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Review Article

Knowledge of Ethiopian Farmers Towards Root Knot Nematodes (RKNs) and the Impact of the Disease in Vegetable Production

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Abstract: Root-knot nematodes (*Meloidogyne* spp.) are one of the most common vegetable diseases. In warm moist sandy soil, they are the most problematic and damaging. With about 5500 plant hosts, it is an economically important obligatory plant parasite. They have a significant impact on important crops around the world, such as vegetables, fruits, and cereal harvests. In most cases, nematode damage to crops is not easily visible, and it is often obscured by the many other factors that limit plant growth. Much of the harm produced by nematodes remains unnoticed or is mistaken for other reasons such fungal infection, water stress, or other physiological diseases, and by the time the disease is discovered, the damage to crops has already been done. A key hindrance to the preservation of vegetable crops is a lack of understanding among farmers about the challenges created by root knot nematodes, as well as ineffective management measures to tackle the threat. Except for a few investors, almost all Ethiopian farmers are unaware of the relevance of plant parasitic nematodes (PPNs). Plant parasitic nematodes not only have a direct impact on agricultural crops, but they also have an indirect impact by exposing the host plant to secondary infection and causing disease complexity in the affected plants. As a result, when compared to other infections, root knot nematode control is extremely challenging. As a result, farmers should receive training and awareness of PPN signs and assaults from the relevant body.

Keywords: Endo-Parasite, Migratory, Obligate Parasite, Root Knot Nematode, Sedentary

1. Introduction

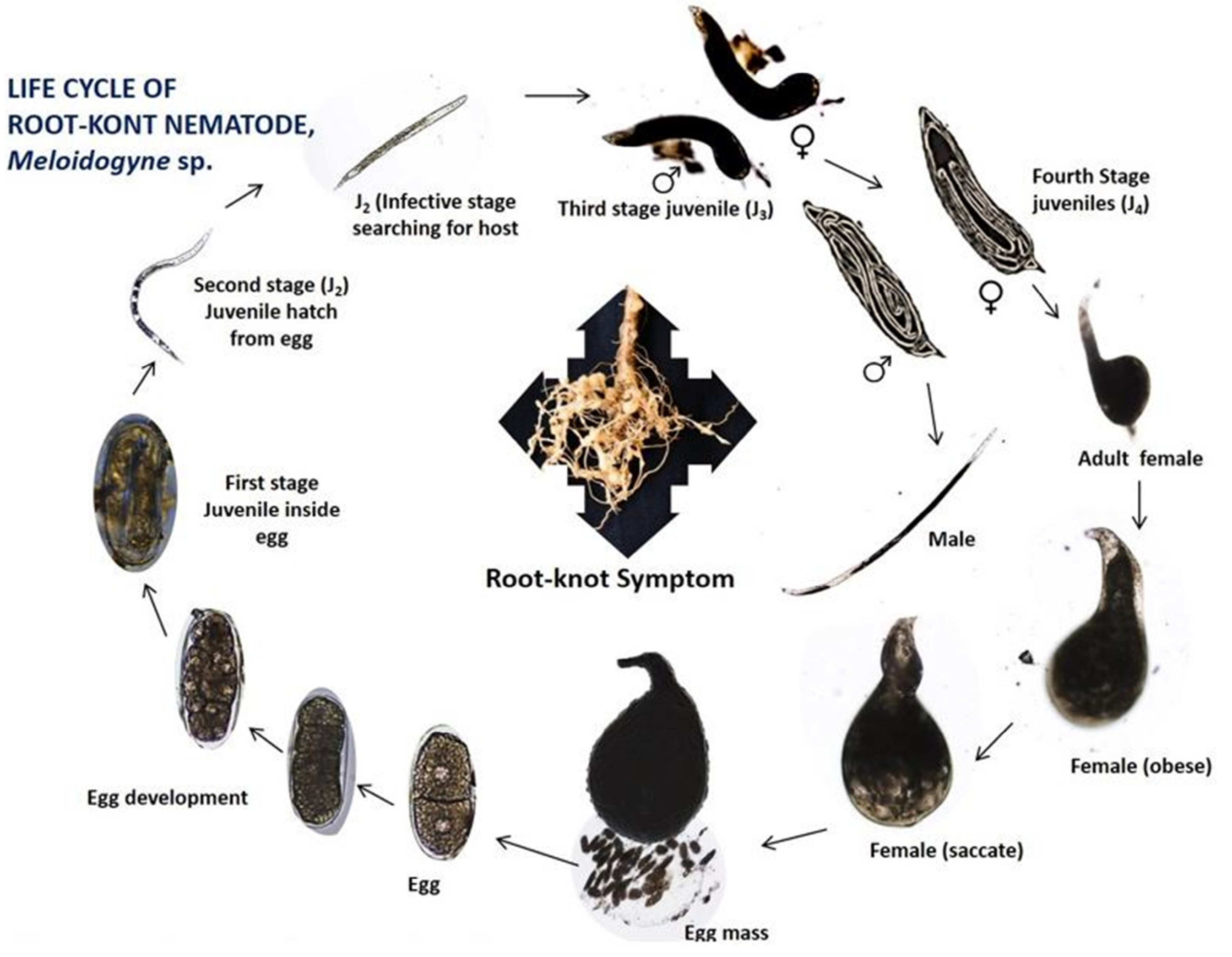
Ethiopians often grow a variety of vegetable crops during both the wet and dry seasons, on small to big farms [2]. Hot and sweet peppers, Ethiopian mustard/kale, onion, tomato, chile, carrot, garlic, and cabbage are among the most commercially important vegetables [15]. Root-knot nematodes (*Meloidogyne incognita, M. javanica,* and *M. ethiopica*) are the most yield-limiting group of PPNs, and they are prevalent throughout the country, reducing the production of these vegetables substantially [27]. Despite this, there was insufficient evidence on the impact of Ethiopian populations of these worms on the growth of major tomato and pepper cultivars.

