ARYAVART SHODH VIKAS PATRIKA
RNI TITLED NO. UPBIL04292
RNI REG. NO. UPBIL/2014/66218
PP. No.- 28-38
ISSN NO.-2347-2944 (Print)
e-ISSN NO.-2582-2454 (Online)
Vol.-18, No.- II, Issues-32, YEAR- April-June-2024

Study Of Correlation With Edaphic Factors And Plant Parasitic Nematodes In Sugarcane Crop

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Abstract: Nematodes are minute, eel shaped worms which live in all soils. The Nematodes possess a cuticle exoskeleton, simple digestive system, and longitudinal muscles for locomotion. Sugarcane is considered a cash crop due to its high economic value and importance as a source of income for many farmers and rural communities The influence of the host plant (tomato), temperature, pH , suction potential, osmotic potential and soil pore size on the hatch, mobility and invasion of the parasitic nematode Meloidogyne javanica were studied to try to define the conditions for maximum infection and to determine any characteristics of the nematode that increase its chances of invading the host. There are three phases of infection as defined in this paper: hatch, migration to the root, and invasion. The optimum temperature for hatching and for movement was about 25 to 30 °C and for invasion 20 to 30 °C. The optimum soil moisture for hatching, movement and invasion was in the region of field capacity when most of the larger pores have drained of water.

Key Words: Sugarcane, rural communities, temperature, suction potential, osmotic potential, mobility, invasion.

India have different types of soil and climates from temperate, subtropical to tropical. The sugarcane production in all types of zones is highly dependent on good disease management practices. All the crops of economic importance are severely affected by the insects and soil borne organisms like plant parasitic nematodes, virus, pathogenic bacteria, fungi and their combined disease complexes. The economic consequences of crop losses due to pests and diseases are to the farmer, consumer and ultimately the state and the Country. Hence, before initiating any pest management studies it is highly important to understand the impact of these pests and diseases including nematode population on crop yield. Plant parasitic nematodes are small, elongated, (0.3-2mm), pseudo coelomate eelworms of the phylum, Nematoda, when seen under microscope, plant parasitic nematodes are slender, un segmented usually shorter than 2 mm in length with serpentine mode of locomotion. Rarely is any crop free from attack of these tiny microscopic organisms. Nematodes are minute, eel shaped worms which live in all soils. The Nematodes possess a cuticle exoskeleton, simple digestive system, and longitudinal muscles for locomotion (Siddiqi, 1985). They may be classed as either free-living or plant parasitic. Majority of plant parasitic nematodes belong to the group known as endoparasitic. They classified under a single genus Meloidogyne (root-knot nematodes), Pratylenchus spp. (root lesion nematodes) and Heterodera spp. (cyst nematodes), which ranks the world's top three plant-parasitic nematodes. Other plant-parasitic nematodes constituting problems to tropical agriculture include; Globodera (cyst nematodes), Ditylenchus (stem and bulb nematodes), Tylenchulus (Citrus nematodes), Xiphinema (dagger nematodes), Radopholus (burrowing nematodes), Rotylenchulus (Reniform nematodes), Helicotylenchus (spiral nematodes), Belonolaimus (sting nematodes), and Scutellonema (spiral nematode).

The estimated annual yield loss of World's major crops due to plant parasitic nematodes has been reported to the extent of 12.3% (Sasser and Freckman, 1987) and the latest estimated annual yield loss of national major crops due to plant parasitic nematodes has been reported to the extent of Rs 21,068.73 million. In economic terms, nematodes cause an estimated loss of about $ 157 billion annually to world agriculture (Abad et al., 2011). It is estimated that annual crop loss due to parasitic nematodes in India accounts for about 21 million. However, In India, it was estimated as 21068.73 million rupees from the 24 major crops growing in the Country. In India, phytonematodes are reported to cause about 10-40 %yield loss in sugarcane crop and could as well go as high as 50-80% in some crops such as okra, tomatoes, brinjal, and potatoes etc; however, losses may become still higher if phytonematodes are associated with other biotic and abiotic stresses in the field. Plant parasitic nematodes cause considerable loss to worldwide agriculture (Chitwood, 2003; Abad et al., 2008; Fuller et al., 2008). However, extensive information on accurate economic loss is often lacking.

Uttar Pradesh is very big state of India. Therefore, the soil texture varies from district to district. There is a wide variation in the characteristics and properties of the soil in the state. However, on the basis of certain common features, the soil of the state is divided into following as: Loam soil, Sandy loam, sandy soil, alluvial soil, rocky soil, Stoney soil, saline and alkaline clay loam etc.

