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Review Article

A Review on Root Knot Nematodes (RKNs): Impact and Methods for Control

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ABSTRACT

Plant-parasitic nematodes are costly burdens of crop production and productivity. Phytoparasitic nematodes are associated with nearly every important agricultural crop and represent a significant constraint on global food security. Root-knot nematodes (*Meloidogyne* spp.) rank at the top of list of the most economically and scientifically important species due to its intricate relationship with the host plants, wide host range, and the level of damage ensued by infection. Root-knot nematodes, *Meloidogyne* spp., are recognized as the most economically important genus of plant parasitic nematodes worldwide. The nematode causes severe damage and yield loss to a large number of cultivated plants and especially on vegetable crops in the tropics and subtropics. The direct and indirect damage caused by various *Meloidogyne* species results in delayed maturity, toppling, reduced yields and quality of crop produce, high costs of production and therefore loss of income. In addition, emergence of resistance-breaking *Meloidogyne* species has partly rendered various pest management programs already in place ineffective, therefore putting food security of the continent at risk.

Keywords: Food security; Phyto-parasitic; Plant parasitic; Root Knot Nematode

INTRODUCTION

Root-knot nematode (*Meloidogyne* spp.) are economically important polyphagous obligate plant parasites, distributed worldwide, and are known to parasitize nearly every plant species of higher plants [1]. Root-knot nematodes belongs to *Meloidogyne* are sedentary endoparasites and their parasitism life depends on the success to induce feeding sites in the roots of host plants [2]. They are considered to be the most wide spread and destructive plant-parasitic nematodes and can cause an estimated yield loss of 25-50% over wide areas of cultivated land [3]. Estimated yield loss on tomatoes is about 24-38% [4]. A large number of crops worldwide are affected by root-knot nematodes and so far more than 100 species have been described [5]. *Meloidogyne incognita, M. javanica* and M. *arenaria* are the most common in the tropical regions while M. *hapla*, M. *fallax* and M. *chitwoodi* are successful in temperate and cooler regions [6]. Damage is more pronounced in tropical climates than in temperate because of the favourable conditions for nematode survival and multiplication [7].

LITERATURE REVIEW

Life cycle of Root knot nematode (*Meloidogyne* spp)

The life cycle of root-knot nematodes, *Meloidogyne* spp. is shown in Figure 1 and is briefly described below: The infective second-stage juveniles move in the soil and penetrate the root tips of the host plant using their stylet [8]. Once inside the roots, they migrate intercellularly and if the plant is susceptible then they can initiate feeding sites [8]. They release pharyngeal secretions that induce the formation of multinucleate feeding cells called giant cells [9]. Giant cells are used as suppliers of nutrients to the growing nematode [10]. Root knot nematodes have six stages: Egg-J1-J4 and adult (female or male). The juveniles (J2) feed, and become sedentary. They then undergo three molts (J3, J4 and adult). Sometimes vermiform males develop and migrate out of the root while the females remain sedentary and are pear shaped [1]. The females feed and produce a large number of eggs in a gelatinous matrix [11]. The gelatinous matrix is believed to protect the eggs against unfavorable environmental

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conditions. Embryogenesis begins inside the egg and after the first molt, second-stage juveniles hatch [10]. The temperature requirement for reproduction and survival depends on the species of root-knot nematodes [11]. The temperature range of 25°C to 30°C is optimum for reproduction and survival of *M. incognita, M. javanica* and *M. arenaria* [3] which are common in tropical and subtropical countries. For cryophils that is *M. chitwoodi, M. hapla, M. naasi* and other temperate *Meloidogyne* species hatching can occur at temperatures below 10°C [1]. Adult females embedded in host roots produce eggs which may be free in the soil or together in a gelatinous matrix which may still adhere to old root tissue segments of the plant host. The nematode develops to the second stage juvenile in the egg. The infective second stage juvenile then hatches and moves into the soil to search for the host root. When a suitable host root is reached the juveniles invade near the root tip. They penetrate the cortex until the juvenile makes contact with the vascular cylinder. Here it forms giant cells upon which the developing nematode feeds. The juvenile grows slightly in length and much in width. As development increases the juveniles become flask shaped and undergo three further moults [3]. After the last moult either a true male, which appears as a long filiform nematode inside the cuticle of the fourth larval stage is produced or an adult female evolves which is pyriform in shape. The females secrete a gelatinous matrix into which they lay up to 500 eggs [12]. Most juveniles develop into females and only under adverse conditions are high numbers of males observed.

