Biological Forum
an International Journal 17(7): 18-21(2025)
ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

A Review on Status and Importance of Foliar Nematode in Plant Pathology

Prajapati P.G.[1*], Patel M.I.[2], Kansara S.S.[2], Chopda G.B.[2], Ghevariya T.V.[3] and Patro S.P.[1]
[1]M.Sc. Scholar, Department of Plant Pathology, NAU, Navsari (Gujarat), India.
[2]Assistant Professor, Department of Plant Pathology, NAU, Navsari (Gujarat), India.
[3]Research Scientist, Main sorghum research station, NAU, Navsari (Gujarat), India.

(Corresponding author: Prajapati P.G.)*
(Received: 09 April 2025; Revised: 20 May 2025; Accepted: 18 June 2025; Published online: 05 July 2025)
(Published by Research Trend)

ABSTRACT: Foliar nematodes, primarily from genera such as *Aphelenchoides*, *Ditylenchus*, *Anguina* and *Litylenchus*, are significant plant pathogens affecting ornamental, agricultural and forest plants through leaf infection, leading to characteristic lesions and potential crop loss. These nematodes exhibit diverse symptoms including vein-delimited lesions and necrosis and can survive in various environmental conditions, including dry tissues and decaying material. Recent studies have advanced understanding of their distribution, ecology and detection methods, including molecular diagnostics like PCR and innovative rapid assays such as LF-RPA. Climate modeling tools like MaxEnt have effectively predicted potential geographic distributions, aiding in management planning. Control strategies emphasize removal of infected plants, proper sanitation, chemical treatments and cultural practices to limit spread. Emerging chemical nematicides further enhance management options, highlighting the importance of integrated approaches to mitigate foliar nematode impact. This review highlights the Current status, Disease and Symptoms, Importance and management strategies associated with Foliar nematodes.

Keywords: *Aphelenchoides, Anguina, Ditylenchus, Litylenchus.*

INTRODUCTION

Nematodes likely evolved around 400 million years ago, predating the Cambrian explosion. These unsegmented, bilaterally symmetrical, triploblastic animals have a pseudocoelomic body cavity. Key damaging genera include *Meloidogyne*, *Rotylenchulus*, *Heterodera*, *Radopholus*, *Pratylenchus*, *Globodera*, *Aphelenchoides* and *Tylenchulus* (Anamika *et al*., 2023).

Foliar nematodes are mostly pathogens of ornamental crops in greenhouses, nurseries and forest trees, as well as field crops (Kohl, 2011). Foliar nematodes include several nematode genera among which *Aphelenchoides*, *Anguina*, *Ditylenchus* and *Litylenchus* (Kohl, 2011). Foliar nematode *Anguina tritici*, it was a first plant parasitic nematode reported in year 1743 (El-Saadony *et al*., 2021). Foliar nematodes have been documented as associated with more than 1100 different species of plants, belonging to 126 botanical families, to include dicots, monocots, gymnosperms and angiosperms, ferns and mosses (Kohl, 2011). *Aphelenchoides*, as well as nematodes of genus *Litylenchus*, are phytoparasites known to infect leaves, stems and buds (Sánchez Monge *et al*., 2015). The damage caused by the foliar nematodes can cause marketability problems in ornamentals because they interfere with the appearance of the plant or they can reduce yield in food crops (Kohl, 2011).

They infect plant leaves by migrating upward along the stems and entering through the leaf stomata. Since their movement depends on water, infection is more likely when plant surfaces are recently moistened by dew, rain or overhead watering. Foliar nematodes feed primarily from within plant tissues (endo-parasitically) and less frequently from outside (ecto-parasitically), depending on the environment and the type of host plant. When feeding inside leaves, they cause lesions that are brown, black or chlorotic, often outlined by veins; these lesions can become necrotic as they age (Kohl, 2011).