The composition of the soil nematode community depends on the vegetation present, soil type, season, moisture

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level, amount of organic matter, and many other factors because they are responsive to so many different factors like biotic and Abiotic. It is believed that plant parasitic nematodes may be used as bio-indicators of the condition of the soil environment (Chaubey and Malhotra, 1988). The biotic and abiotic factors influence the various stages and activities of plant parasitic nematodes and their relationship with the plant. The deleterious effects of plant parasitic nematode damage to certain crops can be offset to some degree by proper nutrition, moisture and protection from adverse environmental conditions. Practices that tend to offset the damage caused by nematode attack include irrigation, conservation of moisture by mulching, fertilization, protection of plants on cold nights and control of root and foliar diseases caused by other pathogens.

Plant parasitic nematodes have a sensitive relationship with their environment and they respond to the spatial and temporal dynamics of resources and stressors in soil habitats. Resources are the sources of nutrition and characteristic of the habitat that enable phytonematodes to survive and reproduce whereas stressors tie nematode biodiversity to fundamental attributes of ecosystems, the plants and microorganisms in a habitat upon which nematodes feed, natural and anthropogenic disturbances, physical and chemical properties of soil and climate. These attributes individually and collectively influence the structure and function of plant parasitic nematode biodiversity.

Two most important factors, temperature and moisture is affecting the vertical and horizontal distribution, spatial and temporal population dynamics, activity and survivality of these plant parasitic nematodes. These two factors also influence each other. Temperature determines the rate of moisture loss and evaporation causes cooling the temperature and moisture requirements for survival and optimum activity differs between and within phytonematodes species. Phytonematodes cannot move through the soil unless a film of moisture surrounds the soil particles. Under dry, hot conditions, nematodes become dormant, allowing them to survive for longer periods of drought (an-hydro-biotic condition). As soon as water becomes available they quickly come back to life of phytonematodes (hydro biotic condition).

Study of soil edaphic factors was done from collected soil samples of sugarcane field, these are soil pH, moisture, soil type, soil organic carbon, macronutrients and micronutrients was estimated with help of standard methods.

Sugarcane is an important crop for several reasons sugar production, ethanol production, food security, economic importance, soil conservation, and cultural significance. Sugarcane is liable to be attacked by a number of insect pests and diseases. According to an estimate, sugarcane production declines by 20% and 19% by insect pests and diseases respectively. Some attack insects, some feed on bacteria while others feed on fungi. Still some other nematodes attack and eat other nematodes. These nematodes are being exploited for biological control of other crop pests and pathogens as insects, fungi and weed. To increase the crop productivity, management of insect-pest and diseases is of great significance. Due to diversity in agro-ecological conditions the importance of insect pests and disease varies and therefore, management strategy should be adopted accordingly. Sugarcane is infested by about 288 insects of which nearly two dozen causes heavy losses to the quality as well as quantity of the crop.

Nematodes are microscopic, wormlike animals that live saprophytic ally in water or soil or as plant or animal parasites. They are the most numerous multicellular organism out numbering even insects in species number. They inhabit all ecological niches, from the top of the mountain to the bottom of the ocean. Even particles of dust carry nematodes. In terms of global distribution 50 % of nematodes inhabit marine water, 35 % live in fresh water and soil while the remaining 15% are found in animal tissues including humans. Nematodes have also been characterized as a tube within a tube, referring to the alimentary canal which extends from the mouth at the anterior end, to the anus located near the tail. They possess digestive, nervous excretory and reproductive system but lack a discrete circulatory and respiratory system.

Climatic and soil conditions, varieties of plants, cropping sequences and various agricultural practices are reported to determine the spread of different genera and species of plant parasitic nematodes in a particular region (Mukhopadhyaya and Prasad, 1986). Survival of most of the phytonematodes and their abundance will be noticed at 150C to 300 C temperature (Ferris, 1985; Kimpinski, 1985). The nematodes become inactive when the temperatures range is below 00C to150C. At high temperatures that range between 300C to 40oC nematodes become inactive (de Leij et al., 1992).

In our studies we noticed that less number of phytonematodes was recorded in summer due to high temperature and these observations are in tune with the statement given by de Leiz et al., (1992). Mehta et al., (1993) concluded that soil types of different location are probably most important factor controlling the spread of nematode species in different areas the result of the present study showing wide variations in phytonematodes population is in conformity with the above findings. Nematodes cold tolerance varies with the environmental changes and thus they may adapt to the most useful and optimized strategies (Wharton et al., 2005).The mechanism of frigid tolerance of nematodes is achieved by survival of nematodes under freezing conditions with water freezes only extra cellular and which in turn finally results in frigid tolerance. This phenomenon is more widespread among nematodes than frigid avoidance (Shapiro-Ilan DI et al., 2006). Frigid avoidance means that nematodes can avoid the formation of ice in their body fluids by means of getting super cooling point down (Dai et al., 2006).

