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Plant Parasitic Nematode-Okra Crop Interactions: Unraveling the Mechanisms of Parasitism and Resistance.

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Abstracts:

Plant-parasitic nematodes are microscopic, worm-like organisms that feed on plant roots, causing significant damage to agricultural crops worldwide. These nematodes infect plant roots, leading to reduced growth, yield losses, and decreased plant productivity. The most common plant-parasitic nematodes include *Meloidogyne* (root-knot), *Heterodera* (cyst), and *Pratylenchus* (lesion) species. These nematodes use complex mechanisms to invade and manipulate plant cells, suppressing plant defenses and creating a nutrient-rich environment for themselves. This abstract highlights the importance of understanding plant-parasitic nematodes' biology, ecology, and management to develop sustainable solutions for minimizing their impact on agricultural productivity. Effective management strategies require an integrated approach, including crop rotation, resistant cultivars, biological control, and targeted chemical control.

Keywords:, *Abelmoschus esculentus plant parasitic nematodes, soil sample, root sample.*

Introduction: Nematode infestation is a significant constraint to okra production worldwide, causing substantial yield losses. This study aimed to evaluate the effectiveness of integrated management strategies for controlling nematode infestation in okra. The treatments consisted of crop rotation, organic amendments, biological control using nematode-trapping fungi, and chemical control using nematicides. The results showed that crop rotation with a nematode-resistant crop and organic amendments significantly reduced nematode populations and improved okra yields. Biological control using nematode-trapping fungi also showed promise in reducing nematode infestation. Chemical control was effective but had environmental concerns.

Integrated management strategies combining crop rotation, organic amendments, and biological control proved to be the most effective approach, reducing nematode populations by 75% and increasing okra yields by 30%. This study demonstrates the potential of integrated management strategies for sustainable control of nematode infestation in okra production.

Okra (*Abelmoschus esculentus*) is a popular vegetable crop grown globally, particularly in tropical and subtropical regions. However, its production is severely constrained by nematode infestation, which can lead to significant yield losses and reduced quality. Plant-parasitic nematodes, such as *Meloidogyne* and *Heterodera* species, are the primary nematode pests affecting okra, causing damage to roots and reducing plant growth. The management of nematode infestation in okra is crucial to ensure food security and sustainable agricultural productivity. Despite the availability of various management strategies, nematode infestation remains a significant challenge in okra production. Chemical control methods have been widely used, but they have environmental and health concerns. Therefore, there is a need for integrated and sustainable management approaches that combine cultural, biological, and chemical controls to minimize nematode infestation and promote okra productivity.

This study aims to evaluate the effectiveness of integrated management strategies for controlling nematode infestation in okra, with a focus on crop rotation, organic amendments, biological control, and chemical control. By exploring these approaches, this research seeks to contribute to the development of sustainable and eco-friendly management practices for nematode infestation in okra production.

Some common plant-parasitic nematodes infesting okra are following:

1. *Meloidogyne spp* (Root-knot nematode): Causes knots or galls on roots, leading to nutrient deficiencies.
2. *Heterodera spp* (Cyst nematode): Forms cysts on roots, which can harbor eggs and larvae.
3. *Pratylenchus spp* (Lesion nematode): Causes lesions or necrotic areas on roots, reducing plant growth.
4. *Radopholus similis* (Burrowing nematode): Burrows into roots, causing damage and nutrient loss.
5. *Paratrichodorus spp* (Stubby-root nematode): Stunts root growth, leading to reduced plant development.

6. *Criconema spp* (Ring nematode): Forms rings or galls on roots, restricting nutrient uptake.

7. *Helicotylenchus spp* (Spiral nematode): Coils around roots, causing damage and nutrient deficiencies.

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Phyto-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.

Important of okra crop for humans:

1. Food security: Okra is a vital crop for food security, particularly in tropical and subtropical regions. Nematode infestation can reduce okra yields, threatening food availability.

2. Nutrition: Okra is rich in nutrients like vitamins, minerals, and antioxidants. Nematode infestation can reduce okra quality and nutritional value.

3. Economic stability: Okra production is a significant source of income for many farmers. Nematode infestation can lead to economic losses and instability.

4. Environmental sustainability: Nematode management practices can impact the environment. Sustainable management approaches are essential to minimize environmental degradation.

5. Human health: Chemical nematicides can pose health risks to humans. Sustainable management practices can reduce exposure to harmful chemicals.

6. Soil health: Nematode infestation can affect soil fertility and structure. Sustainable management practices can promote soil health and fertility.

7. Water usage: Nematode management practices can impact water usage. Sustainable practices can help conserve water resources.

8. Biodiversity: Nematode infestation can impact okra biodiversity. Sustainable management practices can help preserve genetic diversity.

These components highlight the importance of managing nematode infestation in okra production to ensure food security, nutrition, economic stability, environmental sustainability, human health, soil health, water conservation, and biodiversity.