MAJOR GENERA AND SPECIES OF AERIAL NEMATODES

The primary aerial nematodes of significance in plant pathology encompass several key genera and species. It include *Aphelenchoides*, *Anguina*, *Ditylenchus* and *Litylenchus* (Kohl, 2011). *Aphelenchoides besseyi* is known for causing white tip disease in rice and is also capable of infecting strawberries and ornamental plants. Additionally, *Aphelenchoides fragariae* and *A. ritzemabosi* are responsible for foliar necrosis in strawberries as well as various ornamental species (Desaeger and Noling 2017). *Ditylenchus dipsaci* stands out as a versatile pathogen, infecting a broad range of hosts and serving as a quarantine pest in numerous countries (Subbotin *et al*., 2005). These nematode species have evolved adaptations that allow them to survive in dry plant tissues, seed stocks and moist foliar environments, facilitating their persistence and spread across different agricultural and ornamental settings.

SYMPTOMS AND DISEASE IMPACT

Damage caused by foliar nematodes can resemble injuries resulting from bacteria, fungi, viruses, nutrient deficiencies or chemical exposure. Additionally, nematodes may interact with specific fungi or bacteria, leading to severe foliar blight. In strawberries, damage symptoms caused by mites or thrips can also appear similar to those caused by nematodes (Desaeger and Noling 2017).

Foliar nematodes occur mainly within the leaves and crowns of their hosts, where infested buds, young leaves or shoots typically become deformed and will not develop properly. Plants will often remain undersized, become bushy or distorted and produce little or no marketable foliage or flowers. In strawberry, young plants are often dwarfed and present a spider-like appearance. Leaves appear crimped, twisted or crinkled and are a darker green than normal. A reddish color may appear on the leaf edges and veins and leaves tend to become more brittle, with tips of young leaves and stipules of older plants drying up and turning brown. Petioles are often short, thick, less pubescent than those of unaffected plants and have a reddish cast. Damaged plants put on fruit late and it is often of inferior quality, sometimes showing "phyllody" or "broccoli fruit" (Desaeger and Noling 2017).

Xu *et al*. (2020) studied on Population structure and species delimitation of rice white tip nematode, *Aphelenchoides besseyi*, in China. Early symptoms include yellowing and wrinkling of new leaf sheaths, with infested leaves showing white splash patterns or yellow patches; edges may be deformed. Severe infections cause kinked, shortened flag leaves, small distorted grains and sterile clusters on upper tillers.

Sturhan and Brzeski (2020) Studied on Stem and bulb nematodes, *Ditylenchus* spp. Infected plants show yellowing, wilting and premature death, with distinct patches of discolored plants. Garlic bulbs turn brown, shrivel, crack and develop swollen, blister-like areas. Onion bulbs become soft, brown and rot internally, with damage worsening during storage.

Among this foliar nematode *Anguina tritici*, commonly known as the wheat seed gall nematode. It is responsible for causing ear-cockle disease. It was the first plant-parasitic nematode to be documented in scientific literature, dating back to 1743. Its hosts encompass wheat, triticale, rye and other related grasses, with wheat being its primary host (El-Saadony *et al*., 2021)

Subbotin (2024) studied the nematode (*Aphelenchoides fragariae*) targets the above-ground parts of the plant, leading to deformities such as twisted shoots, small puckered leaves with crinkled edges, reddened petioles and discolored areas that are hard and rough in texture. These damage symptoms can be mistaken for powdery mildew or bacterial infections. Specifically, *Aphelenchoides fragariae* can significantly reduce strawberry yields, as heavily infested plants often fail to grow properly or produce fruit.

STATUS

Holajjer *et al*. (2022) surveyed the Prediction of potential geographic distribution of exotic nematode, *Aphelenchoides fragariae* in India based on MaxEnt ecological niche modelling. The MaxEnt model effectively predicted climate suitability for *A. fragariae* in India, with AUC values of 0.972 for training data and 0.942 for testing data. Predicted probabilities of presence, ranging from 0 to 1, were categorized into suitability levels: highly suitable (0.8–1.0), optimally suitable (0.6–0.8), moderately suitable (0.4–0.6), marginally suitable (0.2–0.4) and unsuitable (0–0.2). Highly suitable areas are mainly in northern and eastern India, including Himachal Pradesh, Uttarakhand, Arunachal Pradesh and parts of Jammu and Kashmir, with probability scores of 0.79 to 1.0. Optimally suitable regions also cover northern and eastern India, such as Meghalaya, Mizoram and some high-altitude areas in central and southern India, with scores between 0.59 and 0.79. Areas with scores of 0.39–0.59 and 0.19–0.39 were classified as moderately and marginally suitable, respectively, for the establishment of *A. fragariae.*