MATERIALS AND METHODS- The present study was carried out in Meerut Districts of Western Uttar Pradesh where sugarcane was extensively grown. The study was divided in the following steps:

Collection and processing of samples.
Study of soil Edaphic factors
Extraction and mounting of nematodes
Identification of nematodes
Study of population dynamics
Data Analysis
Statistical Analysis of data

STUDY OF SOIL EDAPHIC FACTORS- Study of soil edaphic factor was studied in collected soil samples in the laboratory of Delhi road Meerut. The soil pH, soil humidity, soil temperature, soil type and soil organic carbon was estimated with the help of standard methods.

The edaphic factors were categorized into three major groups-

MAJOR EDAPHIC FACTORS- Temperature: Soil temperature was measured on the spot at each depth and distance with the help of dial thermometer in both summer and winter season. Highest population of nematodes in Feb. to March and September to November and lowest population of nematodes in June to August. The measured data are presented as in (Table-1& 2).

pH: The pH of the soil was measured by pH meter using 1:4 (soil: water) suspension. The measured data are presented as in (Table-6&7).

Moisture: It was measured by dry and wet weight method. Soil samples, collected from all the depths and distances, were sealed in polythene bags and carried to the laboratory to determine the percentage of the soil moisture. The 200g of soil was weighed (fresh weight) and dried in the oven at 1050C for 24 hrs. and weighed (dry weight) adopting the method as given by Mishra (1968). Moisture content was calculated with the help of following formula:-

%Moisture = (fresh weight-Dry weight)/(Dry weight)×100

The recorded data was presented as in: mean monthly data was quantified at 10-15cm up to 15cm vertical distances from the roots of sugarcane (Table-6&7).

DATA ANALYSIS- Percentage frequency of occurrence was determined using the following formula:

n/N×100

n= number of times an individual occurred in all samples.

N=sample size (380)

Also, the percentage nematode population was calculated using the formula:

In/TN×100

In = individual nematode population in all the samples

TN = the total population of all the nematodes extracted in all samples.

7. STATISTICAL ANALYSIS OF DATA- Analysis of variance (ANOVA) was carried out after nematodes counts using statistical analysis systems (SAS) and means separate by Fishers least significance difference test at a 5% probability level (p?0.05) and other indices using MS Excel and correlations using SPSS (21version).

OBSERVATIONS- The present study was carried out in Meerut Districts of Western Uttar Pradesh where sugarcane was extensively grown. Sugarcane is the main cash crop of this region. Extensive survey was conducted throught the Meerut districts to collect soil & root sample from sugarcane fields in the Western Uttar Pradesh. Soil samples were collected randomly, for the distribution pattern with various factors of some dominant Ecto-parasitic and Endo-parasitic Tylenchids. Samples were collected from all the three tahseels of district Meerut. At least ten villages were selected from each tahseel and about 10 fields from each village for collection soil and root samples. The number of samples collected from each field were five from each corner and one from the center of the field. All five samples were mixed to make a mixed sample of a field. Thus, three hundred soil sample and root sample from successive crop were collected from district Meerut.

STUDY OF SOIL EDAPHIC FACTORS- The analysis of soil edaphic factors was conducted in soil testing laboratory of soil conservation department of U.P. government, Meerut. The soil pH, soil Moisture, soil temperature, soil type and soil organic carbon, Phosphorus, Potassium, Sulphur, Copper, Zinc, Manganese and Iron.(Table-1&2).

Temperature is an important environmental factor for various phytonematodes. Different nematodes have their own optimal temperatures for normal activities and high and low temperature limits they can tolerate. The present study indicated the marked decrease in population of nematodes in high temperature ((44oC-46oC) during summer season (such as May, June.) whereas an increase of population of nematodes were revealed in early and mid of winter season (180C - 270C), (Table - 1&2). About 270C to 340C is suitable temperature for survival of phytonematodes. Population of Hoplolaimus spp was observed in all season, maximum population of Hoplolaimus spp were observed in the month of September and March. Soil temperature was measured on the spot at each depth and distance with the help of dial thermometer.

Survey of soil edaphic factors especially, temperature were recorded data in summer and winter season. Maximum temperature (44oC-46oC) show in June and July and minimum temperature (4oC-12oC) show in December and January. The highest population of plant parasitic nematodes were recorded in February to March and September to November and lowest population of nematodes in June to August observed in sugarcane cultivated fields of District Meerut (Table-1& 2).

The observations revealed that highly significant positive correlations with soil moisture and total population of plant parasitic nematodes at 10-15cm depths. The observations of the effect of moisture infesting sugarcane fields were recorded as: ($r = .487$; $P < .0.03$) and ($r = 0.445$; $P < 0.001$) from the sugarcane fields (Table-5).