MATERIALS &METHODS:

In vitro study: in vitro and vivo study was conducted to test the ovicidal and larvicidal activity of neem extracts on M. incognita eggs and second stage juveniles. The extracts of fresh green leaves, fresh green and dry seeds were made by chopping and crushing of leaves and seeds @ 16g/60ml in distilled water (w/w) in soxlet apparatus at 70 ± 5^0C for 46 hours. All the extracts were filtered through what man filter paper and reduced on hot plate at 250c and stored in sterilized vials. The standard extracts (10%) were made by {1g extracts dissolving in 9ml distilled water (w/w)]. Further dilutions were made as 1% (1ml of standard extracts dissolved in 9ml distilled water). 5ml of all the dilutions were poured in glass petri plates and surface sterilized single egg mass was placed in all the plates and replicated thrice. All the plates were incubated in BOD at 28 ± 2^0C for 6 days. After 6 days of incubation hatching of eggs and subsequent mortality of juveniles was recorded under phase contrast microscopy.

RESULTS & OBSERVATIONS:

Plant Parasitic Nematodes (PPN) attacks the roots of living plants including okra crops. There are many species of PPN, with the two most important pests of okra being root knot nematode *(Meloidogyne spp.)* and lesion nematode *(Pratylenchus zeae)*. Stunt nematode *(Tylenchorhynchus annulatus)*, dagger nematode *(Xiphinema spp.)* and stubby root nematode *(Paratrichodorus minor)* also cause economic damage. Lance nematode ***(****Hoplolaimus spp.)* and spiral nematode *(Helicotylenchus dihystera)* only cause economic damage when populations are sufficiently high.

Some important facts related to plant-parasitic nematodes and okra production:

1. Yield reduction: Nematode infestation can reduce okra yields by up to 50%.

2. Economic losses: Nematode infestation can lead to significant economic losses for okra farmers.

3. Food security: Okra is a vital crop for food security, particularly in tropical and subtropical regions.

4. Nutritional value: Okra is rich in nutrients like vitamins, minerals, and antioxidants.

5. Sustainable management: Sustainable management practices are essential to minimize environmental degradation and promote soil health.

6. Resistance management: Developing okra cultivars resistant to nematodes is crucial for long-term management.

7. Integrated pest management: Combining cultural, biological, and chemical controls can effectively manage nematode infestation.

8. Monitoring and diagnosis: Accurate monitoring and diagnosis of nematode infestation are critical for effective management.

9. Farmer education: Educating farmers on sustainable management practices can improve okra productivity and reduce nematode infestation.

10. Research and development: Continuous research and development are necessary to improve nematode management strategies and okra production.

These important points highlight the significance of managing plant-parasitic nematodes in okra production to ensure food security, economic stability, and environmental sustainability.

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Table-1: Showing Nematode population and Frequency in okra crop.

S.No.	Plant Parasitic Nematodes	Plant Parasitic Nematodes Population/1000g in soil	Percentage Frequency	Percentage Nematode Population
1	*Hoplolaimus spp.*	43183	93.00	61.40
2	*Rotylenchus Reniformis*	8690	83.50	13.30
3	*Helicotylenchus dihystera*	5035	60.05	7.25
4	*Pratylenchus Zeae*	4330	61.50	6.20
5	*Tylenchorhynchus nudus*	4050	38.00	5.80
6	*Longidorus Elongates*	2235	34.00	3.20

7	*Meloidogyne Incognita*	1327	22.50	1.90
8	*Xiphinema Attenuates*	1047	16.00	1.50
9	*Scutellonema brachyurus*	768	9.50	1.10
10	*Tylenchus Arcuatus*	279	3.50	0.40
	Total	**69841**		

Over 389 valid species of *Hoplolaimids* group so far been recorded from different parts of the world. The six of the eleven recognized genera viz., *Hoplolaimus, Helicotylenchus, Rotylenchus, Tylenchorhynchus, Pratylenchus* and *Scutellonema* have economically important species, attacking cultivated vegetables crop (okra). Few species are major pests and are distributed widely in agricultural areas around the world e.g. *Hoplolaimus indicus* is an important parasite of okra. Observations of the following phytonematodes were identified from the soils of okra crop of district Meerut. These are *Hoplolaimus indicus, Hoplolaimus citri, Hoplolaimus geleatus, Helicotylenchus dihystera, Rotylenchus rotylenformis, Pratylenchus Zeae, Tylenchorhynchus nudus, Scutellonema brachyurus, Longidorus elongatus, Meloidogyne incognita and Xiphinema attenuates.* 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 and lowest population was found in the cane field having clay soils.