Munawar *et al*. (2023) studied New Records of *Ditylenchus* Species from Southern Alberta, Canada. This study identified four *Ditylenchus* species in southern Alberta, Canada, including *D. anchilisposomus*, *D. clarus*, *D. tenuidens* and *D. valveus* three of which are new records for Canada. Morphological and molecular analyses confirmed their identities and phylogenetic relationships.

Oliveira *et al*. (2024) surveyed foliar nematodes in Florida strawberry fields from 2016 to 2021, identifying *Aphelenchoides besseyi* only in early years on healthy leaves, while *A. bicaudatus* (new to Florida) and *A. rutgersi* were found on declining leaves. Morphological and molecular analyses confirmed their identities and global relationships. Both species were absent from healthy leaves, suggesting they feed on fungi rather than plants in natural conditions. However, *A. bicaudatus* showed limited ability to damage soybean leaves under artificial conditions. This study improves knowledge of foliar nematode diversity and ecology, highlighting the need for combined approaches for effective nematode management.

IMPORTANCE

A. tritici is on the US Pest List of Economic and Environmental Importance and 'Pests Lists' for Argentina, Brazil, Chile, Colombia, Ecuador, Egypt, Guatemala, Indonesia, Israel, Madagascar, Namibia, Nepal, New Zealand, Paraguay, Peru, South Africa, Taiwan, Thailand, East Timor, and Uruguay (EPPO, 2020).

Howland and Quintanilla (2023) discussed the severe impact of plant-parasitic nematodes, including foliar types on ornamental crops such as chrysanthemum, hosta and fern. In these crops, symptoms like leaf blight and tissue collapse caused by foliar nematodes drastically reduce plant quality. Since ornamental plants are traded widely, infected materials pose a serious threat to both domestic and international markets with potential quarantine implications and trade restrictions.

Burke *et al*. (2024) studied the Beech leaf disease (BLD) is an emerging threat to American beech (*Fagus grandifolia*), spreading rapidly across the north eastern U.S. and into southern Canada. It causes leaf disfigurement, dark interveinal banding, curling and leaf drop, mainly affecting understory leaves and thinning the forest understory. Identifying BLD's cause is vital for protecting *F. grandifolia* and forest health. While the foliar nematode *Litylenchus crenatae* sub sp. *mccannii* is confirmed as a key factor, the role of other organisms remains unknown. This study examined leaf-associated fungi and bacteria to explore their potential contribution to BLD. Nematodes were detected at low levels in areas showing no symptoms, indicating that they can exist without causing visible signs of infestation.

Albaqami *et al*. (2024) emphasized the global concern regarding phytoparasitic foliar nematodes, noting their role in causing crop damage in leafy vegetables and herbs. The study reviewed sustainable approaches to combat these nematodes, highlighting the need for effective, eco-friendly control methods. In many developing countries, the lack of awareness and access to nematode diagnostics further aggravates the problem, leading to undetected spread and increasing economic burden on smallholder farmers.

DETECTION AND DIAGNOSIS

A PCR assay using species-specific primers successfully identified *Aphelenchoides fragariae* from samples initially morphologically identified on *Andrographis paniculata* ('bitter king') in Indonesia. All isolates produced a 169-bp amplicon from the ITS1 rDNA region, confirming the species. Phylogenetic analysis showed clustering with global *A. fragariae* sequences. This represents the first molecular report of *A. fragariae* on bitter king in Indonesia and globally (Djiwanti and Miftakhurohmah 2022).

Han *et al*. (2024) developed a species-specific PCR assay for rapid, accurate detection of *Ditylenchus destructor* and *D. dipsaci*, overcoming limitations of traditional morphology. Targeting rDNA-ITS sequences, it offers high sensitivity, detecting single juveniles and low DNA levels and effectively identifies multiple haplotypes directly in plant roots and soil. This method enhances early diagnosis and improves pest management strategies.