The 24 months study revealed that highly positive correlations with population of plant parasitic nematodes infesting the sugarcane fields (Table-6&7, Fig.2).

The effect of soil pH on the positive correlations with populations of plant parasitic nematodes. However, few exceptions were also recorded although they were insignificant. The results indicated the positive correlations at linear analysis. The fluctuating populations of plant parasitic nematodes were observed at higher concentration of hydrogen ion in the soil of sugarcane. The insignificant positive correlations were recorded ($r = .120$; $P < 0.014$) and the significant negative correlations were also recorded ($r = .120$; $P > .382$) respectively (Table-5).

The results showed significant negative correlations between copper with nematode population indicated the high degree positive correlations (Table-5; Fig.5, 6).The significant positive correlations were recorded as ($r = .330$; $P < .019$) from the host crop during this periods.

Fig: 1: Collection site map

The results indicated a significant population of plant parasitic nematodes on the different soil textures. The highest population of nematodes was found in areas having sandy soil (Partapur, Sarswa) and lowest population was found in the cane field having clayey soils (Daurala). In this study soil sampling from different sugarcane fields showed a significant difference in plant parasitic nematodes population, highest being at Meerut tahseel.

Result and discussion- Soil texture and structure affect nematode movement directly through their effects on pore size. Small pores in clay soils prevent nematode passage so that nematodes must move in the spaces between aggregates. The larger pores in coarse sands may be too big to allow nematodes to gain average between particles. Nematodes therefore tend to reproduce best in fine sands, sandy loams and well-aggregated loams and clay loams. Population of plant parasitic nematodes differed in a season depending on the capacity of host (sugarcane) susceptibility as demonstrated by many workers (Minton Cairns and Smith, 1960). The investigation were co-relate with the findings of Showler (2016) who observed That the physiochemical and physical changes in sugarcane plants associated with water deficit stress and soil richness offer important clues for breeders. Sugarcane cultivars that are drought tolerant accumulate relatively low concentrations of certain nutrients (e.g., free essential amino acids and fructose), and that have leaves that do not curl on drying will probably have moderate to

ISSN NO.-2347-2944 (Print)
e-ISSN NO.-2582-2454 (Online)
Vol.-18, No.- II, Issues-32, YEAR- April-June-2024

strong resistance against E. loftini.

Temperature is an important environmental factor for organisms. Different organisms have their own optimal temperatures for normal activities and high and low temperature limits they can tolerate. The present study was undertaken to record biodiversity, to correlate the soil major edaphic factors (such as temperature, moisture and pH), macronutrients like organic carbon, phosphorus, potash, nitrogen, sulphur, and nitrogen) and micronutrients (copper, zinc, iron and manganese). The study was also centered on to reveal the edaphic factors affecting sex ratio fluctuation of the dominant phytonematodes. Moisture plays an important role in the movement of the soil organism. The findings indicated that during winter period when moisture and humidity is high in soil environment conditions. Populations of plant parasitic nematodes were highest in this season. The present study observed positive correlation of total nematodes population with the work of some nematologists (Anita & Chaubey, 2004; Verma and Jain 2001; Sharma and Trivedi 1995; Chaubey, 1994; Das and Mishra, 1982 Showler, A. T. 2016).

These findings are also in agreement with the findings of Rajendra Singh and Umesh Kumar (2015) have been stated that ten genera of plant- parasitic nematodes other than root-knot have also been reported associated with vegetable crops, including Rotylenchulus sp. Xiphinema sp. Hoplolaimus sp., Tylenchorhynchus sp. Pratylenchus sp. Heterodera sp. Aglenchus sp. Aphelenchus sp. Discolaimus sp. Boleodorus sp. The present investigation observed the marked decrease in population of plant parasitic nematodes during in hot dry season especially in June and July and very cool season especially in December to early January. The maximum populations of plant parasitic nematodes were followed by early and late winters.

Similarly, in the present studies the larger population of plant parasitic nematodes also recorded in September about 2567/500 gm soil during this study. These findings observed that maximum population was recorded during late summer and early winter season because of the high moisture contents and medium temperature in soil due to irrigation and natural rain that also help in to movement of the nematodes towards the deeper strata of the soil.

In the present investigation there is marked, the edaphic factors of soil environment that act as limiting factors, temperature was found to be detrimental to that of the total nemic population of plant parasitic nematodes infesting the sugarcane respectively during the 24 months of the study(Table-1,2&5).