Plant-parasitic nematodes (PPNs) are known as the "secret enemy" of farmers since they live underground in their habitats and producers are unaware of the losses they inflict. Much of the harm produced by nematodes remains unnoticed or is mistaken for other reasons such fungal infection, water stress, or other physiological diseases, and by the time the disease is discovered, the damage to crops has already been done. In developed countries, a significant loss to crops has been documented in quantitative, qualitative, and monetary terms; however, there is insufficient evidence on yield loss owing to nematodes in underdeveloped countries, including Ethiopia. RKN has about 5500 plant species as hosts, including African nightshades [34, 10]. They're found all throughout the planet [19], and given the right conditions, their population in the soil can rapidly grow [8, 18]. Several studies have been undertaken to investigate the possible damage of *Meloidogyne* spp on a variety of vegetable crops, including tomato, and several control measures have been offered. These studies, on the other hand, were not gathered and presented in a way that would benefit many stakeholders.

The goal of this review was to look at farmers' existing awareness of root knot nematode importance, as well as present an overview of the harm potential of root knot nematode (*Meloidogyne* spp.) on vegetables, their contribution to crop production, and root knot nematode general treatment approaches.

2. Life Cycle of Root Knot Nematodes

Root-knot nematodes have a six- to eight-week life cycle [37]. Specifically, an egg, four juvenile stages, and an adult stage. The first four stages are immature, thus they are referred to as juvenile stages, and they go through a straightforward and basic life cycle. This allows them to reproduce and survive at a greater rate, resulting in substantial crop losses in tropical nations [5]. In general, the female lays oval-shaped eggs in the soil or in plant tissues, either alone or in clusters. The external part layer, inner lipid, and actual shell secreted cover the eggs. The eggs are laid on the surface of galled roots, and they can also be found within the galls [21]. The first moult takes place within the egg, resulting in infectious second-stage juveniles (J2s) [29, 21]. The larvae can either spend their entire lives inside the host or abandon the feeding locations. As they reach the root region and feed their material, they are migratory or sedentary endo-parasitic in nature [12]. Most species have a life cycle that lasts about 3-4 weeks at a temperature of 27-30 degrees Celsius. Parthenogenesis is a type of reproduction that is sometimes accompanied by amphimixis [47].



