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Enhancing Okra Yield and Quality with the management of *Meloidogyne incognita* in Western Uttar Pradesh.

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Abstract: Plant-parasitic nematodes (PPNs) are microscopic tiny and hidden worms that feed on roots of plants, causing damage and disease. PPNs are obligate parasites, meaning they require a plant host to survive and reproduce. *Meloidogyne* spp., is a World -Wide distributed and prevalent plant-parasitic nematode in India, and its population density can vary depending on edaphic factors, the region, soil type, and crop grown. Some *Meloidogyne* population densities in different regions of India. My experimental crop Okra (*Abelmoschus esculents),* it is a very important food and cash crop by nutrition, health and economic wise. In the present study the management of *Meloidogyne* spp., on okra crop through the organic amendments (choose the nematicidal plant *Azadiractha indica*). The application of various parts of *Azadiractha indica* (oils, cake, seeds, and leaves) altered the physiology of host plant (okra) and developed the strong defensive mechanism of the root against nematodes.so the use of Neem products stimulated and change the physiology of plant cells and tissue to repel the plant nematode parasite. Extracts of fresh greens leaves, showed max. Reduction in egg hatching and cause great mortality of juveniles and followed by fresh green seed and dry seed extracts. In vivo and vitro conditions the powder of fresh seed showed highest plant growth and reduction in root knot formation and followed by fresh leaves and dry seed powder. Overall, *Meloidogyne incognita* is a significant pest in Indian agriculture, and its management is crucial for maintaining crop productivity and soil health.

Key Words: *Meloidogyne incognita, Amendments of Azadiractha indica, Abelmoschus esculents, dominant plant-parasitic nematodes.*

INTRODUCTION

Nematodes, especially the plant-parasitic are the most abundantly evolved and diversified metazoans on the planet Earth. Nematodes which infest the Kingdom of plantae which known as plant parasitic nematodes, Phyto-nema or Phyto-nematodes which damage more than seventy billion dollars of crop loss in the World each year.

Plant-parasitic nematodes (PPNs) are microscopic tiny and hidden worms that feed on roots of plants, causing damage and disease. PPNs are obligate parasites, meaning they require a plant host to survive and reproduce. They infect plant roots, stems, or leaves, using their piercing mouthparts to feed on plant tissues. Common examples of PPNs include: Root-knot nematodes (Meloidogyne spp.), Cyst nematodes (*Heterodera spp.* and *Globodera spp.), Reniform* nematodes *(Rotylenchulus reniformis)*

PPNs can cause various disease of crop, some symptoms of crop are include: Root- knot or gall formation, Stunted or distorted plant growth, Yellowing or wilting of leaves and reduced yields or plant death.

These tiny worms can have a significant impact on plant health and agricultural productivity*! Meloidogyne incognita* is a species of plant-parasitic nematode, commonly known as the southern root-knot nematode (SRKN). *M. incognita* is a major pest of many crops, including vegetables, fruits, and ornamentals. It infects plant roots, causing the formation of characteristic swellings or "galls" (also called "root knots"). The nematode's life cycle includes: Egg stage: eggs are laid in the soil, Juvenile stages: hatch from eggs and migrate to plant roots, Adult stage: mature nematodes feed on plant tissues, causing damage

M. incognita can lead to significant yield losses, reduced plant growth, and increased susceptibility to other diseases. Management strategies include crop rotation, resistant cultivars, and nematicides.

This plant parasitic nematode is a significant problem in warm and temperate regions worldwide, especially in agricultural fields, crops and gardens. *Meloidogyne incognita*, the root-knot nematode, has a complex life cycle and races in India:

Life Cycle of Meloidogyne spp:

1. Egg stage: Eggs are laid in the soil and can survive for several months.
2. Juvenile stages (J1-J4): Hatch from eggs and migrate to plant roots.
3. Adult stage: Mature nematodes feed on plant tissues, causing damage.
4. Reproduction: Females lay eggs in the soil, starting the cycle again.

Some critical conditions observed my study for *Meloidogyne incognita* infestation in okra crops in Western U.P.

1. High population density: >600 eggs per 1000 cc of soil
2. Severe symptoms: Okra plants show severe stunting, yellowing, blackish due the insufficient nutrients (feeding of nematodes) and wilting, with significant reduction in fruit yield and quality
3. Widespread infestation: >59% of plants in a field are infested
4. Soil moisture: High soil moisture levels (>45%) favor nematode survival and mobility
5. Temperature: Optimal temperature range for nematode development: 28-32°C
6. Soil type: Sandy loam or clay loam soils with pH 6-7 favor nematode survival
7. Crop age: Okra plants are more susceptible at seedling and flowering stages
8. Nutrient deficiency: Nutrient-deficient soils (e.g., low calcium, magnesium) can exacerbate nematode damage. If these critical conditions are met, it may lead to a significant reduction in okra yield and quality, and may require immediate management interventions to prevent further damage.