These observations indicated that the presence of highest population of plant parasitic nematodes during late summer and early in winter season because of the high moisture contents in soil due to irrigation that also help in to movement of the nematodes towards the deeper strata of the soil. The edaphic factors of the soil environment that act as limiting factors, such as temperature was found to be detrimental to that of the total nematodes population under the host sugarcane respectively, during the 24 months of study. The results of the effect of temperature on studied nemic population were recorded as: (Table-3&4).

The investigation of seasonal fluctuations in the population of phytonematodes can be correlated with the earlier workers (Norton, 1959; Prasad and Chawla, 1965; Khan et al., 2011; Malhotra and Chaubey, 1990). The present study can also be correlated with work of Jonathan and Rajendra et al, (2015) they observed minimum population during the dry season and maximum population of phytonematodes during the early winter season. The investigation were correlate with the findings of Santana-Gomes et al., (2013) reported that the plant mineral nutrition can be considered an environmental nutrition factor that can be manipulated relatively easily, and is an important component in disease control, as well as a tool for managing phytonematodes reported to be causing losses in countless important agricultural crops.

Temperature was a major environmental factor influencing the behavior of the plant parasitic nematodes. Soil temperature was the most constantly changing factors that nematode encounters. The diurnal fluctuations vary greatly depending on the atmospheric conditions, season of the year and the other factors. Such fluctuations might be due to differences in soil texture was identified as clay loam in which sand percent was determined 60%. Soil with high sand content was more suitable for movement of plant parasitic nematodes. The investigation of seasonal fluctuations in the population of phytonematodes can be correlated with the earlier workers (Oka, 2007; Tsai, 2008).

The investigations of soil factors are interrelated and one factor affects the other and ultimately influenced the population of phytonematodes. Amongst the soil edaphic factors, the soil temperature and moisture are the most important factors to the population of phytonematodes. Temperature is an important environmental factor for plant parasitic nematodes. Nematodes have their own optimal temperatures for normal activities and high and low temperature limits they can tolerate. Some traditional ways of Phyto-nematode management strategies, such as solarization, crop rotation, and fallow, may be useful alternatives to chemical nematicides. Solarization controls nematodes by the heat from solar energy. It requires information on the response of nematodes to high temperatures. Crop rotation reduces nematode population by growing non-host or poor host plants to limit accessibility of food to phytonematodes. The duration phytonematodes can survive without food is also influenced by temperature because consumption of the reserved energy is dependent on the level of activity which is influenced by temperature.

Soil environment played important role in the seasonal population fluctuation of the plant parasitic nematodes. Soil temperature is a major factor influencing plant parasitic nematode development. Diurnal fluctuations in temperature vary in extent and depend upon soil type, texture, moisture, atmospheric conditions, latitude, elevation, season and soil cover. Fluctuations are greatest at the soil surface and decrease with increasing depth. In tropical regions, plant parasitic nematodes multiply throughout the year but in subtropical and temperate climates, most of the important plant parasites are most active during the warm summer months, when soil temperatures of 250-350C are common. Cool climate species often develop slowly in winter and become more active when temperatures rise in spring.

In the present study that population of phytonematodes observed inverse relation to soil temperature. However, a converse relation was observed ($r= 0.397$; $P < 0.29$) and highly positive correlation recorded as ($r=0.360$; $P < 0.10$) from sugarcane crop. The influence of temperature on nematode reproduction may turn affect plant growth and productivity. The results of the present investigation can be correlated with the work of Khan et al., (1971) reported no definite correlations in the population of Hoplolaimus spp. and Helicotylenchus sp. to soil temperature around crops. Temperature-induced phase transitions in the lipid positions of the biological membranes had been related to thermal susceptibility in M. javanica (Lyons et al., 1975).

The linear regression analysis of the present investigation strongly revealed the negative influence of soil temperature on the population dynamics of plant parasitic nematodes around the studied crop. The optimum phytonematodes were observed around 280C to 320C soil temperature in sugarcane fields at 10-15cm. The results are also in conformity with the observations of A. T. Showler (2016: Choudhary and Sivakumar (1999), where they had reported the negative effect of temperature on the nematode population at 0.0-10 cm depth. Significant negative correlations were observed between the soil temperature and nematode population, Tsai, B. Y. 2008; Muzna et al., 1998; Anita and Chaubey, 2003). These observations revealed that temperature was found to be more effective to minimize the population of phytonematodes than the other edaphic factors.
Moisture plays an important role in the movement of the soil nematode population. The findings indicated that during winter period when moisture and humidity is high in soil environmental conditions. The sandy -clay soil are composed of extremely small particles, have an enormous surface area, small particles, have an enormous surface area, small pores and thus have a great water retaining ability. This also tends to increase the reproductive index of phytonematodes.

