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The Impact of Plant Parasitic Nematodes on Major Crops in Ethiopia and Their Management Strategies: A Review

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ABSTRACT

Pest management has a significant impact on Ethiopia's national priority goal which is food self-sufficiency through agriculture. In Ethiopia, there is a significant knowledge gap about the impact of plant-parasitic nematodes on different crops. The existing state of knowledge makes it difficult for the country to apply effective pest management strategies. Assessment of plant-parasitic nematodes in major crops and the ongoing search for plant parasitic nematodes in the country's major agro-ecological zones was previously studied. The majority of nematodes in Ethiopia affect a variety of crops. Thus, the goal of this review was to look at what we know about nematode pests that harm major crops. *Meloidogyne*, *Pratylenchus*, *Aphelenchoides*, *Helicotylenchus*, *Cephalenchus*, *Rotylenchus*, *Xiphinema*, *Ditylenchus*, *Tylenchorhynchus* and *Tylenchorhynchus* species were found in abundance in enset, khat, banana, wheat and potato crops. Several plant-parasitic nematode species have been linked to different crops in Ethiopia, though *Pratylenchus* species had a broad host range. Cultural measures, physical means, chemical use and host-plant resistance are some of the nematode species control strategies used to reduce the risk of crop loss. For long-term pest management, more research is needed to determine the aggressiveness and toxicity of particular plant-parasitic nematodes on major crops in the country.

INTRODUCTION

Hunger and famine are long-term challenges in human life and in the years 2012-2014, the majority of people in developing nations were underfed. Africa has the greatest rate of malnutrition, with the majority of Ethiopians suffering from malnutrition[1]. Every year, more than 15 million peopledie as a consequence of starvation[2]. Nematodes are one of the most significant difficulties to crop production, causing a 12% yearly yield loss of essential crops around the world[3]. Plant-parasitic nematodes (PPNs) are small roundworms which attack plants and live in the soil. They inflict significant economic losses in agriculture all around the world[4]. Farmers are largely unaware of the effects of PPNs because damage isn't seen until plant or soil samples are collected for worm diagnostics. PPNs have formed a unique connection with their host plant for nutrition that has changed over many years. By sucking the fluid with their stylet, they nourish on the contents of living cells[5].

Nearly ten genera are believed to be the primary cause of agricultural losses worldwide. *Meloidogyne* spp., for example, has complicated relations with the host plant root, resulting in significant morphological and developmental alterations. When populations of PPNs are high, they can destroy annual plants in particular[6]. They cost billions of dollars in crop losses every year. Most of the economically important nematode types directly attack the roots of main crops, preventing nutrient and water uptake, causing poor agronomic growth and yield losses[7]. Every plant species is parasitized by at least one species of nematode and practically every crop is impacted by plant parasitic nematode[8]. The annual damage caused by nematodes is estimated to be more than 358 billion dollars globally, or roughly 12.6 percent of total crop production[9]. In Ethiopian agriculture, staple crop yield is low and is influenced by a number of factors, the most important of which are crop diseases. Plant parasitic nematode related problems in Ethiopia have a major influence on agricultural output, according to the studies conducted so far on crop diseases[10].

The levels of damage are influenced by the host crop and the type of nematode species. Some of the frequent symptoms for nematode infestations are leaf chlorosis, early wilting, senescence, stunting and low yield[11]. Some surveys have been carried out after primary nematological study in Ethiopia. Following that, a number of plant-parasitic genera such as *Pratylenchus*, *Rotylenchulus*, *Helicotylenchus*, *Scutellonema*, *Longidorus*, *Xiphinema*, *Paratrichodorus*, *Meloidogyne*, *Tylenchorhynchus*, *Ditylenchus*, *Hemicycliophora*, *Criconemella* and *Heterodera* have been associated to different crops[12]. All of those research concentrated on identifying the nematode species and no reports on the extent of yield losses caused by those nematodes are published.

Due to the above-ground sign of nematode root damages are ordinary and similar to some other reasons such as lack of nutrients and water, the crop damages by nematodes have not yet given much attention as a pest of economic consequence in Ethiopia[12]. Reports on the biodiversity, spreading, occurrence, economic importance and management of plant parasitic nematodes in Ethiopia is limited. Up to now, a small number of studies has been conducted and the implementations of these research outcomes by policy makers and stakeholders has been insignificant. Thus, this review focused on the effect of plant parasitic nematodes on Ethiopia's main crops.