Source; Ziaul Haque (2017) [52]

Figure 1. *Life cycle of Root knot nematode (Meloidogyne spp.).*

3. Damage Symptom of Root Knot Nematodes

In most cases, nematode damage to crops is not easily visible, and it is often obscured by the many other factors that limit plant growth. Root penetration, development, reproductive potential, and inoculum density of *M. incognita* in nearby soil all influence plant damage [45]. Galls or knots formed as a result of root cell growth. Wilting, yellowing leaves, food deficiencies, and delayed or stunted growth are subsequent signs [42]. *Meloidogyne incognita* is a serious tomato pests that causes harm by feeding on and causing enormous galls or "knots" throughout the root system of infected plants, which can obstruct water and nutrient intake and thus photosynthetic transfer [3]. It also changes the physiology of the host and, in extreme infestations, can kill the tomato plant completely [20]. Nematode attacks usually cause physical damage to a plant's roots, stems, or leaves. Their propensity to attack crops, particularly the roots and leaves, can have an impact on plant growth, yield, and quality [26, 28]. When the plant is stressed, such as during a lengthy dry season, the effect of nematode assault is more evident [13]. Nematode outbreaks can be devastating to a country's agricultural economy and food security [6, 16, 35].

4. Economic Importance of Root Knot Nematodes

Because of their economic relevance, there is a growing need to create long-term RKN management strategies and treatments. *M. incognita* is sedentary endo-parasites that attack a wide range of crops [43], causing substantial output losses primarily in tropical and sub-tropical agriculture [24]. Cover crops, fruit trees, weeds, decorative, and agronomic plants are among the most common hosts [23]. *M. incognita* can cause total crop failure in the absence of efficient control. It has been discovered in most of the world's tomato-growing regions, posing a threat to tomato yields [4]. Globally, an estimated $500 million is spent on RKN control [22]. They harm tomatoes severely, reducing both the amount and quality of marketable crops. RKNs (*Meloidogyne* spp.) have a negative impact on tomato production [44], with yield losses of 30 to 40% in tropical areas [44, 9]. *M. hapla* causes a 24–55 percent quantitative loss and a 13–77 percent qualitative loss in carrots when it infects the roots [33]. Not only can nematodes reduce agricultural output, but they also make the plant more prone to bacterial and fungal illnesses [51].

5. Knowledge of Farmers Towards Root Knot Nematodes

Nematodes that live in the soil are considered a farmer's hidden enemy. This is owing to the difficulty of detecting them without the assistance of skilled professionals. It must go through a number of steps before their presence and damage threshold can be determined. Plant parasitic nematode damage is closely linked to other causes, therefore their actions go unrecognized. The true degree of global nematode damage is likely to be underestimated, as growers are frequently unaware of their presence due to non-specific symptoms in the plant, making it difficult to ascribe crop losses to worm damage [19, 46]. Additional losses could result from poor food quality and aesthetic flaws linked to illness symptoms [38].

6. Management of Root Knot Nematodes (RKNs)

Effective treatment of PPNs is critical for long-term food supply. Root-knot nematodes (RKN) are the most common PPNs, especially in the tropics. It is safe to presume that once root-knot nematode has been identified, it will remain in the soil for many years. Nematode populations in soil might change from year to year, although they rarely vanish completely. The management of nematodes should be complex. Because it is impossible to completely eradicate nematodes, the goal is to regulate their population and keep them below dangerous levels. The logical application of effective control approaches in combinations that are economically acceptable to the grower will be required for management. Cultural controls are often utilized, although they have greater restrictions due to *Meloidogyne* spp extensive's host range and the existence of mixed populations of several RKN species in the field [49]. Crop rotation, antagonistic crops, resistant cultivars, soil solarization, bio-fumigation, Biological control, integrated nematode management, and nematicides are some of the nematode management approaches used to reduce nematode populations in soil.

6.1. Crop Rotation

Crop rotation is a traditional cultural practice with significant potential as a long-term method for controlling plant parasitic nematodes [7]. Incorporating crops that trap, are poor hosts for nematodes, or are antagonistic to nematodes into a rotation program has been proven to diminish the initial nematode population, allowing the following crop to develop before worm numbers reach economic threshold levels [36, 32]. Because root knot nematodes are exceedingly polyphagous, there are just a few non-host plants accessible for crop rotation management.