Present study showed the relationship between the nematode population levels and the soil type. Comparatively higher number of nematodes was observed in sandy soils than in other types of soil. Sandy soils provide better aeration and better porosity for nematode migration which leads rapid multiplication. These findings were co-relate with the findings of Many other workers (Tsai, B. Y. 2008; Wallace, 1958; Williams, 1963; Hu & Chu, 1964) also observed that the population of nematodes was generally larger in sandy and light soils than in other soil types.

The present investigations revealed that population of plant parasitic nematodes were at high density during the early and late winter. Phytonematodes can move freely in moist than in soil and therefore may exhaust their energy. Nematodes were more sensitive to high soil moisture gradient as compared to lower gradients in turns of nematodes reproduction and establishment. The soil moisture content between 24-30% appears to be the most favorable range for higher populations of nematodes in the area. Throughout the world nematode populations differ qualitatively and quantitatively with soil factors, climate and altitudes.

The present study showed positive correlations of phytonematodes with soil moisture which can also correlated with the work of some nematologists (R. A., Wilschut et al. (2019); Delcour, I., Spanoghe, P. and Uyttendaele, M. (2014). Tsai, B. Y. 2008; Showler, A. T. 2016: Anita & Chaubey, 2003; Chaubey, 1994). The observations of the present study revealed that the plant parasitic nematodes were more sensitive to high soil moisture gradient for reproduction, multiplication and for easy movement in around the host (sugarcane crop). The 24 months study revealed that highly negative correlations with population of plant parasitic nematodes infesting the sugarcane fields during this periods (Table-1, 2 &5). The influence of moisture was observed ($r = .487$; $P <0.03$) and influence of moisture was observed ($r = .487$; $P < 0.03$) and ($r =0.445$; $P < 0.001$) from the sugarcane fields.

ISSN NO.-2347-2944 (Print)
e-ISSN NO.-2582-2454 (Online)
Vol.-18, No.- II, Issues-32, YEAR- April-June-2024

The functional linear regression trends showed significant correlations were during this periods (Table-5). However, insignificant positive were recorded (r = .017; P > .903).

Effect of pH (hydrogen ion concentration) on the occurrence and biology of phytonematodes have been acquired little observations. There are some negations indicating complimentary factors, which are bound to exist in such a complex environment as soil. Although much is known about soil pH and less is known its effect on phytonematodes.

The pH of the soil was found to range between 4.5-5.5 which is acidic and conducive for the production of tea. There was no significant correlation between the number of nematodes and the pH; this could be attributed to the adaptation of nematodes to survive in such acidic conditions. The acidic medium of the soil is harmful not only for the nematode population but also harmful for the beneficial living biota of the soil environment. According to Kanyanjua et al., 2002 acidic soils have a pH of less than 7.0, the traditional ecological zone map of Kenya, areas with acidic soils are referred to as 'tea-dairy', 'coffee-tea' and 'main coffee' climatic zones.

Data of the present observations reported that the hydrogen ion concentration showed the positive correlations with population of phytonematodes infesting sugarcane crop. Our findings are similar to the findings of Kago et al., (2013) reported that a significant correlation relationship was established (r=0.415, P<0.05) between the Plant Parasitic Nematodes and the soil pH although the relationship was not significant (P>0.05) in Root Knot Nematodes, Filenchus and Tylenchulus species.

The results indicated the negative correlations at linear analysis. The fluctuating populations of plant parasitic nematodes were observed at higher concentration of hydrogen ion in the soil of sugarcane crop. The significant correlations were recorded (r = .120; P <0.014) during 2013-14 and the insignificant correlations were also recorded (r = .120; P>0.382) (Table - 5). Our findings are similar to the findings of IPCC (2019) reported that soils with extreme pH (6.0-10) are not suitable for the reproduction of Meloidogyne sp. in vegetable crop. Accordingly R. A., Wilschut et al. (2019) reported that pH range 7.1-7.8 is suitable for the reproduction of Hoplolaimus indicus on citrus and similar work of Okulewicz, A. (2017) observed that pH ranged between 6 - 7.5 was preferable pH for Pratylenchus sp., where this nematode attained its maximum population.

Our observation that Soil pH seems to be important for phytonematodes activity, although the probable effects are indirect, due to the alteration of the micro biota in the soil and the availability of micronutrients to sugarcane crop, Where pH values higher than 6.0 intensified the damage caused by the plant parasitic nematode and immobilized micronutrients (zinc, iron and copper) in the soil, causing deficiencies in the plants and reducing natural parasitism on eggs and cysts. Similar work done by Rocha et al., 2006 that pH values higher than 5.0 intensified the damage caused by the nematode and immobilized micronutrients in the soil.