The impact of plant parasitic nematodes on crops: In agricultural crop production, plant-parasitic nematodes (PPNs) constitute a major problem. Nematodes that attack plants have been discoveredin over 4100 species of plants[13]. Crop loss costs the economy a billion dollars every year[14]. The most commercially significant nematode species attack plant roots directly, preventing nutrient uptake and resulting in lowproductivity and yields. The PPNs are divided into two classes based on their feeding approaches: ectoparasitic and endoparasites. Ectoparasitic are nematodes nourish on roots without entering the root tissue, whereas endoparasites develop inside the plant host for at least one stage. Symptoms of PPN feeding on plant roots can be misinterpreted as nutritional or water deprivation. Stunting, yellowing, wilting and yield loss are visible aboveground indications of worm damage, while abnormalities of roots, such as lesions, galls and distortions, are visible belowground, relying on the nematode species[15].

The stationary groups of plant-parasitic nematodes, which create a stable feeding spot within the crop, acquire nutrition and completing their lifecycles, are the most successful of all the significant plant-parasitic nematodes. Because of a unique and sophisticated process of host cell transformation that results in the creation of a sustained feeding structure, a natural advantage over their migratory counterparts exists for stationary nematodes. Surprisingly, just a small percentage of the roughly 4100 plant-parasitic nematodes reported cause major agricultural losses. *Pratylenchus*, *Heterodera*, *Hoplolaimus*, *Meloidogyne*, *Rotylenchulus* and *Xiphinema* were the principal genera of phytoparasitic nematodes were found to be the main types responsible for crop losses[16].

Plant Parasitic Nematodes are one of the common plant pests but statistics on their impact is scarce, particularly for crops farmed in resource-poor areas. Crop losses due to nematodes were predicted to be 14.6% in tropical and sub-tropical regions, compared to

8.8% in affluent countries. When populations of plant parasitic nematodes reach large densities, they can damage crops, especially annual host plants. Yield loss can occur at lower densities without causing noticeable variations to the plant, measurement the loss becomes difficult. The amount of yield loss caused by nematode damage is determined by nematode density, species, host crop resistance and soil environment. Thus, in Ethiopia, like other countries with a lack of skilled nematologists, plant parasitic nematodes have given little attention as key agricultural determinants[17].

Nematode problems on key staple and economically important crops in ethiopia

Plant parasitic nematodes on enset crop: Ensetis linked to a variety of plant parasitic nematode species in the enset grower regions in south and south western part of Ethiopia[18]. *Pratylenchus*, *Meloidogyne*, *Helicotylenchus*, *Scutellonema*, *Tylenchorhynchus* and *Rotylenchulus* were among the plant-parasitic nematodes identified in enset root samples[19]. Of those nematodes *Pratylenchus goodeyi* dominates and is the most prominent species[19]. Galling injury was seen on enset roots in the study, indicating that it is becoming increasingly challenging in enset production. Root-knot nematodes (*Meloidogyne* spp.) were also isolated from some of the root samples, with low densities. As a result, the study shows the prevalence of *Meloidogyne* spp. linked with the enset crop through the region, confirming the rising concern that this damage is becoming more challenging on enset crops[20]. Other types of nematodes such as *Cephalenchus*, *Pratylenchoides* and *Trophurus* species were found in the study area, which do not appear to pose a serious threat to the crop[19]. However, there is no much information on how this affects crop development and production, therefore the extent of enset damage is unknown. Differences in nematode densities between enset cultivars revealed possible differences in *Pratylenchus* goodeyi resistance[19].

Pratylenchus goodeyi was the dominant plant-parasitic nematode found in roots, aside from a few nonparasitic nematodes in enset samples. Despite the fact that the stage of development of the suckers was not documented for each sample, younger suckers looked to be less infested than older suckers. The nematode-infected suckers are planted into fresh fields, frequently with visible lesions on the roots and corms[20]. A few farmers were conscious of nematode pests or had a little information about them. They had some knowledge of other foliar diseases, such as bacterial wilt on enset but not nematodes. Even though nematodes are regarded as economically significant pests of the majority of crops in the region, many smallholder farmers and agricultural agents in Ethiopia are still largely unaware of nematodes as pests and how to control them[18].

