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Plant Parasitic Nematodes: A Critical Challenges for Agricultural Sustainability

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ABSTRACT:
Phytonematodes are obligate parasites, meaning they rely entirely into roots of crops or plants for their survival and reproduction or other activity. Phytonematodes can be identified by their specialized or fine feeding structures called stylets—needle-like mouthparts used to pierce plant cells and withdraw nutrients. These nematodes range in size from 0.3 to 3 millimeters and are often invisible to the naked eye, making early detection challenging. Plant parasitic nematodes are a silent but serious threat to global agriculture. Effective management requires early detection, a combination of cultural practices, and the use of resistant crop varieties. By addressing this issue, farmers can safeguard crop productivity and reduce economic losses caused by these microscopic pests.

Keywords: Sugarcane, Plant Parasitic Nematodes, Soil Sample, Root Sample.

INTRODUCTION:

Plant parasitic nematodes are microscopic, worm-like organisms that feed on plants, causing significant damage to crops worldwide. Unlike beneficial nematodes that support soil health, plant parasitic nematodes are harmful and can be considered major agricultural pests. They invade plant roots, stems, leaves or seeds, extracting nutrients and often introducing pathogens, which weakens the plant and reduces crop yields. Plant parasitic nematodes are a major cause of crop loss in agriculture, affecting cereals, fruits, vegetables and ornamental plants. They reduce crop yields. By impairing root systems, nematodes limit the plant's ability to absorb water and nutrients. They weaken plants as infested plants are more susceptible to drought, diseases, and secondary infections. They transmit pathogens as some nematodes carry harmful viruses, compounding the damage. Lastly, nematode infestations result in billions of dollars in global crop losses annually. Sugarcane is the World's major cash crops providing about 75% of the sugar harvested for human consumption (FAO 2004). FAO estimates it was cultivated on about 23.8 million hectares, with a worldwide harvest of 1.69 billion tones. India was the second largest producers with 277,750,000 tones than Brazil. The yield gap of sugarcane in India with respect to 10 major sugarcane producing countries during the last 5 years is ranges 1.33 – 31.22t/ha. Nematodes are present in a habitat and in proximity of hosts conducive to their development, they may rapidly multiply. A major global challenge in the coming years will be to ensure food security and to feed the increasing human population. Nowhere will the need to sustainably increase agricultural productivity in line with increasing demand be more pertinent than in resource poor areas of the world, especially India, where populations are most rapidly expanding. It is essential that the full spectrums of crop production limitations are considered appropriately, including the often overlooked nematode constraints. Plant parasitic nematodes species obtain food directly or indirectly

from plants either feeding on roots or stem portions. The problems caused by phytonematodes are common, which was a highlighted by Severino *et al*; (2010). At present 48 genera and 310 species of endoparasitic and ecto parasitic nematodes species have been reported to be associated with rhizosphere soil and roots of various crops including sugarcane (Cadet and Spaull, 2005). Species of five genera namely *Hoplolaimus, Helicotylenchus, Pratylenchus, Tylenchorhynchus* and *Meloidogyne* is listed as major plant parasitic nematodes with wide distribution and common occurrence in soil of India (Mehta *et al*., 1992). A disease complex, known as stubble decline, is responsible for reductions in the ratooning ability of sugarcane crop (Edgerton *et al*., 1934; Edgerton, 1939).

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, plant parasitic nematodes are reported to cause about 10-40 %yield loss in sugarcane and could as well go as high as 50-80% in some crops such as okra, brinjal, and potatoes etc; however, losses may become still higher if plant parasitic nematodes 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.

Showing, the most common symptoms are: root lesions, root pruning, root galling, and cessation of plant roots. Roots damaged by nematodes cannot efficiently use the water moisture and nutrients available in the soil. Among different plant parasitic nematodes, root knot nematodes are by far the most important. Their easily recognized galls on the roots make their presence obvious. Galls result from growth of plant tissues around juvenile nematode, which feed near the center of the root. Root-knot gall tissue is firm without a hollow center, and is an integral part of the root; removing a root-knot gall from a root tears root tissue.

A common feature of plant parasitic nematodes on annual crops is that they have an uneven distribution within a field and the symptoms of damage, normally associated with high population densities, occur in patches (McSorley, 1998). Where a susceptible annual crop is replanted year after year the nematodes spread and the patches increase in size and eventually coalesce. Sugarcane is one of the major cash crop of Meerut region, Uttar Pradesh state of India. In India Uttar Pradesh is the major sugarcane growing state, contributing about 48% of the area and 40% of the production. Maharashtra is the second largest producer of sugarcane after Uttar Pradesh in area and after Tamilnadu in productivity. In India sugarcane is mainly used for the production of white sugar (50%), Gur and Khandsari (40%). Molasses, an important by-product of sugar industry is used for alcohol production. The objective of this work was to identify most important plant parasitic nematodes associated with sugarcane crop of district Meerut. Plant parasitic nematodes are a significant threat to global food security and sustainable agriculture. Ongoing research aims to improve our understanding of their biology, ecology, and management. The distribution and taxonomic study has great significance to overcome the problem of these nematodes. It will provide the appropriate management tools and practices to control the population of the plant parasitic nematodes according to the cropping patterns of the particular agriculture areas. .