In the present study the change in pH also related to change in other factors. Therefore, it is difficult to separate the influence of one from the other. Although plant parasitic nematodes seemed to tolerate wide pH (5-7) range, there are limits in which the hydrogen ion affected by pH and ultimately becomes toxic. The host (sugarcane) parasite interaction indicated that the pH in soil and other factors affect the crop growth relative to phytonematodes and thus host may be under stress and that phytonematodes damage is enhanced in and around the sugarcane crop. In a long-term study by IPCC (2019), they observed that combinations of high Copper and low pH significantly reduced the number of bacterial-feeding nematodes, whereas the number of hyphal-feeding (fungivorous) nematodes increased. Their results suggested that the nematode community structure was indirectly affected by Copper and pH via other components of the soil food web by Martin Moluwa Matute (2013).

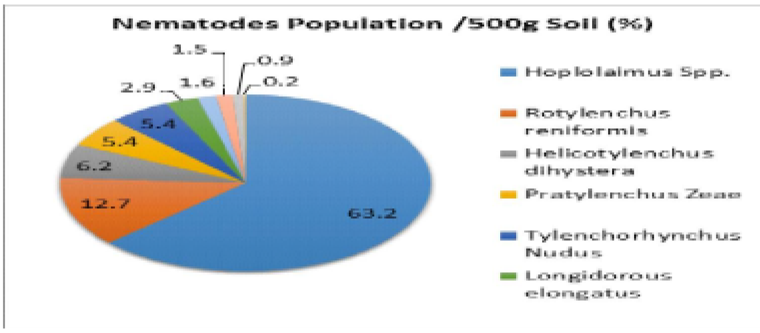

Fig: 2: Nematode population in Sugarcane cultivated fields of district Meerut

ISSN NO.-2347-2944 (Print)
e-ISSN NO.-2582-2454 (Online)
Vol.-18, No.- II, Issues-32, YEAR- April-June-2024

Accordingly, Warner, (2009) that soybean cyst nematode population densities are often highest in soils of pH 7.0 or higher as compared to areas of soil pH 5.9-6.5, in their field and laboratory studies. Hoogen, J., Geisan, S., Routh, D. et al. (2019).The greatest numbers of Pratylenchus spp. colonized soybean roots at pH 6.0. Hoplolaimus spp and members of the Tylenchinae-Psilenchinae survived best at pH 6.0, while members of the Dorylaimoidea were greatest at both pH 6.0 and 8.0. The non-stylet nematodes were recovered in greater numbers from pH 8.0 soils. Nematodes were fewest at pH 4.0 in the soil. Hence, it is the evident that some nematode groups thrive best in acidic conditions while others are favoured by alkaline soil conditions.

Conclusion- The temperature was detrimental to that of the total nematodes population of the plant parasitic nematodes. Temperature was observed important to minimize the population of phytonematodes.

Moisture indicated the insignificant positive correlations with dominant plant parasitic nematodes.

There is need to educate local farmers on the large diversity of phytonematodes associated with sugarcane fields and their damage potentials by creating awareness programmes. Screening of seed plants and regular plant quarantine services should be employed prior to the introduction of new varities of sugarcane farmers and also, more effective phytonematodes management stragies should be considered in order to improve yield in sugarcane plantations.

Table -1: Showing monthly values of soil edaphic factors of top soil from different Sugarcane cultivated fields. (Site-1).

Months	Temperature (°C)	Moisture (%)	pH
May	39.93±std3.08 (36.22-44.03)	0.93±std,1.06 (0.02-2.23)	7.52±std,0.14 (7.30-7.70)
June	44.01±std,3.47 (40.22-48.44)	0.71±Std,0.47 (0.09-1.32)	7.54±Std,0.08 (7.40-7.60)
September	35.38±Std,1.73 (33.01-37.33)	3.18±Std,0.98 (1.89-4.02)	7.48±Std,0.14 (7.30-7.70)
October	25.69±Std,1.18 (24.01-27.22)	27.04±5.23 (22.01-33.03)	7.52±0.08 (7.40-7.60)
November	22.03±Std,1.37 (20.33-24.03)	25.01±2.36 (22.02-28)	7.54±0.15 (7.30-7.70)
December	17.87±2.02 (15.33-20.03)	20.63±1.76 (18.33-23)	7.54±.114 (7.40-7.70)
January	11.31±3.22 (8-15.33)	22.43±1.72 (20-24.78)	7.50±0.10 (7.40-7.60)
February	23.85±1.96 (21.01-26.02)	10.02±4.73 (6.02-19.03)	7.46±0.89 (7.40-7.70)
March	30.50±2.05 (28.09-33.06)	3.71±1.37 (2.01-6.03)	7.52±0.10 (7.40-7.70)
April	32.67±3.57 (29.02-38.45)	1.39±0.67 (0.56-2.06)	7.50±0.15 (7.50-7.90)