Plant parasitic nematodes on khat crop: The presence and occurrence of a variety of ecto-parasitic and endo-parasitic nematode types were observed in this study along the key khat growing areas in the eastern part of Ethiopia, Hararghe Zone. *Hemicyclophora*, *Helicotylenchus*, *Longidorus*, *Criconema*, *Meloidogyne*, *Paratylenchus* and *Rotylenchulus* have all been linked to decreased yields in a variety of crops around the world[21]. Many factors, such as soil type, cropping system, climatic conditions and cultural practices used, have contributed to the dissemination of these nematodes pests in the key khat growing areas. The kind of soil has a big impact on nematode spread. Khat was intercropped with other vegetable crops including tomato, pepper, cabbage, potato and sweet potato, maize, sorghum and groundnut by farmers in the East Hararghe Zone of Ethiopia. High population densities of *Pratylenchus*, *Meloidogyne* and *Longidorus* were discovered, which could be harmful to khat growth and biomass output. The presence of nematodes could be associated with the cropping system or the suitability of khat as a host for them. There seems to be a link between the nematode type found in a particular location and the intercropped crops growing in the area. *Meloidogyne*, *Pratylenchus* and *Longidorus* were the main species in khat areas intercropped with solanaceous or cereal crops, respectively. Farmers are unaware of the presence of nematode pests and were concerned about leaf miner insect pests concerning their understanding of nematodes. Thus, they should be informed about plant-parasitic nematodes and the cropping patterns may affect them as a short-term solution[22]. Furthermore, knowing the destructive capability of specific nematode types found in a specified location will be crucial for determining the economic threshold level and estimating cost-benefit relationships when adopting control techniques. This is the first time in Ethiopia that plant-parasitic nematode genera have been linked to khat.

Plant parasitic nematodes on banana crop: Plant-parasitic nematodes are one of the main productivity barriers in the production of bananas and plantains, although they have received little attention[20]. Various nematode species have been linked to the crop in a few studies, one of the nematode genera, *Pratylenchus goodeyi* becoming to be the most common in banana crop[19]. *Meloidogyne incognita*, *Meloidogyne javanica* and *Meloidogyne ethiopica*, as well as *Aphelenchoides ensete*, have been also identified as potential nematode pests which lowers banana production[23]. In comparison to other infections, nematodes are underappreciated in Sub-Saharan Africa and Ethiopia in particular[20]. As a result, primary information on the level of damage caused by plant parasitic nematodes in Ethiopia is critical. It is critical to do studies on damage levels in order to effectively manage banana

Table 1: The distribution of plant parasitic nematodes associated with major crop varieties in Ethiopia

Host crop	Nematode type	Location	References
Enset	*Pratylenchus* spp. *Meloidogyne* spp., *Aphelenchoides* spp., *Helicotylenchus* spp., *Tylenchorhynchus* spp. and *Cephalenchus* spp.	Dawro, Guraghe, Sidama Hadiya, Kembata, Wolayita and Keffa zones	Kidane *et al*.[18]
Khat	*Pratylenchus* spp., *Meloidogyne* spp., *Helicotylenchus* spp., *Hemicyclophora* spp., *Criconema* spp., *Paratylenchus* spp., *Longidorus* spp. and *Rotylenchulus* spp.	East Hararghe Zone	Coyne *et al*.[22]
Banana	*Rotylenchus* spp., *Radopholus* spp., *Pratylenchus* spp., *Helicotylenchus* spp. and *Meloidogyne* spp.	Arba Minch Zuria Woreda	Seid *et al*.[24]
Wheat	*Pratylenchus* spp., *Hoplolaimusspp* and *Rotylenchus* spp.	Afeshum Wereda, Tigray Region	Gebremedhin[1]
Bean	*Pratylenchus* spp., *Rotylenchus* spp., *Xiphinema* spp., *Ditylenchus* spp., *Tylenchorhynchus* spp., *Tylenchus* spp. and *Radopholus* spp.	Afeshum Wereda, Tigray Region	Gebremedhin[1]
Potato	*Pratylenchus* spp., *Radopholus* spp., *Ditylenchus* spp., *Helicotylenchus* spp. and *Longidorus* spp.	Afeshum Wereda, Tigray Region, Amhara region and Oromia Region	Gebremedhin[1] Mandefro and Mekete[25]

nematode infestations in any specific banana farm. *Pratylenchus*, *Meloidogyne*, *Helicotylenchus*, *Radopholus* and *Rotylenchulus* were the most common plant parasitic nematode genera connected with banana (Table 1). A variety of plant parasitic nematodes harmed banana roots in Arba Minch, Ethiopia. As a result, while devising nematode management strategies, the total harm produced by phyto-nematode populations must be considered. These discoveries also revealed nematode-infected suckers that were ready to be shipped across the country. As a result, selecting nematode-free planting material for planting on fields that have not previously been planted with bananas would be a good place to start.