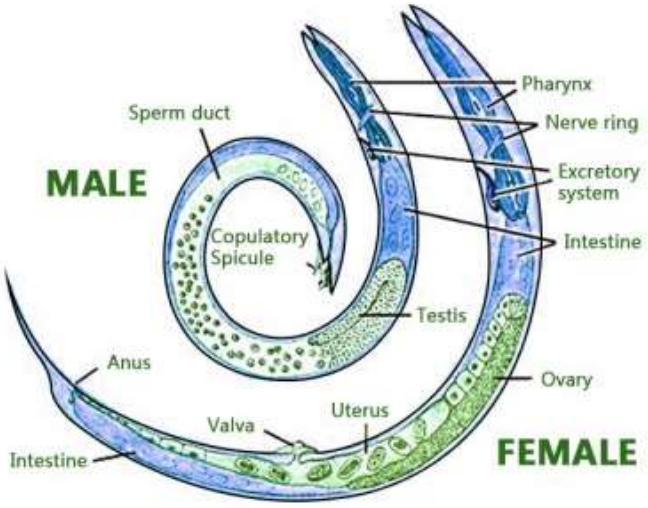
MATERIALS AND METHODS:

1. NEMATODE EXTRACTION FROM ROOTS AND SOIL:

Endoparasitic nematodes can usually be seen by examining small amounts of plant tissue with a stereoscopic microscope at magnifications from 15x50x using transmitted/or incident light. Roots should be gently washed to remove as much soil as possible. Small pieces of plant parts, such as roots, stem, leaves, buds and seeds, may be examined in clear water by tearing the tissue apart with dissecting needles. Endoparasitic nematodes if present, will float out and can be collected with a handling needle and fixed in 3% formaldehyde and sent for species identification in a vial. Immature females may be seen on the outside of roots. The white, yellow or golden flask shaped females may be seen attached to the surface of the roots. The brown leathery, flask shaped cysts are the swollen, egg-containing bodies of the females which have matured and fallen into the soil from the roots and are approximately the size of a pinhead, visible to the naked eye. Place a soil sample (approximately 250 ml) into bucket. Stir with hand and break up clumps of soil while adding tap water to bucket (approximately 3/4 full). When solution is uniform, wait 30 seconds for some of the heavy sediment to settle, lift bucket gently and pour through the stacked sieves (20, 60, 325) at one time (leaving the settled sediment in the bottom of the bucket). Discard the 20 mesh sieve. Collect cysts and large eel-shaped forms from 60 mesh sieve by back washing into a beaker. Collect other eel-shaped forms and larvae from 325 mesh sieve by backwash into a separate beaker. After the beakers have settled for about an hour, decant the water from the top (sometimes dry old cysts can be seen floating on top) and add 3% formaldehyde solution to the rest of the material. Let settle down again, decant and place the rest in a vial for further study and identification purposes. .

RESULTS AND DISCUSSION:

During this study period from June 2022 to May 2023 it was observed that there is diversity of plant parasitic nematode associate with sugarcane crop in Khultabad taluka Aurangabad region. The highest diversity was recorded of genus Dorylaimus, Meloidogyne and Partylenchus from all visited fields of the sugarcane crops. As a result the population of nematodes in sugarcane fields causes decline in sugarcane productivity (Shuddhodhan Ratnaparkhe and Deepak Gaikwad 2025). The current study disclose some new facts about plant parasitic nematode from Meerut region around the sugarcane root zone. I have identified seven genera which are belonging to genus Meloidogyne, heterodera, pratylenchus, dorylaimus, xiphinema, monhystera and hoploaimus etc. meloidogyne, prathlenchus and dorylaimus showed high frequency than other genera.



The symptoms are general lack of vigor, discoloration of foliage, and stunted plants (Hall and Irey, 1992). Plant-parasitic nematodes damage is an important factor in tuber quality reduction and yield loss in sugarcanes both in the field and in storage. Sugarcanes are vulnerable to nematode damage as they reduce the yield and quality of the tubers as a result of root gallings, root lesions, dry and soft rots depending on the type of plant parasitic nematodes. Nandwan et al., (2005) reported the community analysis of phytonematodes in the sugarcane ecosystem in Bundi district of Rajasthan. Prakash et al; (2009) reported on collection and distribution frequency of plant-parasitic nematodes associated with sugarcane in Uttar Pradesh. In Meerut region Chaubey and Satyandra (2010) have studied the prevalence and management of different species of Meloidogyne spp. Padma Bohra (2012) has studied on twelve species of nematodes: new records for India. The presence of plant parasitic nematodes could constitute serious impediments to the growth and yield of sugarcanes in Meerut regions of U.P. States. Farmers have limited knowledge of nematode symptoms and may attribute them to other factors, such as nutrient deficiency or soil toxicity. Root damage or lesions caused by nematode infection could also be attributed to soilborne pathogens such as *Pythium* spp., *Pachymetra chaunorhiza* (a major root disease of sugarcane in Australia), *Fusarium* spp., or *Athelia rolfsii* (Bhuiyan et al. 2019b; Hoy 2000; Magarey 2022; Stirling and Blair 2000).

The plant parasitic nematodes species associated with the soil and roots of sugarcane in Meerut district. *Hoplolaimus* and *Helicotylenchus* species during growing season were above damage threshold level at many locations although population levels of other plant parasitic nematodes were below economic or damaging levels. There need to educate local farmers on the large diversity of plant parasitic nematodes associated with sugarcane their damage potentials by creative awareness programmes. In view of above aspect the present study was taken to evaluate the distribution and prevalence of different species of plant parasitic nematodes in Meerut. Managing plant parasitic nematodes involves integrated pest management (IPM) strategies, including: Crop Rotation: Planting non-host crops disrupts the nematode life cycle. Resistant Varieties: Using nematode-resistant crop varieties reduces susceptibility.. Biological Control: Beneficial microbes, such as fungi and bacteria, can suppress nematode populations.. Cultural Practices: Practices like deep plowing, solarization, and using organic amendments improve soil health and reduce nematode infestations.. Chemical Nematicides: While effective, these should be used judiciously to avoid environmental harm.

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