Factors Associated with Plant Parasitic Nematode (PPN) Population: A Review

Belay Feyisa
Ethiopian Institute of Agricultural Research (EIAR), Ambo Agricultural Research Centre, Ambo, Ethiopia

Email address: belay22feyisa@gmail.com

To cite this article: Belay Feyisa. Factors Associated with Plant Parasitic Nematode (PPN) Population: A Review. Animal and Veterinary Sciences. Vol. 10, No. 2, 2022, pp. 41-45. doi: 10.11648/j.avs.20221002.15

Received: February 24, 2022; Accepted: April 6, 2022; Published: April 25, 2022

Abstract: *Meloidogyne* spp., root-knot nematodes (RKNs), are sedentary endoparasites that harm practically every crop on the planet. The root knot nematode attacks a variety of vegetable crops, causing delayed maturity, lower yields and quality, high production costs, and, as a result, a loss of income. The number of Root Knot Nematodes fluctuates from time to time, which can be caused by changes in temperature, soil type, and soil moisture. However, because the damage displays indications of drought and nutrient stress, it is frequently disregarded and goes unrecognized by most farmers. They degrade product quality in addition to reducing crop output owing to disruption in the host plant's physiology. The lack of awareness among farmers about the issues caused by root knot nematodes, as well as poor management strategies to combat the threat is a serious impediment to the protection of vegetable crops. To increase farmer acceptance, management techniques should be implemented in accordance with integrated pest management (IPM) practices. Vegetable growers should also be informed about the dangers of root-knot nematodes. In general, the paper summarizes elements that influence root knot nematode population dynamics, the significance of root knot nematodes and their development, as well as the pathogen life cycle and control methods.

Keywords: Endoparastic, *Meloidogyne* spp, Plant Parasitic Nematodes, Root Knot Nematodes

1. Introduction

The phylum Nematoda is made up of roundworms called nematodes. Plant-parasitic and animal-parasitic species are found in just a small percentage of nematode genera, and the vast majority of nematodes are free-living [29, 34]. Approximately 50% of known nematode species are marine, 25% are free-living species found in soil or freshwater, 15% are animal parasites, and 10% are plant parasites. Plant parasitic nematodes are the world's worst adversaries because of the havoc they wreak on crops. They can be found all across the world in a variety of settings, causing significant losses to economically vital crops. Root-knot nematodes (*Meloidogyne* spp.) are a dangerous pest that can cause significant economic losses in a variety of agricultural crops. On coffee, twenty-one *Meloidogyne* species have been discovered [30, 15]. *Meloidogyne* parasitizes a wide range of cultivated plant species from the Cucurbitaceae and Solanaceae families [31]. Root-knot nematodes (*Meloidogyne* spp.) are the most destructive and commercially important secondary endoparasitic worms [29]. In tropical, subtropical, and warmer regions of the world, *M. incognita* is the most commercially important plant-parasitic nematode species. It is found throughout the world's tropical and subtropical zones in all continents [3]. The overarching purpose of this review is to learn what factors influence root knot nematode population dynamics, the significance of root knot nematodes and their development, as well as the pathogen life cycle and control methods.

2. Literature Review

2.1. Importance of Root Knot Nematodes

*Meloidogyne* is the genus of root-knot nematodes. With about 5500 plant hosts, it is an economically important obligatory plant parasite [23]. However, because growers and farmers are generally ignorant of the presence of phytoparasitic nematodes, the overall global output losses
caused by PPNs are likely underestimated, particularly in underdeveloped countries. Reduced growth, stunting, chorses, mid-day wilting, leaf drop, tiny fruit, yellowing, curling and twisting of leaves and stems, galls, and stubby roots are all symptoms caused by PPNs, making it difficult to identify crop losses to nematode infection [32]. Plant parasitic nematodes are responsible for roughly 10% of yearly global crop yield losses, amounting to an estimated $173 billion in lost revenue each year [5, 8].

2.2. Life Cycle of Root Knot Nematodes

*Meloidogyne* species, or RKNs, are sedentary endoparasitic worms whose life cycle is reliant on feeding locations. It has a straightforward life cycle that includes an egg, juvenile one (J1), J2, J3, J4, and an adult stage. Female nematodes produce an egg mass by laying their eggs in a gelatinous matrix of 500-1000 eggs. The J2 stage of the RKN is the furthestmost essential, since it hatches from the egg and uses sensory compounds secreted from roots to choose a suitable host, which has an effect on plant roots. Second-stage juveniles (pre-parasitic J2s) develop from eggs under ideal conditions and are the sole infective stage that enters the plant roots at the root-tip. They employ the spear to build an entry site into the proper host by releasing enzymes that weaken plant cell walls.

