the period of the study.

Soil temperature showed positive but insignificant relationship with nematode population (r = (+) 0.2006, P > 0.10). Ramana *et al.* (1978) showed 21-26^{0}C soil temperature to be the most favourable for the population build-up and in agreement with the present finding. Sabir (2000) observed the maximum population density of some ecto- and endo-parasitic nematodes during the monsoon (July-August) with a maximum ambient temperature of around 24-37^{0}C which shows close compatibility with the present study. The effect of temperature on the development and population growth of nematodes may have major adaptive significance and may lead to orient towards new optimal temperature tolerance. Munteanu (2017) studied that the comfortable temperature range for nematodes was found to be 15-25^{0}C.

Soil moisture is one of the major factors in regulating the nematode population being related mainly to rainfall of a particular area. In the present study, significant population growth of nematodes occurred with the increasing moisture content of the soil (r = (+) 0.3483, P < 0.05). Khan and Sharma (1990) observed no considerable role of moisture on some nematode species having negative correlation with population build-up in apple orchard which contradicts the present observation in its extreme. On the other hand, a positive correlation was observed between certain genera and rainfall in pastures (Mc Sorley, 1997), which helped to maintain a consistent increase in plant feeders with increasing soil water in prairie system (Todd *et al.,* 1999) and that of omnivorous and predatory nematodes in an irrigated orchard (Porazinska *et al*., 1998). Griffin *et al*. (1996) concluded that the positive relationship exists between high soil water and maximum population densities of *Tylenchorhynchus acutoides* which is in conformity in general with the present observation.

Acknowledgement

The author is grateful to the Director, Zoological Survey of India, Kolkata to give permission to carry out the work, to provide every sort of facilities and to publish the result.

References

Azmi, M.I. 1995. Seasonal population fluctuation behaviour of plant parasitic nematodes in carribean stylo. *Indian Journal of Nematology,* **25**(2): 168-173.

Bakonyi, G. and Nagy, P. 2000. Temperature and moisture induced changes in the structure of nematode fauna of a semi-arid grass land- patterns and mechanisms. *Global Change Biology,* **6**: 697-707.

Bakonyi, G., Nagy, P., Kovács-Láng, E., Kovács, E., Barabás, S., Répási, V. and Seres, A. 2007. Soil nematode community structure as affected by temperature and moisture in a temperate semiarid shrub land. *Applied Soil Ecology,* **37**(1–2): 31-40. https://doi.org/10.1016/j.apsoil.2007.03.008

Chowdhury, B.N. and Phukan, P.N. 1990. Seasonal fluctuation of nematode population in banana. *Indian Journal of Nematology,* **20**(2): 189-192.

Christie, J.R. and Perry, V.G. 1951. Removing nematodes from soil. *Proceedings of Helminthological Society of Washington,* **17**: 106-108.

Cobb, N.A. 1918. Estimating the nema population of soil. *Agric. Tech. Cir.* Us Dept. Agric., **1**: 48pp.

Croll, N.A. 1970. *The Behaviour of nematode, their activity, senses and responses*. Edward Arnold (Publishers) Ltd., London. pp. 1-117.

Das, P.K., Ahmad, N. and Baqri, Q.H. 1984. The study on the seasonal variations in the population of *Hirschmanniella gracilis* (de Man, 1880) Luc and Goodey, 1964 (Tylenchida: Nematoda) at Hooghly, west Bengal, India. *Indian Journal of Helminthology (n. s.),* **1**: 17-25.

Dasgupta, M.K. 1998. *Phytonematology*. Naya Prakash, Calcutta, India. pp. 1-846.

Deshmukh, R., Saxena, G.C. and Singh, Y.P. 1990. Seasonal variations in the population of *Helicotylenchus dihystera* in the rhizosphere of eggplant. *Journal of Nematology,* **6**: 83 – 86.

Dwivedi, B.K., Malhotra, S.K. and Misra, S.L. 1987. Interrelationship of population distribution of *Hoplolaimus indicus* around root zones of *Psidium guajava* with season and soil temperature at Allahabad. *Indian Journal of Nematology,* **17**(1): 49 – 53.

Ferris, J.M. 1970. Soil temperature effects on onion seedling injury by *Pratylenchus penetrans. Journal of Nematology,* **2**: 248 – 251.

Griffin, G.D., Asay, K.H. and Horton, W.H. 1996. Factors affecting population trend of plant-parasitic nematodes on Rangeland grasses. *Journal of Nematology*, **28**(1): 107-114.

Griffiths, B.S., Neilson, R. and Bengough, A.G. 2003. Soil factors determined nematode community composition in a two year pot experiment. *Nematogy,* **5**(6): 889-897.

Harris, A.R. 1979. Seasonal population of *Xiphinema index* in vineyard soils of North-Eastern Victoria, Australia. *Nematologica,* **25**: 336-347.

Jones, R. K. 1980. Population dynamics of *Helicotylenchus multicinctus* and other nematodes on banana from a subtropical environment. *Nematologica*, **26**: 27-33.