Subbotin (2024) performed A rapid, reliable diagnostic method for *Aphelenchoides fragariae* using a lateral flow recombinase polymerase amplification (LF-RPA) assay targeting the ITS rRNA gene. This assay detects the nematode directly from crude extracts or plant tissues without DNA extraction, delivering results in 18–25 minutes with high sensitivity. Validated across various samples, it successfully identified *A. fragariae* in California seed samples and offers a practical tool for nematode diagnosis with minimal equipment.

MANAGEMENT STRATEGY

Current management approaches include the use of hot water treatments (drenches and dips) and preplant fumigation. Hot water drenches are applied to disinfect plants from pests such as insects and plant-parasitic nematodes (PPNs), including species like the stem and bulb nematode *Ditylenchus dipsaci* as well as *A. fragariae* and *R. similis*. Typically, plant materials such as bare-rooted plants, tubers, runners and dormant plant parts are treated by immersing them in large tanks of hot water followed by cooling in secondary water tanks to complete the process (Howland and Quintanilla 2023).

The most crucial initial step in managing foliar nematodes is to eliminate infected plants. It’s important not to place these infected plants in compost or cull piles, as foliar nematodes can survive drying out and could be reintroduced into the production area. Only pest-free planting material should be used and efforts should be made to prevent foliar nematodes from contaminating propagation zones. Avoid using infected cuttings or stock plants during vegetative propagation, as this is a key method of control. Additionally, reducing overhead watering and minimizing leaf wetness through proper plant spacing and placement can help manage the spread. Keeping greenhouses and propagation houses free of weeds is also essential, as many weeds can serve as hosts. Lastly, it’s important to familiarize yourself with the characteristic symptoms of foliar nematode infection; to confirm their presence, samples should be taken and sent to a plant diagnostic laboratory for analysis (Joan *et al*., 2024)**.**

New chemical nematicides have been granted registrations in recent years like Fluopyram (Velum Prime®) and fluensulfone (Nimitz®) (Walia, 2024).

CONCLUSIONS

Aerial nematodes, though lesser known than their soil-dwelling counterparts, pose a serious threat to agriculture and horticulture. Their cryptic nature and broad host range make them difficult to manage. Effective management of foliar nematodes necessitates early detection, strict sanitation measures and the use of resistant or pest-free planting materials. Advances in molecular diagnostics and predictive modeling have improved identification and understanding of their distribution, facilitating targeted control efforts. Combining cultural practices, chemical treatments, and vigilant monitoring remains essential to prevent the spread and mitigate the damage caused by these adaptable and widespread plant parasites. Continued research and integrated strategies are vital for sustainable control and protection of susceptible ornamental, agricultural, and forest species.

FUTURE SCOPE

There is a lack of comprehensive data on the economic losses caused by these pathogens. Our understanding of their ecology and survival strategies remains limited. Many crops lack resistant germplasm, making control more challenging. There is a need for improved diagnostic tools that allow rapid detection directly in the field.

Future research should prioritize genomics-based identification methods, studies on host-pathogen interactions and the development of environmentally sustainable management strategies.

REFERENCES

Albaqami, M., Alghamdi, A., Almehmadi, R. M. and El-Hefny, M. (2024). Control of foliar phytoparasitic nematodes through sustainable natural materials: A review. *Plants, 13*(1), 50.

Anamika, Manish Kumar, Neeraj and Anil Sirohi (2023). Identification of Egg Development Genes in *Meloidogyne incognita* as Potential Targets for Nematode Control. *Biological Forum – An International Journal, 15*(6), 947- 949.

Burke, D. J., Carrino-Kyker, S. R., Hoke, A. J., Galloway, E., Martin, D. and Chick, L. (2024). Effects of the nematode *Litylenchus crenatae* subsp. *mccannii* and beech leaf disease on leaf fungal and bacterial communities on *Fagus grandifolia* (American beech). *Applied and Environmental Microbiology, 90*(6), e00142-24.

Desaeger, J. and Noling, J. (2017). Foliar or bud nematodes in Florida strawberries. *University of Florida, IFAS Extension Publication ENY-068*.