2.3. Symptoms of Root Knot Nematodes

*Meloidogyne* spp. infected plants exhibit typical symptoms. Both aboveground and belowground plant sections might be affected by nematode damage. Stunting and general unthriftiness, premature wilting and poor recovery to increased soil moisture conditions, leaf chlorosis (yellowing), and other nutrient shortage signs are common foliar symptoms of nematode infestation of roots. Gall is a symptom caused by root knot nematodes that appears below ground. The formation of feeding sites (giant cells and syncytia) allows RKNs to draw in huge amounts of nutrients from the plant, enhances nematode growth, and causes a pathologically disrupted allocation of photosynthetic products, resulting in decreased plant growth and yield [29].

2.4. Farmers’ Knowledge of Root Knot Nematodes Damage

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. Because parasitic nematodes' impact is closely linked to other circumstances, their actions go unchecked.

2.5. Basic Characteristics of Root Knot Nematodes

Root-knot nematodes (RKNs) are obligate biotrophic plant-endoparasites of the genus *Meloidogyne* that are found across the tropical and subtropical world. *Meloidogyne* has been found to damage over 3,000 plant species, resulting in multibillion-dollar annual losses [11, 9]. RKN females are globose and inactive at development, not like most other PPNs. Once they have established a feeding spot within the plant root, they’ll stay there indefinitely. The feeding site for root-knot nematodes is a cluster of cells known as "giant-cells."

2.6. Giant-Cell and Its Purpose

When a nematode uses its stylet to enter a plant cell, it injects secretory proteins that cause alterations in the parasitized cells. Nuclear division proceeds in the absence of skilled professionals. It must go unchecked. 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. Because parasitic nematodes' impact is closely linked to other circumstances, their actions go unchecked.

2.7. Factors Affect Root Knot Nematode Population

Plant parasitic nematode life cycles, seasonal fluctuations, overwinter survival rates, and dispersion patterns in the soil are all significant factors to consider while sampling.

2.7.1. Temperature

The temperature range has a significant impact on *M. incognita*'s life expectancy. As the temperature rises over the typical range, the shelf life of the eggs decreases, but the hatching rate of J2 eggs increases to some amount as the
temperature rises. Below 10°C, eggs are unable to hatch. The ideal temperature for the hatching of M. incognita eggs was 15–30°C, according to [10]. J2 is capable of surviving at temperatures ranging from 10 to 25 degrees Celsius. Below 10°C, the eggs proved unable to hatch. Under ideal climatic circumstances, RKNs can complete their creation within three to four weeks.

2.7.2. Soil Type

The root knot nematode likes and produces the most damage in soils with a low clay concentration. Its population density is higher on sandy soils than in silt and clay soils [17]. It travels and aerates easily in light sandy soil, causing more damage to host plants [35]. The number of galls, egg mass forms, and root penetration rates of M. incognita increased in sandy soil compared to other soil textures [7, 1].

2.7.3. Soil Moisture

In warm damp sandy soils, root-knot nematodes (RKNs) are the most problematic and devastating. The survival and pathogenicity rate of M. incognita are influenced by the moist sandy soil texture and its temperatures in an ecological sense. M. incognita demonstrated reduced penetration rates in well-watered soil, according to [20].

2.8. Management of Root Knot Nematode

Because of their economic relevance, there is a growing need to create long-term RKN management strategies and treatments. 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 [27].

2.8.1. Cultural Method

Planting resistant crop cultivars, rotating crops, integrating soil amendments, and spraying pesticides are all common PPN control approaches. In some circumstances, soil solarization may be a viable option [27]. Crop rotation and cover crops are important components of integrated pest management because they help to reduce plant parasitic nematode density. Cover crops such as Mucuna pruriens and Crotalaria spectabilis have shown resistance to Meloidogyne arenaria, M. javinica, and M. incognita [2]. Rotational crops such as garlic, onion, asparagus, corn, cahaba white vetch, and nova white vetch help to diminish Meloidogyne spp. infestations as well as diseases and insect pests. Root knot Nematode is resistant to resistant crops including crotalaria, velvet bean, and grasses like rye (RKN). By exhibiting antagonistic effects, an antagonistic crop such as marigold can infest or reduce the population density of 14 genera of Plant parasite nematodes, including Meloidogyne spp [19].

