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14. Strategies for Management of Root-Knot Nematodes on Okra

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Abstract:

One of the most harmful pests affecting okra (Abelmoschus esculentus) globally, root-knot nematodes (Meloidogyne spp.) cause large yield losses. Using efficient management techniques is essential to lessening their influence on the growing of okra. Various management strategies for okra root-knot nematodes are presented in this review. By upsetting the life cycle of nematodes, cultural techniques like fallowing, crop rotation, and intercropping can aid in lowering their populations. In managing nematodes, the adoption of resistant/tolerant okra cultivars or rootstocks might also be crucial. Plant extracts, biocontrol agents, and soil amendments containing organic matter have also demonstrated potential in reducing nematode populations. Nematicides, or chemical control, can stop nematode damage right away, but their effects on the environment and possible health risks mean that they should be used carefully and according to specified application guidelines. For the treatment of root-knot nematodes in okra, integrated pest management (IPM) techniques that integrate a number of strategies such as chemical, biological, and cultural control methods offer a thorough and long-lasting solution. This review highlights the need of using an integrated strategy that is customised to particular agro-ecological conditions and suggests more research to create novel, environmentally acceptable approaches for sustainable nematode management in okra agriculture.

Keywords:

Meloidogyne spp., okra, management strategies, chemical control, biological control, cultural practices, integrated management.

14.1 Introduction:

Okra (*Abelmoschus esculentus* L. Moench, family Malvaceae), which is also widely grown in tropical and subtropical regions of the planet, is one of the most important vegetable crops in the world (Singh, 2012). Alegbejo *et al*. (2008) state that although it is primarily harvested for human food, it is also used as fibre in industry. According to Santos *et al*. (2013), this vegetable is high in protein and contains the elements K, Mg, Na, Ca, and Fe. Additionally, it has vitamins A and B in it (Gemede *et al.*, 2014). According to the FAO, India is the world's largest producer of okra, followed by Nigeria and Iraq. At the moment, 503.68 thousand hectares of it are grown in India, where it produces 5708.69 thousand million tonnes at a productivity of 11.3 mt/ha. (Anonymous, 2015a). It makes almost 12 percent of India's fresh vegetable exports and has great potential as an export crop.

Okra is a crop that is widely farmed throughout India's different agro-climatic zones, although it is negatively impacted by a worm called *Meloidogyne incognita*, which causes knots in roots, and by major productivity constraints. The signs of harm to the okra plant that are visible below ground are root knots or galls. The signs that are visible above ground are therefore those of slow root weakness in terms of their ability to take up and move water and nutrients. The plants could be small, yellowish, with lesser quality, fewer fruits, and less foliage.

A hidden threat to okra among plant parasitic nematodes is the root-knot nematode (*Meloidogyne* sp.) (Marin *et al.*, 2017). According to reports, the root-knot nematode can cause okra losses of up to 22% each year (Sasser, 1979). Additionally, M. incognita on okra resulted in 22.45 to 45.50% unnecessary production losses, according to Baheti and Bhati (2017). The management of worms by traditional approaches primarily relies on chemical nematodes. Nematicides are effective treatments for nematodes that parasitize plants. Nematode pests of annual crops can be efficiently controlled with a variety of nematicides (Van Berkum and Hoestra, 1979). Nematicides are extremely harmful substances. However, the majority of chemical nematipides are now completely banned or have their usage severely restricted due to their harmful effects on human health and the environment, high cost, and lack of effectiveness after extended use (Zukermn and Esnard, 1994).

Through the use of all available pest control techniques, integrated pest management, or IPM, is a comprehensive ecological approach that strives to maintain the number of pests below the level of economic threshold. These include using crop types that are resistant or tolerant, as well as cultural, mechanical, biological, and, finally, chemical treatments used in an appropriate way. To reduce damage to the environment and preserve ecological balance, the IPM strategy also strives for the minimal and safe use of pesticides. Although it offers only temporary relief, using chemicals to combat sickness is costly. Alternative strategies for dealing with root-knot nematodes have been proposed, such as integrated management, where resistant varieties are not available and chemical pesticide use is restricted due to environmental and financial concerns.