Plant parasitic nematodes on some other crops: Some of genera of plant parasitic nematodes identified from soil and root samples of faba bean. These nematodes are *Pratylenchus*, *Rotylenchulus*, *Tylenchoryhnchus*, *Xiphinema*, *Ditylenchus* and *Tylenchus*. The presence of these plant parasitic nematode taxa was discovered connected with the rhizosphere of faba bean crops in two regions of Ethiopia namely Oromia and Amhara[25]. Though, the economic impact of these nematodes in terms of yield loss and their impact on national agricultural output is unknown. The presence of significant nematode pests such, as well as their density, are causing low level of faba bean production in the country[25]. In order to successfully control plant parasitic nematodes in cropping systems in faba bean, it is important to determine the economic significance of the reported nematodes in Ethiopia. The presence of plant parasitic nematodes in pulse cropping systems has to be explored further and the nematode's responsiveness to cultural activities would be useful information for management procedures. In wheat and potato, *Pratylenchus* spp. and *Radopholus* spp. had the highest occurrence. *Hoplolaimus* spp. ranked third among wheat nematodes. The two genera of nematodes *Pratylenchus* spp. and *Radopholus* spp. have a great impact because of their wide distribution and abundance compared with other genera. The sole plant parasitic nematode found on potatoes has been *Meloidogyne* spp.[25].

Plant parasitic nematode management strategies: A comprehensive survey and integrated nematode management program are required to increase the yield of valuable plants and vegetables[26]. Some of the nematode species control strategies to limit the danger of crop loss includes cultural approaches, physical means, chemical use and host-crop resistance. A range of procedures are used to generate healthy planting materials, including *in vitro* tissue culture, micro propagation and sucker cleaning by water treatments[27]. In smallholder cropping systems in which, costly management techniques are not possible, the use of clean and healthy planting material is vital in reducing the growth of nematodes and other root-borne plant disease, as well as the harm they cause. Because nematode pests appear to be constantly propagated through the transfer of infected planting material between farmers, measures to inhibit transmission are needed.

Most farmers in Ethiopia were unaware of plant parasitic nematodes and the potential harm they could do. Plant parasitic nematode contamination has evident consequences for production and quality and therefore necessitates quick action. Interventions are needed to promote knowledge of nematodes, the harm they cause and effective management techniques. For enset and banana farms, it is important to apply easy and useful techniques for the development of healthy seedling systems and planting material sanitation. One of the most prevalent ways for nematodes to propagate on major crops is through the dissemination of contaminated planting material. Because tissue-culture plantlets are free of fungal, bacterial and nematode diseases, they should be employed whenever possible. When they're made from indexed mother plants, they're also clear of viral and viroid infections[28]. To prevent nematode damage to crops in the area, cultural approaches were applied[1]. Crop rotation, the use of pathogen-free planting material, soil additives, manuring, sanitation, deep cultivation and the use of better crop types are all cultural nematode management techniques. Cultural approaches have an advantage compared with other control strategies, as it requires less resources and infrastructures and are adaptive to the resource-

poor smallholder farmers. Crop rotation, flooding, use of antagonistic plants, soil additives, deep cultivation and enhanced crop husbandry are some of the cultural approaches that are currently applied by the farmers to control plant parasitic nematodes[29].

CONCLUSION

In Ethiopia, the majority of nematodes have an impact on various crops. As a result, the purpose of this review was to examine numerous agricultural nematode genera as well as their host crops. The species and host crop they present on the damaged plant were investigated. Nematode species such as *Pratylenchus* spp., *Meloidogyne* spp., *Aphelenchoides* spp., *Helicotylenchus* spp., *Cephalenchus* spp., *Rotylenchus* spp., *Xiphinema* spp., *Ditylenchus* spp. and *Tylenchorhynchus* spp. were found in abundance in enset, khat, banana, potato, wheat and potato crops in different parts of Ethiopia. *Pratylenchus* spp., one of those nematode species, had a wide host range and was detected in practically all crop kinds. Some of the nematode species control tactics to limit the danger of crop loss includes cultural approaches, physical means, chemical use and host-plant resistance. Some of the management measures that can be utilized to control nematode spreads include field sanitation and the use of clean and healthy planting materials. More investigation is required into know the toxicity and invasiveness of each plant-parasitic nematode's harm to different crops.

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