2.8.2. Biological Control

It is described as the participation of beneficial organism genes or their various products in reducing unfavorable impacts on plants while promoting positive benefits. Bio-pesticides is another name for it. "Products aimed at protecting plants made from living organisms or natural substances from species coevolution, not produced by chemistry, and use of which is recommended for pest control or bio-aggressor for a better response of the bio-cenosis and environment," according to the definition of bio-pesticides [33].

2.8.3. Biotechnology Method

Plant parasitic nematode species biotechnological research helps to reveal the crop species resistance present in their gene pool. To exhibit their synthetic type of resistance, they kill their feeding cells and inject the damaging material into the nematode invading cells [25].

2.8.4. Host Plant Resistance Method

Meloidogyne-resistant cultivars have proven to be an effective management tool for RKN; however, few resistant cultivars are commercially available, and resistance may be overcome by new developing RKN species like M. enterolobii [36, 14]. The scientist and researcher identified between the several forms of natural genes that are employed to generate nematode resistance in plants. Traditional breeding methods for nematode resistance plants have had limited results. RNA interference (RNAi) technology is regarded as a reliable approach for nematode control [32]. In the link between host plant and nematode resistance, there are two types of resistance: passive and active resistance. The nematode infestation is influenced by anatomical, physiological, and chemical barriers in passive resistance. Active resistance produces histological changes in the worm, resulting in the formation of necrosis around the nematode and the nematode’s death.

2.8.5. Chemical Method

The goal of employing a chemical pesticide is to build a poisonous barrier between the pathogen and the host. Nematicides have remained the most common short-term management strategy against RKN [13, 21] however, several chemicals, including methyl bromide and aldicarb, have been withdrawn from the market in recent decades due to environmental and human health concerns, as well as toxicity to non-target organisms [7, 36]. Based on their mobility in the soil, nematicides can be divided into two groups. There are fumigants and non-fumigants in this category. Fumigants are liquid formulations that become vapourized after coming into contact with air. Their molecules become unattached in the vapourized form, move through the soil, and disintegrate into products that penetrate the cuticle of worms, affecting metabolic function. Non-fumigants include organophosphates and carbamates, which have a systematic impact on phytonematodes and are more effective at low dosages [6]. Furthermore, many nematicides are poisonous and volatile in nature, posing serious risks to human and animal health as well as the environment, resulting in serious issues such as ozone layer depletion and groundwater contamination [16].

3. Conclusion and Recommendation

Root knot nematodes are found all over the world [18] and under the right conditions, their population in the soil can
quickly grow [4, 12]. The continued usage of areas for vegetable production has the potential to increase root-knot nematode population and outbreak. Despite this danger, nematodes are largely ignored and omitted from crop production and protection plans. More resources must be directed toward research in order to fully address this problem. It should be focused at assessing and understanding the species identity, genetic diversity, population structure, parasitism methods, and overall threat that root-knot nematodes pose by surveying fields. As a result, researchers must pay special attention to the vast distribution of root systems.

References

[1] Anwar SA. and McKenry MV., 2010. Incidence and reproduction of *Meloidogyne incognita* on vegetable crop genotypes. Pakistan J. Zool., 42: 135-141.

[2] Bernard, G. C., Egnin, M., & Bonsi, C., 2017. The impact of plant-parasitic nematodes on agriculture and methods of control. Nematology-Concepts, Diagnosis and Control. DOI: 10.5772/intecoem69858.

[3] CABI., 2020. *Meloidogyne incognita* (root-knot nematode), Invasive Species Compendium, CABI, Wallingford, UK, https://www.cabi.org/isc/datasheet/33245.

[4] Calderon-Urrea, A., Vanholmle, B., Vangestel, S., Kane, S. M., Bahaji, A., Pha, K., et al., 2016. Early development of the root-knot nematode *Meloidogyne incognita*. BMC Dev. Biol. 16, 1–14. doi: 10.1186/s12861-016-0109-x.

[5] Dutta, T. K., Khan, M. R., and Phani, V., 2019. Plant-parasitic nematode management via biofumigation using brassica and non-brassica plants: Current status and future prospects. Curr. Plant Biol. 17, 17–32. doi: 10.1016/j.cpb.2019.02.001.