On the basis of World-Wide survey the ten most important genera are reported to cause severe crop losses (*Meloidogyne, Radopholus, RotylenchusTylenchorinchus, Xiphinema, Ditylenchus, Globodera, Helicotylenchus and Heterodera*). Several hundred Ecto-parasitic nematodes might feed on a plant without seriously affecting production while other group only single Endo-parasitic nematodes can kill a plant or reduce its productivity (Ingham, 1996). Endo-parasitic nematodes especially the root-knot nematodes (Meloidogyne spp.) have been found one of the major constraints in the production of vegetables and other crops.

The highly dangerous Endo-parasitic nematode *Meloidogyne* spp., represented about 400 species all over the World. *Meloidogyne incognita* is a widely distributed and prevalent plant-parasitic nematode in India, and its population density can vary depending on the region, soil type, and crop grown.

However, here are some approximate estimates of *Meloidogyne* population densities in different regions of India: North India: 200-500 eggs per 100 cc of soil (moderate to high infestation). South India: 100-300 eggs per 100 cc of soil (low to moderate infestation), East India: 150-400 eggs per 100 cc of soil (moderate infestation), West India: 250-600 eggs per 100 cc of soil (high infestation), above study show the highest infection is an infected in Western Uttar Pradesh due the favorable environmental conditions like temperature, moisture and pH etc., for growth of *Meloidogyne* spp.

Overall, *Meloidogyne incognita* is a significant pest in Indian agriculture, and its management is crucial for maintaining crop productivity and soil health. Critical conditions for *Meloidogyne incognita* infestation in okra crops in India.

Neem components have attracted global attention for their insecticidal, fungicidal, bactericidal and nematicidal properties. Crude Neem extracts have been used at a local and small-farm level for some time in countries where Neem grows. In the major countries such as USA, Canada and Europe, the commercial Neem insecticides have reached the markets. Integrated Pest Management (IPM) strategies that combine these methods can provide effective overall control of *Meloidogyne incognita* infestation in okra crops.

It's important to note that the most effective method will depend on the severity of infestation, soil type, climate, and other factors, so it's important to monitor the field and adjust the control strategy accordingly.

The effective, inexpensive and environmental friendly control of this major pest is a serious problem. Although the chemical control is effective but their residues remain undegradable in soil for long time. Therefore most of the chemical nematicides are banned now a day. Various workers contributed significantly to the management of root knot nematode. Some of the significant contributors are A.K. Singh et,al (2020), J. Singh et al (2019), Graham R. Stirling and John Bridge (2017), Wani (2006); Ram et.al (2009); Sharma et al (2007); Khan (2012); Mohnta et al (2012). To overcome this problem various soil amendments by green and compost Goswami & Neetu Singh (2012).manures, organic, inorganic fertilizers, botanicals, bioagents like nemato phagous fungi, soil bacteria are found to be more satisfactory to reduce the

nematode population and increased crop yield. R. K. Singh et al (2018) have reported integrated management of root-knot nematode on okra using biological control methods, These Neem extracts can be used as natural nematicides, either alone or in combination with other methods, to manage Meloidogyne incognita infestation in okra crops. However, it's important to note that the efficacy of these Neem extracts may vary depending on the severity of infestation, soil type, and other factors.

MATERIALS AND 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 sox let 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.

The recorded data are presented in tabular form and statistical tools were applied to find out the level of significance (Table-2).

In vivo and vivo study: Pot and field experiment was conducted on okra plants to root knot nematode, to observe the efficacy of amendments of Neem such as leaves, fresh and dry seed powder, after the establishment of infection by second stage IJ_2. The study was carried out in following steps:

- **Sowing of seed**: The okra seeds were procured from the NSC, New Delhi. Seeds were raised in the sterilized soil along with the compost manure @ 120g/kg soil, at Nematology Laboratory, Department of Zoology, C.C.S. University, and Meerut. Earthen pots were filled with 1kg sterilized soil and four seeds were sowed in each pot. After 14 days of germination three seedlings was maintained in each pot. And in vivo study, seed of okra was sowing in a field (small field approx.. 100meters) of ccs university

- **Culture of (IJ2):** The infected okra plant samples were collected from the agricultural fields of Meerut district. The plants were carefully uprooted and after removing the soil, the roots were placed in well labelled polyethylene bags. The collected roots were washed with tap water & eggs masses were isolated in petri plates. The isolated egg masses were incubated for five days at 28±2^{0}C in BOD. Freshly, hatched IJ_2 were collected in water in 250ml beaker. The content was further reduced to small quantity to count the no. of nematodes. Homogeneous aliquot was placed in counting dish and the no. of IJ_2 in 1ml was under the stereoscopic microscope.
- **Experimental Design**: After 3 -4 weeks of seed sowing, okra seedlings were inoculated with freshly hatched *M. incognita* infective @ 1000 IJ_2. After 7days of inoculation plants were treated with the fresh green leaves, dry and fresh seed powder of Neem @ 8% powder/ soil (w/w). All the experimental pots were replicated thrice and irrigated regulatory as needed.
- **Termination of experiment**: plants were uprooted at 75 days after inoculation. After washing, data were recorded on various plant growth parameters viz. - length of root and shoot, weight of fresh and dry shoot and root and also on disease parameters (root knot index) on the basis of no. root knots/plant. The scale (0-5) given by Taylor & Sasser (1978), was applied to find out root knot index as follows: 1, 0= no galling, 2, 1= light galling (0-25%), 3, 2= moderating galling (25-50%), 4, 3= severe galling (51-75%), 5, 4= very severe galling (76-100%).