14.2 Strategies for Management of Root-Knot Nematodes:

In kharif 2017, a field experiment was conducted, as per Mahalik *et al*. 2020, to assess the effectiveness of oil cakes, specifically neem and jatropha oil cakes, and bio control agents, namely *Purpureocillium lilacinum*, *Trichoderma viride*, and *Pseudomonas flourescens*, in different combinations, against the nematode that was infecting okra. This study included three replications using Randomised Block Design, and it included eight environmentally friendly treatments, a chemical standard check (Carbofuran 3G @ 1kg a.i/ha), and an untreated check. Plant growth and root knot nematode reproduction were observed during harvest.

All the treatments documented a significant increase in plant growth and decrease in nematode reproduction over untreated check. Among all the management treatments, soil application of Jatropha oil cake @ 1.0 t/ha 15days before sowing + seed treatment with *T. viride* + *P. fluorescens*, each @ 5g/ kg seed + soil application of *P. lilacinum* @ 2.5kg/ha 15days after sowing was the most effective integrated combination which recorded the maximum increase in plant height (68.1%), root length (95.3%), fresh shoot weight (57.0%), fresh root weight (92.8%), shoot dry weight (90.9%), root dry weight (77.5%), biomass yield (87.6%) and fruit yield (65.5%) with maximum reduction in number of galls per plant (84.7%), number of egg masses per plant (88.3%), number of eggs per egg mass (48.3%), nematode population (81.1%) and root knot index (34.0%) over untreated check followed by soil application of neem oil cake @ 1.0 t/ha 15days before sowing+ seed treatment with *T. viride* + *P. fluorescens*, each @ 5g/ kg seed + soil application of *P. lilacinum* @ 2.5kg/ha at15days after sowing.

In a field experiment carried out in a plot infested with root-knot nematodes during the month of Karabi in 2016, Mahalik and Sahu (2018) assessed the effectiveness of liquid bio-agents, specifically *Purpureocillium lilacinum* and *Pochonia chlamydosporia*, when combined with an organic biofertilizer (vermicompost). In addition, a routine check was performed using a chemical treatment (soil application of carbofuran at 1 kg a.i./ha + seed soaking with carbosulfan 25 EC @ 0.2% for 12 hours before to sowing). The findings showed that, in comparison to the untreated control, all treated plots with chemicals considerably improved plant development parameters and decreased the multiplication of root knot nematodes. Seed treatment with *Purpureocillium lilacinum* @ 5 ml/kg + soil application of vermicompost @ 2.5 ton/ha enriched with *P. lilacinum* (@ 10 ml/kg recorded highest increase of 51.28 %,87.0%, 55.53%, 67.62% in plant height, root length, shoot dry weight, root dry weight over untreated check recpectively with reducing final nematode population in soil (171.0 J2/200cc soil) and in root of okra (41.25/ 5g. root) with the lowest root knot index (2.0) followed by seed treatment with *Pochonia chlamydosporia* @5 ml/ kg+ soil application of vermicompost @ 2.5 ton/ha enriched with *P. chlamydosporia* (@ 10 ml/kg. Furthermore, the highest fruit yield (7.19 tons/ha) was obtained by treating the seeds with *P. lilacinum* at a rate of 5 ml/kg and adding 2.5 tons/ha of vermicompost that was enriched with *P. lilacinum* at a rate of 10 ml/kg. This combination of treatments was found to be the most cost-effective, with the exception of chemical treatment for managing root-knot nematodes in okra, which had the highest incremental cost-benefit ratio of 2.75.

In order to evaluate the effectiveness of different bacterial and fungal antagonists as seed coating treatments against *Meloidogyne javanica*, a root-knot worm that infects okra plants, a pot research was carried out by Bishnoi *et al.* in 2023. *Trichoderma viride*, *Purpureocillium lilacinum*, and *Pseudomonas fluorescens* were applied to okra cv. Pusa Sawani seeds at a rate of 2 g/kg seed. Carbosulfan 3G was administered as a control at a rate of 3g/kg soil to serve as a comparison. Next, the treated seeds were sown in soil that had two juveniles in the second stage of the root knot nematode for every gramme of soil. The okra plants showed improved development after 45 days of seeding, and all treatment groups had much lower populations of root-knot nematodes than the untreated control. *Purpureocillium lilacinum* shown to be the most effective bio agent among those evaluated, with *Trichoderma viride* and *Pseudomonas fluorescens* following closely behind. These bio agents increased plant growth characteristics and decreased nematode reproduction.