Root-knot damage

The presence of galls on the root system is the most evident diagnostic symptom caused by root-knot nematodes. Root-knot nematodes limit vegetable production worldwide and cause high losses especially in vegetable crops [13]. *Meloidogyne* spp. causes an estimated annual loss of $157 billion globally [10]. However, in most cases, the impact of *Meloidogyne* spp. is grossly underestimated. This is more so in Africa than anywhere else in the world. Hence it is probable that the overall annual losses due to these pathogens are much higher. In many crop producing regions in Africa, there has been no comprehensive assessment that focuses specifically on the economic impact of *Meloidogyne* spp. [14]. Most vegetable crops have been recorded as a host for at least one of the most frequently occurring species of root knot nematodes, *M. incognita, M. javanica* and *M. arenaria*. These nematodes not only affect the crop yield in a direct manner but also make the plant more susceptible to bacterial and fungal attacks [15]. Plant's resistance toward root-knot nematodes is unstable and often results in decreased yields [16]. They cause a considerable loss in annual yield of vegetables, which may range from about 10 to 30% depending on the severity of infection [17]. It is very difficult to grow important vegetables such as tomato in tropical or semi-tropical soil infested with root-knot nematodes, particularly *M. incognia*.

Symptoms of root knot nematode

The root-knot nematodes feed and mature inside the roots of plants. Their feeding induces abnormal enlargements of the root, called galls. The root-knot nematode does not survive very long without a host plant, except in very low numbers and probably in egg stage. Root galls are the primary symptom of root-knot nematodes but species identification needs laboratory analysis. Feeding of many PPNs creates entryways into plant roots for secondary pathogens, while feeding of some species directly transmits plant viruses [18].

Above ground symptoms

Root-knot nematodes (RKNs) are obligate parasites which feed mainly on plant roots with common aboveground symptoms of stunting, yellowing, wilting, and yield losses. Above ground symptoms are mimic with that of nutrient deficiency and other pathogen symptoms. So laboratory diagnosis is very important for conformation.

Belowground symptoms

Below ground symptom of nematode also show symptoms like; Root malformation due to direct feeding damage galls on root, Root lesion. As a result of feeding of root-knot nematode, small to large galls or "knots" can form throughout the root system of infected plants. As the name implies, root lesion nematodes produce characteristic necrotic lesions (darkened areas of dead tissue) on the surface and throughout the cortex of infected roots. The impairment of water and mineral transport pathways leads to the appearance of symptoms resembling water or nutrition deficiency like small, chlorotic, and less vigorous plants [19].

MANAGEMENT

Managing nematodes in tropical and subtropical environments are a challenge. There are a few control measures that are effective, and these must be used under conditions in which they will work. For effective management of nematodes, the critical steps are (1) accurate diagnosis and (2) proper selection of the most effective and environmentally benign control method.

Control of nematodes

Nematode management should be multifaceted. Since eliminating nematodes is not possible, the goal is to manage their population, reducing their numbers below damaging levels. Common management methods used include planting resistant crop varieties, rotating crops, incorporating soil amendments, and applying pesticides. In some cases, soil solarization also may be practical.

Control methods not involving pesticides

Use of resistant plant cultivars is limited because there are only a few and their nematode resistance is very specific. Because resistance is specific, accurate identification of the nematode species and race is necessary before the proper cultivar can be selected. Crop resistance is ideally combined with a long-term crop rotation schedule and the best management practices available to favor vigorous and healthy plant growth. Crop rotation involves growing a crop that is not a host for the nematode present before growing a crop that is susceptible. The non-host or immune crop will cause nematode numbers in the soil to decline, giving the subsequent host crop a chance to establish a good root system. The success of this method depends on growing the non-host crop long enough to reduce the nematode numbers. The rotation crop must be selected carefully because some nematodes (such as root-knot, reniform, and burrowing nematodes) have very wide host ranges. Also, some undesirable species may emerge on the rotational crop and become a pest. Variations on the crop rotation concept include fallowing, multicropping (intercropping), and green manuring.

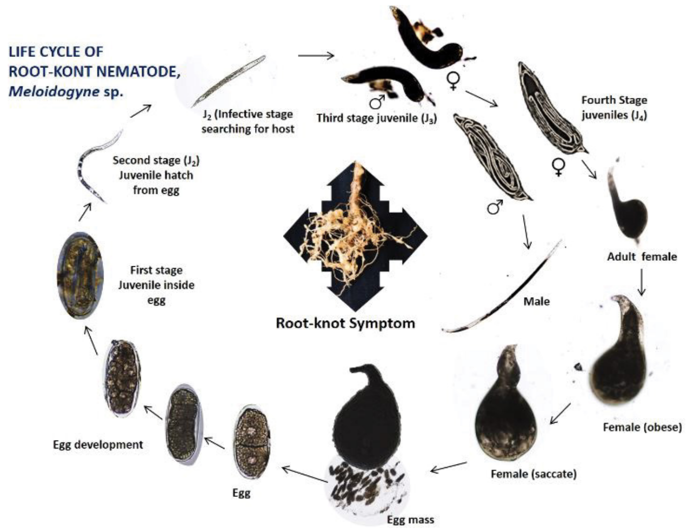

Figure 1: Life cycle of Root-knot Nematode, *Meloidogyne* species.