[6] Ebene, L. A., Kovaleski, M., & Deuner, C. C., 2019. Nematocides: history, mode, and mechanism action. Plant Science, 168, 1–13. (2), 91-97. DOI: https://doi.org/10.14719/ps.2019.6.2.468.

[7] E. Kim, Y. Yunhee Seo, Y. S. Kim, Y. Park, and Y. H. Kim., 2017. “Effects of soil textures on infectivity of root-knot nematodes on carrot,” *Molecular Plant Pathology*, vol. 33, no. 1, pp. 66–74.

[8] Elling A. A., 2013. Major emerging problems with minor *Meloidogyne* species. *Phytopathol.*, 103: 1092-1102.

[9] Forghani, F., and Hajihassani, A., 2020. Recent advances in the development of environmentally benign treatments to control root-knot nematodes. Front. Plant Sci. 11: 1125. doi: 10.3389/fpls.2020.01125.

[10] F. U. Zhao-hui, D. U. Chao, and W. U. Jun-xiang., 2006. Effects of Temperature, Humidity and Acidity-alkalinity on Growth and Development of *Meloidogyne incognita*.

[11] Gowda, M., Rai, A., and Singh, B., 2017. Root Knot Nematode a Threat to Vegetable Production and its Management. NewYork: IVR Technology.

[12] Hajihassani, A., Lawrence, K. S., and Jagdale, G. B., 2018. “Plant parasitic nematodes in Georgia and Alabama,” in Plant Parasitic Nematodes in Sustainable Agriculture of North America, Vol. 2. Eds. S. A. Subbotin and J. J. Chitambar (Northeastern, Midwestern and Southern USA: Cham: Springer International Publishing), 357–391. doi: 10.1007/978-3-319-99588-5_14.

[13] Hajihassani, A., Davis, R. F., and Timper, P., 2019a. Evaluation of selected nonfumigant nematicides on increasing inoculation densities of *Meloidogyne incognita* on cucumber. *Plant Dis.*, 103, 3161–3165. doi: 10.1094/PDIS-04-19-0836-RE.

[14] Hajihassani, A., Rutter, W. B., Schwarz, T., Wolfedemskel, M., Ali, M. E., and Hamidi, N., 2019b. Characterization of resistance to major tropical root-knot nematodes (*Meloidogyne spp.*) in *Solanum sisymbriifolium*. *Phytopathology* 110, 666–673. doi: 10.1094/PHYTO-10-19-0393-R.

[15] Humphreys-Pereira DA, Flores-Chaves L, Gómez M, Salazar L, GómezAlpizar L and Elling AA., 2014. *Meloidogyne* lopezi n. sp. (*Nematoda: Meloidogynidae*), a new root knot nematode associated with coffee (*Coffea arabica L.*) in Costa Rica, its diagnosis and phylogenetic relationship with other coffee-parasitising *Meloidogyne* species. Nematology 16, 643–661.

[16] Hussain, M., Zouhar, M., & Rysaneck, P., 2017. Comparison between biological and chemical management of root knot nematode, *Meloidogyne hapla*. Pakistan Journal of Zoology, 49 (1). DOI: http://dx.doi.org/10.17582/journal.pzj/2017.49.1.205.210.

[17] Jaraba-Navas, C. S. Rothrock, and T. L. Kirkpatrick., 2007. “Influence of the soil texture on the interaction between *Meloidogyne incognita* and *Dielaviopsis basicola* on cotton,” *Phytopathology*, vol. 97, p. S51.

[18] Jones, J. T., Haegeman, A., Danchin, E. G., Gaur, H. S., Helder, J., Jones, M. G., et al., 2013. Top 10 plant-parasitic nematodes in molecular plant pathology. *Mol. Plant Pathol.* 14, 946–961. doi: 10.1111/mpp.12057.

[19] Kafle, A., 2013. Evaluation of Antagonistic Plant Materials to Control Southern Root Knot Nematode in Tomato. *Journal of Agriculture and Environment*, 14, 78-86. DOI: https://doi.org/10.3126/ajae.v14i0.19788.

[20] Ma J., 2012. “Effects of *Meloidogyne Incognita*, Soil Physical Parameters, and *Dielaviopsis Basicola* on Cotton Root Architecture and Plant Growth,” http://scholarworks. uark.edu/etd/544.