The effectiveness of several botanicals against *Meloidogyne incognita* in pot conditions was tested by Sujata *et al*. 2022. Screen house settings were used to assess five native botanicals, including Brassica sp. (cabbage and cauliflower), *Ricinus communis*, *Eucalyptus globules*, and *Azadirachta indica*, against *Meloidogyne incognita*. Increased okra plant growth parameters and decreased nematode reproduction were seen in soil treated with botanical leaves. Comparing the nematode population to the untreated control, *A. indica* considerably lowered it across all treatments. When *Ricinus communis* chopped leaves (20 g/kg soil) were added to the soil, the shoot length (23.14 cm), root length (12.08 cm), and shoot weight (5.81 g) all grew significantly.

However, the treatment that applied *A. indica* chopped leaves (20 g/kg soil) produced the fewest galls. When comparing all treated pots to the untreated control, the infestation of root-knot nematode in okra was lower.

In order to determine the effectiveness of *Trichoderma viride*, *Pseudomonas fluorescens*, and neem cake alone and in combination for the management of *Meloidogyne incognita* in okra, Mishra *et al*. (2018) conducted a pot culture study in net house conditions during kharif 2016. Out of all the treatments, the okra plant growth parameters increased most when neem cake was applied to the soil at a rate of one tonne per hectare fifteen days before sowing, and most when *Trichoderma viride* was applied at a rate of two kilogrammes per hectare fifteen days later. The plants treated with neem cake at a rate of one tonne per hectare plus *T. viride* at a rate of one and a half kilogrammes per hectare also showed the highest reduction (79.0%) in the population of root knot nematode and the lowest reproduction factor (0.34). In comparison to other treatments, the application of *T. viride* in conjunction with neem cake at several doses was found to be more effective against M. incognita, as evidenced by an increase in plant development metrics and a decrease in the population of root knot nematodes in the soil.

In order to evaluate the impact of two bio-fumigants, namely cabbage and cauliflower leaves, on the population of plant parasitic nematodes infecting okra, Das and Behera (2019) conducted a pot culture study. The experiment's findings showed that, when compared to the untreated control, the okra plant's fresh shoot weight (28.4–81.9%), fresh root weight (22–38.7%), dry shoot weight (11.6–85.7%), and dry root weight (24–39%) decreased, while the root knot nematode (40.7%), lance nematode (40.8–80.1%), spiral nematode (49.1–79.7%), and stunt nematode (40.8–81.3%) decreased. Cauliflower and cabbage leaves performed similarly in terms of reducing the number of nematodes and improving the factors related to plant growth. But in all of the aforementioned categories, cabbage leaf at 88 g/kg soil (5.0 kg/m2) performed better. Root knot, lance, spiral, and stunt nematodes all had population reductions of 50%, 52.4%, 61.2%, and 50.9%, respectively. With this therapy, there was an increase in shoot length, root length, fresh shoot weight, dry shoot weight, fresh root weight, and dry root weight of 49.3%, 46.5%, 79.3%, 78.5%, 38.7%, and 39.5%, respectively.

In order to generate systemic resistance in monocotyledonous and dicotyledonous agricultural plants against a wide range of pests and pathogens, including plant parasitic nematodes, Baheti *et al*. (2018) employed a number of natural or manufactured chemicals. According to reports, the exogenous administration of specific chemicals minimises the damage caused by root-knot nematodes on crops by creating systemic resistance. This approach has lately been considered as a viable nematode management tool. Therefore, two chemical inducers-salicylic acid (250 ppm) and ascorbic acid (500 ppm) were tested for controlling the root-knot nematode, *Meloidogyne incognita*, on okra in fields with an initial inoculum of 410-460 larvae per 100 cc soils during two consecutive Kharif seasons.

The treatments included seed soaking (12 hours) and foliar spray (30 and 60 days after sowing). For comparison, untreated and chemically treated (monocrotophos 500 ppm) controls were also kept. At harvest, observations were made about the number of galls per plant, egg masses per plant, eggs and larvae per egg mass, final nematode population per 100 cc of soil, and yield. The results showed that ascorbic acid was the most effective treatment to reduce infection of *M. incognita*, a root-knot nematode, on okra and to increase crop yield (27.66–29.81%).

Salicylic acid was the next most effective treatment to apply as a seed soaking + foliar spray (21.15–23.40%), and ascorbic acid was the most effective treatment to apply as a foliar spray (15.38–17.02%) compared to the untreated control during the first and second year, respectively.

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