Keeping the soil free of plants (fallow) deprives plant-parasitic nematodes of a host, which, over time, reduces their populations. Maintaining good weed control is a critical component of fallowing for nematode control because weeds are hosts of many species of plant-parasitic nematodes.

Multicropping (intercropping): with plants that either are not good nematode hosts or are antagonistic to the nematodes also reduces nematode numbers. Sunn hemp (*Crotalaria juncea*) and spider plant (*Cleome gynandra*) produce strong odour and farmers report little incidence of arthropod and nematode pests on them compared to exotic ones [20]. The above observation suggests that these vegetables possess inherent pest repellent effects and antagonistic properties. According to Wang et al. [21], these vegetables also suppress non-edible weeds in fertile soils. African nightshade, sunn hemp and spider plants were used as intercrops for arthropod and nematode pest management in the current study. Sunn hemp reduces egg oviposition in nematodes and as a legume has an added advantage of increasing yields through nitrogen fixing capacities [22].

Green manuring: tilling under a crop that grows rapidly and produces a large quantity of biomass adds organic matter and, depending on the green manure crop used, may add substances that repel or kill nematodes. Sudan grass and corn are excellent green manure crops that provide good nematode control.

Biological control: Another nonchemical approach to controlling nematodes is biological control using other organisms against the pest organism. A high level of natural biological control is ordinarily present in the soil. This natural control probably keeps the nematode populations at 10–20 percent of what they would be in its absence. Nevertheless, the level of natural control is seldom adequate to prevent plant damage from nematodes. The strategy of inoculating soils with biological control organisms to increase or supplement the control organisms naturally present has proven to be unrealistic and is not recommended until more predictable inoculants are developed. A more realistic strategy for biological control of nematodes is to incorporate soil amendments such as manure (particularly poultry manure) and compost. Such additions of organic matter contribute to biological activity in the soil and enhance the natural activity of organisms antagonistic to nematodes.

Solarization: heating soil under clear plastic tarps that trap and increase the sun's heat can be an effective means of controlling nematodes in the soil. The soil needs to be moist, well tilled, and heated to at least 140°F (60°C) for several days, preferably several weeks. This method can be practical for home gardens, but it should be done during the hot months and long days of mid-summer. Similarly, other heat and steam-based pasteurization methods can be used to prepare potting soil. Healthy plants grown in nematode-free media have a better chance to survive after being transplanted to the field.

Nematicides: are sometimes used in agriculture, but there are few on the market. Most nematicides are highly toxic synthetic pesticides commercially available only to commercial growers. These products can be used only on particular crops, and they usually must be purchased and applied by a licensed pesticide applicator. However, several organically based nematicides are being marketed that can be purchased without a license. Two types of nematicides are fumigants and nonfumigants. Fumigant nematicides are usually more effective, but nonfumigant nematicides can also be used effectively. Fumigant nematicides such as metam sodium and 1,3-dichloropropene are applied before planting. Some nonfumigant nematicides such as Nemacur®, Mocap®, or Vydate® are moderately effective and can be used both pre- and post-planting.

The key and way forwarded of root knot nematode managing in garden plants

Check roots of seedling for nematode gall before transplanting them. Susceptible plants can be grown in containers with a nematode free soil or growth media by keeping containers off the ground. Add large amount of organic matter to the soil and keep weed free as root knot nematode have many hosts. As soon as plants harvested up root them to stop their roots from hosting nematodes. Infected plant root systems should be destroyed and not composted. Rotate susceptible plants with resistant or immune plants.

DISCUSSION AND CONCLUSION

Among over 4,100 species of plant-parasitic nematodes have been identified, 100 species are root-knot nematodes. In addition to direct feeding and migration damage, nematode feeding facilitates subsequent infestation by secondary pathogens, such as fungi and bacteria. Significant improvements are consequently necessary in terms of resource use efficiency. In moving crop yields towards an efficiency frontier, optimal pest and disease management will be essential, especially as the proportional production of some commodities steadily shifts. Today a large number of crops worldwide are affected by root-knot nematodes. They are considered to be the most wide spread and destructive plant-parasitic nematodes and can cause an estimated yield loss of 25-50% over wide areas of cultivated land. Estimated yield loss on tomatoes is about 24-38%. So, the aim of this work was to review some root knot nematodes genera and their management methods/options. In this review work the root knot nematode feeding habit/damage, life cycle, host and symptoms they show on the effected plant and management of root knot nematode genera was reviewed. Further research has to be done beside the above mentioned management options to evaluate the efficacy of some promising botanicals for the management of some nematode like root rot nematode under field condition of different agro-ecologies and improve their application technology. Other area of further research may include the use of such promising botanical extracts in integrated pest management strategy and evaluation of their effects on other soil-borne plant diseases and characterization of nematodes using modern techniques like molecular characterization has to be done for formulating of effective management practices.

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