[21] Medina-Canales, M. G., Terroba-Escalante, P., Manzanilla-López, R. H., and Tovar-Soto, A., 2019. Assessment of three strategies for the management of *Meloidogyne arenaria* on carrot in Mexico using *Pochonia chlamydosporia* var. *mexicana* under greenhouse conditions. *Biocontrol Sci. Technol.* 29, 671–685. doi: 10.1080/09583157.2019.1582267.

[22] Mejias, J., Truong, N. M., Abad, P., Favary, B., and Quentin, M., 2019. Plant proteins and processes targeted by parasitic nematode effectors. *Front. Plant Sci.* 10: 970. doi: 10.3389/fpls.2019.00970.

[23] Mitkowski NA. & Abawi, GS., 2003. Root-knot nematodes. The Plant Health Instructor. DOI: 10.1094/PHI-2003-0917-01.

[24] Nagachandrabose S., 2018. Liquid bioformulations for the management of root-knot nematode, *Meloidogyne hapla* that infects carrot. *Crop Prot* 114: 155–161. https://doi.org/10.1016/j.cropro.2018.08.022.
[25] Nyarko, J., & Jones, M. G., 2015. Application of biotechnology for nematode control in crop plants. Advances in Botanical Research, 73, 339-376. Academic Press. DOI: https://doi.org/10.1016/bs.abr.2014.12.012.

[26] Palomares-Rius, J. E., Escobar, C., Cabrera, J., Vovlas, A., and Castillo, P., 2017. Anatomical alterations in plant tissues induced by plant-parasitic nematodes. Front. Plant Sci. 8: 1987. doi: 10.3389/fpls.2017.01987.

[27] Schmitt, D. P., & Sipes, B. S., 2000. Plant-parasitic nematodes and their management. Plant Nutrient Management in Hawaii’s Soils. Approaches for Tropical and Subtropical Agriculture J. A. Silva and R. Uchida, (eds.). College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Pp. 145-149. Retrieved from https://www.researchgate.net/publication/29744605.

[28] Sharma, I. P. & Sharma, A. K., 2015. Effects of initial inoculum levels of Meloidogyne incognita J2 on development and growth of tomato cv. PT-3 under control conditions. African Journal of Microbiology Research, 9, 1376-1380.

[29] Siddique S, Grundler FM., 2018. Parasitic nematodes manipulate plant development to establish feeding sites. Curr Opin Microbiol 46: 102–108.

[30] Souza RM., 2008. Plant-parasitic nematodes of coffee. Berlin, Germany, Springer International Publishing. 340 pp.

[31] Taba, S., Sawada, J. and Moromizato, Z. I., 2008. Nematicidal activity of Okinawa Island plants on the rootknot nematode Meloidogyne incognita (Kofoid and White) Chitwood. Plant and soil 303 (1-2): 207-216.

[32] Tamilarasan, S., & Rajam, M. V., 2014. Engineering crop plants for nematode resistance through host-derived RNA interference. Cell Dev Biol, 2 (2), 2-7. DOI: 10.4172/2168-9296.1000114.

[33] Tranier, M. S., Pognant-Gros, J., Quiroz, R. D. L. C., González, C. N. A., Mateille, T., & Roussos, S., 2014. Commercial biological control agents targeted against plantparasitic root knot nematodes. Brazilian Archives of Biology and Technology, 57 (6), 831-841. DOI: https://doi.org/10.1590/S1516-8913201402540.

[34] Van Megen H, van den Elsen S, Holtermann M, Karssen G, Mooyman P, Bongers T, Holovachov O, Bakker J, Helder J., 2009. A phylogenetic tree of nematodes based on about 1200 full-length small subunit ribosomal DNA sequences. Nematology. 11: 927–950.

[35] V. H Dropkin., 1980. Introduction to plant nematology, p. 293, JohnWiley & Sons Inc, New York, NY, USA.

[36] Xiang, N., Lawrence, K. S., and Donald, P. A., 2018. Biological control potential of plant growth-promoting rhizobacteria suppression of Meloidogyne incognita on cotton and Heterodera glycines on soybean: A review. J. Phytopathol. 166, 449–458. doi: 10.1111/jph.12712.

[37] Zhou, L., Yuen, G., Wang, Y., Wei, L., Ji, G., 2016. Evaluation of bacterial Biological control agents for control of root-knot nematode disease on tomato. Crop prot. 84, 8-13.