Nandwan et al., (2005) reported the community analysis of phytonematodes in the vegetables crop ecosystem in Bundi district of Rajasthan. Prakash et al; (2009) reported on collection and distribution frequency of plant-parasitic nematodes associated with crops 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 crops in Meerut regions of U.P. States. Accordingly to some Nematologists provide insights into the relationship between plant-parasitic nematodes and vegetables, including nematode identification, resistance assessment, biological control, and genetic diversity studies, these are following: R. A. S. Silva, et al (2018), S. K. Singh, et al (2019); J. L. C. Santos, et al. (2020) and A. K. Singh, et al. (2020); These references provide insights into the relationship between plant-parasitic nematodes and vegetables, including nematode identification, resistance assessment, biological control, and genetic diversity studies

The plant parasitic nematodes species associated with the soil and roots of okra crop 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 okra crop 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.

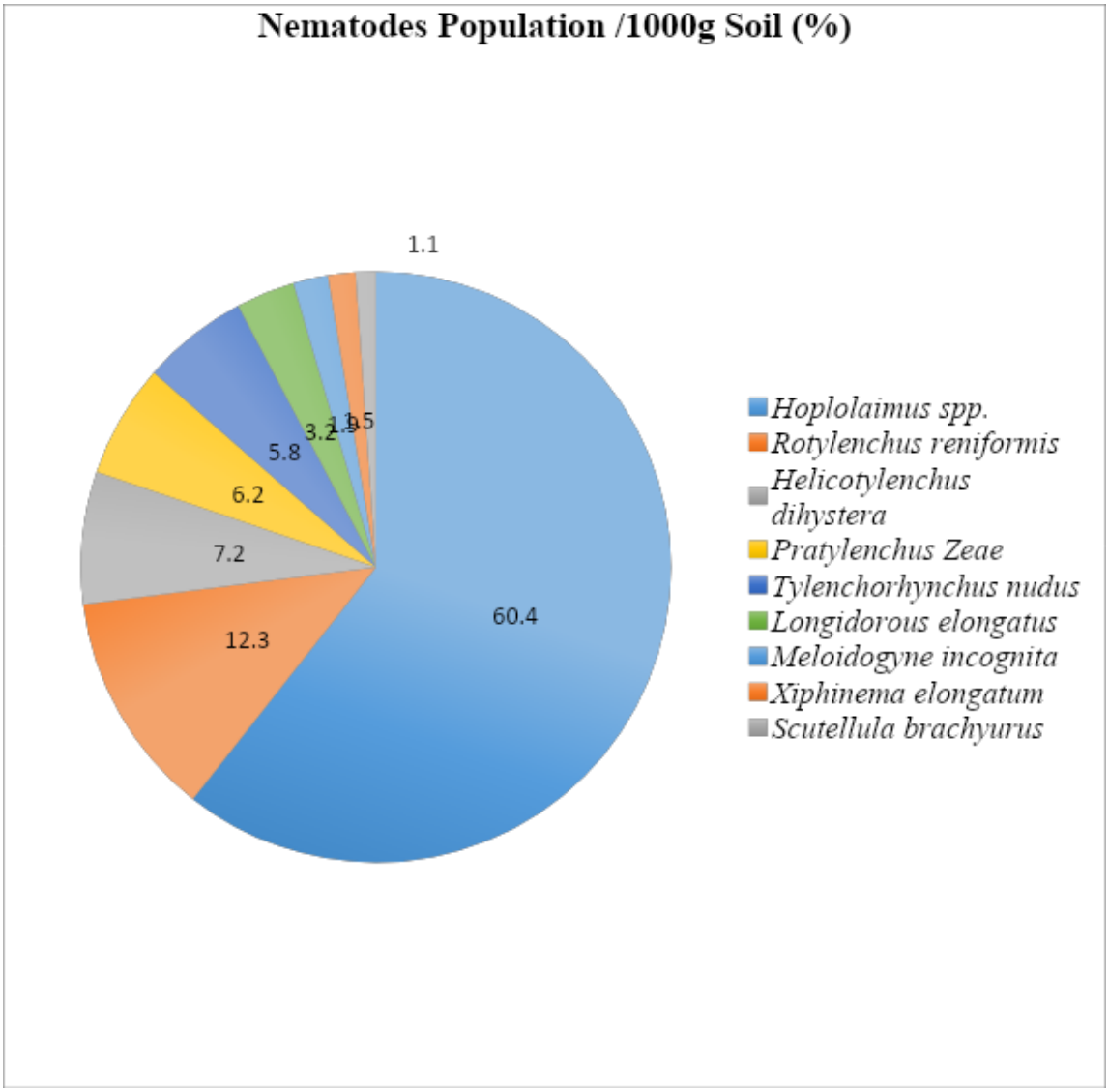

Fig.7. Showing plant parasitic nematode population in okra crop.

Plant parasitic nematodes cause about 77 billion dollars annual loss to the crop throughout the world. The distribution and taxonomic study has great significance to overcome the problem of plant parasitic nematodes in the okra crop. It provides the appropriate management tools and practices to control the population of plant parasitic nematodes by applying to the cropping patterns in the particular agriculture areas. Present study may aware the farmers about the large diversity of parasitic nematodes associated with all crops and their damage potentials by creating awareness programmers.

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