RESULT AND DISCUSSION:

An investigation was carried out to study the pathogenicity of root knot nematode, *Meloidogyne incognita* on okra and its management through organic amendments. The present investigation was conducted to okra plants in pot and field conditions. The results revealed determine the efficacy of Neem leaves and seeds (fresh & dry) powder against *M .incognita* infesting okra plants in pot and field conditions. The result revealed that the inoculated plants treated with FSP showed max. Plant growth parameters viz, length (shoot & root) and (fresh & dry) weight (shoot & root) and the plant disease parameters viz, no. Of root galls/root; no. Of egg mass/root; root gall index followed by FGP &DSP. The data calculated on % reduction in root knot formation in all the treatments showed highest reduction (64.76%) in FSP alone and followed by combined FSP+FLP (63.75%); DSP+FLP (53.93%); FLP (46.16%) & DSP alone (27.49%). The estimation of egg masses reduction was maximum in combined treatment of

FSP+FLP (53.06%) and slightly low (52.56%) in FLP alone followed by DSP+FLP (42.15%); FLP (40.77%) and DSP alone (36.17%). The work of Tariq &Siddiqui, 2005; Rather & Siddiqui, 2007; they also found same result in tomato also.

Azadirachtin is the main active and nematicide content of Neem and is reported very effective and target specific to controlling insects and nematodes pests of the various crops. The findings of the present study can be correlated with of R.K. Singh et al (2022) reported that "impact of organic amendments on Meloidogyne incognita population and okra yield, Graham R. Stirling and John Bridge (2017), they observed integrated management of root-knot nematodes on okra using crop rotation and organic amendments, A.K. Singh et al (2020) this study evaluated the management of *Meloidogyne incognita* on okra using bioagents and organic amendments, J. Singh et al in 2019 observed some nematicidal activity of some botanicals against *Meloidogyne javanica* on okra, R. K. Singh et al (2018) have reported integrated management of root-knot nematode on okra using biological control methods, Egumnjobi & Afolami (1976) where they have reported the successful use of Neem leaves extracts in nematode control. Mishra (1999) states that the Neem formulations are most effective control of root knot nematode Meloidogyne sp. as compared to other botanicals.

Akhtar and Malik (2000), Siddiqui & Alam (2001), they have reported that phenols, amino acids, aldehydes and fatty acids are release from neem which is antagonistic to root knot nematodes. Our results are supported by the study of Siddiqui & Alam, (2001); Satyandra et al (2007); Ravishankar & Sharma (2005); Ganai,et al (2014); Satyandra et al (2011); **Babu** & Rana (2012), Archana & Prasad (2014) states that organic amendments of soil using dried poultry litter, municipal refuse, oil cakes of ground nut, Neem mustard & neem products (which are commercial available in market) have been found effective in the control of *Meloidogyne incognita*. These all studies provide valuable insights into the management of okra infestation by nematodes using various approaches including biological control, organic amendments and crop rotation.

In present study thus it may be concluded that changes in protein after infection are related to defense action, because abnormal metabolites are produced in adjacent non-infected tissues. Such metabolites accumulated in infected tissues and are toxic to parasites and inhibit their growth and

penetration. The metabolites released from the chemical constituents of Neem (*Azadirachtin, salannin, limonoids, triterpenoids, phenolic compounds, carotenoids, steroids and ketones*) stimulated the plant cells to release abnormal metabolites which repel the nematodes from the uninfected cells of plant. However, the green leaves are rich in *azadirachtin, salannin, meliantrol and nimbin* (Jacobson, 1990; National Research Council, 1992). So the use of neem products stimulated and changes the physiology of plant cells and tissue to repel the nematode parasites.

Table-1: Month wise population dynamics of Meloidogyne spp., infesting okra crop in the field study.

Serial No.	Months	Temperature (^{0}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)

Suggestion for farmers and other like a gardening lovers suggest some simple ways to manage *Meloidogyne* infestation in okra crops:

1. Crop rotation: Rotate okra with non-host crops like cereals or legumes to break the nematode life cycle.

2. Soil solarization: Traps soil moisture and heat under a clear plastic tarp, killing nematodes and eggs.

3. Organic amendments: Add organic matter like compost, manure, or neem cake to improve soil health and reduce nematode populations.

4. Resistant cultivars: Grow okra varieties with some resistance to Meloidogyne incognita.

5. Nematode-trapping crops: Plant crops like marigold or sesame that attract and trap nematodes.

6. Physical barriers: Use physical barriers like plastic or paper mulch to prevent nematodes from reaching okra roots.

7. Biofumigation: Plant crops like mustard or broccoli that release nematicidal compounds when incorporated into soil.

8. Soil aeration: Improve soil aeration through tillage or mulching to reduce nematode populations. These simple methods can be used alone or in combination with other management strategies to reduce *Meloidogyne* infestation and improve okra crop productivity.

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