6.2. Antagonistic Crops

Plants that negatively affect the population of nematodes, such as trap plants, unsuitable hosts, and those with nematicidal/nematostatic substances in their tissues, which can be discharged into the environment or act just within the plant, are termed hostile [30]. These plants can be utilized as green cover, organic matter, or to improve the overall quality of the soil in addition to controlling the infestation of plant parasitic nematode [30]. There are several antagonistic plant species, but Tagetes spp., Azadirahta indica, Brassica spp., and Crotalaria spp. are the most well-known ones that are used to combat significant PPNs [17]. Organic additives are environmentally friendly, but the enormous volumes required per unit area make them unsuitable for large-scale farming operations. Organic soil additives with nematicidal qualities, such as organic matter from antagonistic plants Tagetes minuta, Ricinus communis, and Datura stamonium, have been reported to considerably boost crop yields [25, 1]. A common way for combating RKN that affects tomatoes is to amend the soil using commercially available neem components and products.

6.3. Resistant Cultivars

Two of the most essential management measures are the usage of resistant plants and providing optimal care. Despite nematodes, it is feasible to build and maintain an attractive landscape with careful care. Root-knot nematodes can be managed more cost-effectively by using resistant or tolerant plant cultivars. To cut production costs, farmers must obtain and employ resistant varieties. Resistant genotypes help safeguard the environment from pollution caused by nematicides' chemical leftovers. Because resistance is species specific, the use of resistant cultivars in the management of *Meloidogyne* spp. is dependent on the target species. Several vegetable crops have been created with resistance genes against several *Meloidogyne* spp. [40]. Tomato varieties with *M. incognita* resistance (thanks to the Mi-1 gene) have been created.

6.4. Soil Solarization

Soil solarization is a non-pesticide approach for weed, nematode, and disease control. They lower nematode populations in the top 12 inches of soil, allowing for the production of shallow-rooted annual crops and the establishment of young woody plants before nematode numbers rise. Solarization, on the other hand, will not safeguard fruit trees, vines, or woody decorative plants in the long run [14]. Controlling nematodes in the soil can be as simple as heating the soil under clear plastic tarps that trap and intensify the sun's heat. The soil must be moist, well tilled, and heated to at least 140 degrees Fahrenheit (60 degrees Celsius) for several days, preferable weeks. This method is suitable for residential gardens; however it should be used during the hot summer months and lengthy days.

6.5. Bio-fumigation

Bio-fumigation is a long-term solution for controlling diseases, nematodes, insects, and weeds in the soil. Bio-fumigation using Brassicaceae has been reported to be efficient in controlling soil pests such as root-knot nematodes in a number of studies [11]. Brassicaceous bio-fumigants have been shown to inhibit soilborne diseases, weeds, and plant-parasitic nematodes in multiple laboratory, greenhouse, and field experiments [39, 50].

6.6. Biological Control

Root-knot nematode infestation can be controlled by utilizing biological control agents such as fungus or bacteria that can effectively combat the nematodes. Although biological control is a feasible alternative to pesticides, limitations in mass production, biodiversity imbalances, and smallholder farmers' inability to finance it limit its adoption [24, 48]. Biological control agents and organic amendments have been combined with some success.

6.7. INM

Integrated nematode management (INM) is a set of pest management evaluations, decisions, and controls, rather than a single technique of treatment. Before making a nematode management choice, INM must establish nematode action thresholds, or a point at which nematode population or environmental factors indicate that worm control is required.

6.8. Nematicides

Chemical nematodes are thought to be the most effective way to control nematode populations. Nematicides are routinely employed in developed cropping systems, and they can either kill nematodes directly or paralyze them for a set amount of time (nematistatic). The use of variable rates of nematodes for precision plant protection against nematodes has been proven to be effective [31]. In general, nematode nematicides are the most successful in controlling nematode populations in a short period of time [41].

7. Conclusion

Effective treatment of plant parasitic nematodes is critical for long-term food supply. Root-knot nematode (RKN) is a plant parasitic nematode that can severely damage a wide range of crops, particularly vegetables, resulting in major yield losses mostly in tropical and sub-tropical agriculture. Knowing the biology, location, and symptoms of root knot nematodes on their host plant is critical prior to worm control. Producers are unaware of the influence due to its hidden parasite nature and similarity to other abiotic elements. Nematodes cause yield loss directly and indirectly by exposing animals to secondary infections that cause disease complexes. As a result, interested parties should be made aware of the importance of plant parasitic nematodes to farmers. In the future, nematode management will likely rely on more than one sort of metric, with additional measures being applied as needed to reduce waste. The findings of this research influence disease and pest control policies that are integrated and ongoing, ensuring that the country's food security is more stable.

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