Kamra, A. and Sharma, S.B. 2000. Soil temperature regimes and nematode distribution in India. *Indian Journal of Nematology,* **30**(2): 219-224.

Khan, A.H., Haseeb, A., Rehman, R., Saxena, S.K. and Khan, A.M. 1980. Population fluctuation of some nematodes around roots. *Geobios,* **7**: 55-57.

Khan, M.L. and Sharma, G.C. 1990. Effect of temperature and moisture on population fluctuation of nematodes in an apple orchard. *Indian Journal of Nematology,* **20**(1): 10-13.

Kumar, S. 2002. Population dynamics and seasonal incidence of nematodes in banana. *Indian Journal of Nematology,* **32**(1): 93-94.

Liu, W., Zhang, Z. H. E., and Wan, S. 2009. Predominant role of water in regulating soil and microbial respiration and their responses to climate change in a semiarid grassland. *Global Change Biology*, **15**: 184-195. DOI: 10.1111/j.1365-2486.2008.01728.x

Mc Sorley, R. 1997. Relationship between crop and rainfall to soil nematode community structure in perennial agro-ecosystem. *Applied Soil Ecology,* **6**: 147-159.

Munteanu, R. 2017. The effects of changing temperature and precipitation on free-living soil Nematoda in Norway. Bachelor degree thesis (Unpublished), Department of Physical Geography and Ecosystem Science, Lund University, Sweden. pp. 1-30.

Neher, D.A. 2001. Role of nematodes in soil health and their use as indicators. *Journal of Nematology,* **33**(4): 161-168.

Neilsen, C.O. 1949. Studies on soil microfauna II. The soil inhabiting nematodes. *Natura Futlandica,* **2**: 1-131.

Pinochet, J., Verdejo, S., and Soler, A. 1990. Observations on the seasonal fluctuations of *Meloidogyne hapla* on Kiwi (*Actinidia delicosa*) in Spain. *Nematropica,* **20**: 31-37.

Porazinska, D.L., Mc Sorley, R., Duncan, L.W., Graham, J.H., Wheaton, T.A. and Parsons, L.R. 1998. Nematode community composition under various irrigation schemes in a citrus soil ecosystem. *Journal of Nematology,* **30**: 170-179.

Rama, K., and Dasgupta, M.K. 2000. Population ecology and community structure of plant-parasitic nematodes associated with ginger in Northern West Bengal. *Indian Journal of Nematology,* **30**(1): 42-45.

Ramana, K.V., Prasad, J.S. and Rao, Y.S. 1978. Influence of atmospheric conditions and soil temperature on the prevalence of the lance nematode (*Hoplolaimus indicus* Sher, 1963) in rice fields. *Proceedings of Indian Academy of Science B*, **87**: 39-43.

Sabir, N. 2000. Population fluctuation of important nematodes in the rhizosphere of papaya in Lucknow. *Indian Journal of Nematol*ogy, **30**(2): 261-263.

Sasser, J.N. and Freckman, D.W. 1987. A world perspective on nematology: the role of the society. In: *Vistas on Nematology, A commemoration of* the *25th. Anniversary of the Nematologists* (Eds. A. Veech and D. W. Dickson) Publ. Society of Nematologists, Inc. Hyaattsville, Merryland 87. pp. 7-14.

Sen, D., Chatterjee, A. and Manna, B. 2008. Population fluctuation of *Helicotylenchus* Steiner, 1945 in relation to soil temperature, moisture and pH in guava orchard at south 24-Parganas, West Bengal, India. *Records of the zoological Survey of India,* **108**(2): 75-81.

Sharma, V. and Kumar, R. 1989. The effect of soil temperature on the population of *Hoplolaimus indicus* (Nematoda : Hoplolaimidae) under tomato crops in Doon Valley. *Revista Parasitology* (1987), **4**(48): 215 – 218.

Song, M., Li, X., Jing, S., Lei, L., Wang, J. and Wan, S. 2016. Responses of soil nematodes to water and nitrogen additions in old-field grassland. *Applied Soil Ecology*, **102**: 53-60.

Srivastava, N., Rawat, V.S. and Ahmad, M. 2000. Seasonal population dynamics of plant parasitic nematodes associated with *Litchi chinensis* in Doon Valley, U. P. (India). *Indian Journal of Nematol*ogy, **30**(2): 256-257.

Todd. T.C., Blair, J.M. and Milliken, G.A. 1999. Effects of altered soil-water availability on a tall grass prairie nematode community. *Applied Soil Ecology*, **13**: 45-55.

Waele, D.D. and Wilken, R. 1990. Effects of temperature on the *in vitro* reproduction of *Ditylenchus destructor* isolated from ground nut. *Revue de Nematologie,* **23**(2): 171-174.

Wallace, H.R. 1973. *Nematode Ecology and Plant Disease*. Edward Arnold (Publishers) Ltd., 25 Hill Street, London, 228 pp.

Yeates, G.W. 2002. Pressure plate studies to determine how moisture affects access of bacterial-feeding nematodes to food in soil. *European Journal of Soil Science,* **53**: 355-365.