Table-2: Showing monthly values of soil edaphic factors of top soil from different Sugarcane cultivated fields. (Site-2)

Months	Temperature (°C)	Moisture (%)	pH
May	41.15±1.5 (39.22-0.43)	1.53±0.96 (.08-2.34)	7.56±.114 (7.40-7.70)
June	43.57±2.97 (40.01-47.31)	1.03 ±0.76 (0.01-2.02)	7.54±.151 (7.30-7.70)
September	35.69±1.96 (33.22-38.01)	0.85±0.44 (.49-1.56)	7.60±.100 (7.50-7.70)
October	26.09±1.51 (24.22-28.01)	3.54±1.99 (1.23-5.63)	7.60±.187 (7.40-7.90)
November	22.96±1.62 (21.22-25.01)	22.08±1.82 (19.68-24.02)	7.08±.192 (6.80-7.30)
December	13.26±2.61 (10.02-16.11)	18.47±1.75 (16.01-20.01)	7.16±.089 (7.10-7.30)
January	10.33±2.45 (8.23-14.33)	3.35±2.05 (2.01-6.68)	7.34±.151 (7.10-7.50)
February	16.26±4.2 (10.22-21.66	3.11±0.75 (2.01-3.78)	7.10±.245 (6.80-7.40)
March	30.85±2.53 (28.22-34.02)	7.39±1.27 (6.01-9.03)	6.96±.135 (6.80-7.10)
April	40.53±3.11 (37.01-44.22)	11.26±2.77 (9.02-16.06)	7.32±.238 (7.00-7.60)

Table-3: Month wise population dynamics of Plant parasitic Nematodes infesting Sugarcane crop. (Site 1).

Serial No.	Months	Temperature (°C)	No. Of Population Of Nematodes/500gm
1.	May	39.93±3.08 (36.22-44.03)	1143.60±223.09 (890-1446)
2.	June	44.01±3.47 40.22-48.44)	999.20±90.89 (873-1120)
3.	September	35.38±1.73 (33.01-37.33)	2271.60±232.11 (1975-2528)
4.	October	25.69±1.18 (24.01-27.22)	1280±149.71 (1098-1470)
5.	November	22.03±,1.37 (20.33-24.03)	1919±542.13 (1008-2374)
6.	December	17.87±2.02 (15.33-20.03)	819.20±218.69 (586-1105)
7.	January	11.31±3.22 (8-15.33)	1367±150.28 (1165-1531)
8.	February	23.85±1.96 (21.01-26.02)	1860±59.82 (1765-1931)
9.	March	30.50±2.05 (28.09-33.06)	774.80±163.83 (565-980)
10.	April	32.67±3.57 (29.02-38.45)	1919±542.13 (1008-2374)

Table-4: Month wise population distribution of plant parasitic nematodes infesting Sugarcane (Site 2)

Serial No.	Months	Temperature (°C)	No. Of Population Of Nematodes/500gm
1.	May	41.15±1.5 (39.22-0.43)	1319.80±103.36 (1230-1460)
2.	June	43.57±2.97 (40.01-47.31)	1065.60±107.14 (978-1221)
3.	September	35.69±1.96 (33.22-38.01)	2327±254.80 (2017-1375)
4.	October	26.09±1.51 (24.22-28.01)	1326±119.71 (1186-1496)
5.	November	22.96±1.62 (21.22-25.01)	1163.60±155.24 (1021-1375)
6.	December	13.26±2.61 (10.02-16.11)	995±81.53 (875-1102)
7.	January	10.33±2.45 (8.23-14.33)	814±122.10 (655-980)
8.	February	16.26±4.2 (10.22-21.66	1056.80±82.37 (991-1191)
9.	March	30.85±2.53 (28.22-34.02)	1196±119.51 (1098-1371)
10.	April	40.53±3.11 (37.01-44.22)	682±225.62 (365-902)

Table -5: Functional linear regression depicting correlation of soil edaphic factor with plant parasitic nematodes with host (Sugarcane).

S. No.	Soil Edaphic Factor	2013-2014	2014-2015
1.	Temperature	Y= 1099.12+12.02 r =0.397; P <0.029	Y= 842+13.26 r =0.360; P <0.10
2.	pH	Y = 3366.11 – 260.27 r = 0.120; P >0.382	Y = 2731.18 – 215.41 r = 0.330; P <.019
3.	Moisture	Y = 1437.75+ 192.81 r = 0.487; P <0.405	Y = 964.26+25.81 r = 0.445; P <0.001
4.	Organic carbon	Y= 1516.61–221.59 R = 0.55; P > 0.691	Y= 1043.45 ± 348.62 R = 0.138; P > 0.338

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