Djiwanti, S. R. and Miftakhurohmah (2022). Molecular detection and identification of the foliar nematode *Aphelenchoides fragariae* on Andrographis paniculata in Indonesia. *Australasian Plant Pathology, 51*(3), 301-304.

El-Saadony, M. T., Abuljadayel, D. A., Shafi, M. E., Albaqami, N. M., Desoky, E. S. M., El-Tahan, A. M. and Saad, A. M. (2021). Control of foliar phytoparasitic nematodes through sustainable natural materials: Current progress and challenges. *Saudi Journal of Biological Sciences*, *28*(12), 7314-7326.

EPPO (2020) EPPO https://www.eppo.int/ACTIVITIES/plant_quarantine/alert_list (2020)

Han, X., Chang, Q., Xu, Y., Wang, P., Li, H., Li, Y. and Peng, H. (2024). Efficient and direct identification of *ditylenchus destructor* and d. Dipsaci in soil and plant tissues using a species-specific PCR assay. *Horticulturae*, *10*(3), 250.

Holajjer, P., Gawade, B. H., Hhan, Z. and Sivaraj, N. (2022). Prediction of potential geographic distribution of exotic nematode, *aphelenchoides fragariae* in India based on maxent ecological niche modelling. *Indian Journal of Plant Protection, 50*(1), 51-55.

Howland, A. D. and Quintanilla, M. (2023). Plant-parasitic nematodes and their effects on ornamental plants: A review. *Journal of Nematology*, *55*(1), 20230007.

Joan Allen, Assistant Extension Educator, and Leanne Pundt, Extension Educator, University of Connecticut, 2013, latest revision by L. Pundt July 2024. Reviewed by Dr. Li, CAES.

Kohl, L. M. (2011). Foliar nematodes: A summary of biology and control with a compilation of host range. *Plant Health Prog*., *12*, 23.

Munawar, M., Rahman, A. U., Castillo, P. and Yevtushenko, D. P. (2023). New Records of *Ditylenchus* Species from Southern Alberta, Canada. *Plants*, *12*(5), 998.

Oliveira, C. J., Subbotin, S. A., Desager, J. A., Dahlin, P., Vau, S. and Inserra, R. N. (2024). Morphological and molecular analysis of two mycophagous nematodes, *Aphelenchoides bicaudatus* and *A. Rutgersi* (Nematoda: Aphelenchoididae) from florida strawberry. *Journal of nematology*, *56*(1), 20240021.

Sánchez Monge, G. A., Flores, L., Salazar, L., Hockland, S. and Bert, W. (2015). An updated list of the plants associated with plant-parasitic *Aphelenchoides* (Nematoda: Aphelenchoididae) and its implications for plant-parasitism within this genus. *Zootaxa, 4013,* 207-224.

Sturhan, D. I. E. T. E. R. and Brzeski, M. W. (2020). Stem and bulb nematodes, Ditylenchus spp. In *Manual of agricultural nematology* (pp. 423-464). CRC Press.

Subbotin, S. A., Madani, M., Krall, E., Sturhan, D. and Moens, M. (2005). Molecular diagnostics, taxonomy, and phylogeny of the stem nematode Ditylenchus dipsaci species complex based on the sequences of the internal transcribed spacer-rDNA. *Phytopathology, 95*(11), 1308-1315.

Subbotin, S. A. (2024). Rapid detection of the strawberry foliar nematode *aphelenchoides fragariae* using recombinase polymerase amplification assay with lateral flow dipsticks. *International Journal of Molecular Sciences, 25*(2), 844.

Walia, R. K. (2024). Chapter 4 current status of nematode problems of crops in India.

Xu, X., Qing, X., Xie, J. L., Yang, F., Peng, Y. L. and Ji, H. L. (2020). Population structure and species delimitation of rice white tip nematode, Aphelenchoides besseyi (Nematoda: Aphelenchoididae), in China. *Plant Pathol., 69*(1), 159-167.

How to cite this article: Prajapati P.G., Patel M.I., Kansara S.S., Chopda G.B., Ghevariya T.V. and Patro S.P. (2025). A Review on Status and Importance of Foliar Nematode in Plant Pathology. *Biological Forum, 17*(7): 18-21.