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Field Symptoms and Microscopic Observations of Meloidogyne spp. Associated with Brinjal Decline in Jhansi District, India

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Abstract

Root-knot nematodes (Meloidogyne spp.) are obligate root endoparasites whose field symptoms often mimic drought, nutrient deficiency, or fungal wilt, complicating accurate diagnosis. This study examines three geo-tagged field photographs and four microscopic images associated with brinjal (Solanum melongena) decline in the Jhansi district of Uttar Pradesh, India. Field observations recorded at Nohatachhir on 13 March 2026 and Dani Pura on 28 September 2026 revealed severe canopy desiccation, lower-leaf chlorosis, and marginal necrosis across affected crops. Microscopic examination of root tissue recovered from symptomatic plants confirmed the presence of swollen, ovoid to pear-shaped female bodies with distinct projecting necks, morphological features characteristic of adult Meloidogyne species. These findings support Meloidogyne spp. as a likely contributor to brinjal decline in the region, highlighting the necessity of combining field symptomology with microscopic diagnostics for reliable identification. Future research should focus on molecular species identification, mapping local infestation dynamics, and developing eco-friendly management strategies, such as resistant cultivars and biocontrol agents, to mitigate crop losses in Uttar Pradesh.

Keywords: Solanum melongena; Meloidogyne spp.; adult females; light microscopy; Jhansi

1. Introduction

Brinjal (*Solanum melongena* L.) is cultivated intensively across northern and central India, serving as a vital food crop and a primary source of farm income. Sustaining high productivity requires an intact, fully functioning feeder-root system throughout successive flowering and fruiting cycles. However, root damage typically manifests above ground as non-specific canopy stress—such as lower-leaf chlorosis, midday wilting, stunted shoot development, and irregular fruit growth. Because these field symptoms closely resemble abiotic stresses like drought and nutrient deficiency, or biotic conditions like fungal wilt, diagnoses based solely on canopy observations can be highly misleading.

Root-knot nematodes (*Meloidogyne* spp.) are obligate, sedentary root endoparasites that establish permanent feeding sites within host vascular tissues. Infectious second-stage juveniles invade young roots and induce specialized giant cells, causing infected root tissues to swell into characteristic galls and distorting the root architecture. This structural damage severely impairs water and nutrient uptake, leading to severe canopy desiccation and plant collapse even in well-irrigated soils. In warm vegetable-growing areas such as the Bundelkhand region, continuous cropping of susceptible hosts and the presence of weed reservoirs allow *Meloidogyne* populations to persist and cause recurring crop decline (Trudgill & Blok, 2001; Perry et al., 2009).

Morphologically, adult female *Meloidogyne* differ markedly from vermiform juveniles and males. Mature females become swollen, adopting ovoid to pear-shaped bodies with distinct projecting anterior necks embedded near the feeding site. While this characteristic body plan provides clear genus-level identification under light microscopy, general female shape alone is insufficient to resolve individual species due to significant morphological overlap among closely related taxa. Comprehensive species identification relies on additional diagnostic features, including perineal pattern preparations, stylet and juvenile characters, host response, and, increasingly, molecular assays (Blok & Powers, 2009).

To bridge the gap between non-specific field symptoms and laboratory diagnostics, this research article documents geo-tagged field observations recorded at Nohatachhir and Dani Pura alongside light-microscopic examinations of recovered

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root-knot nematode specimens from symptomatic brinjal fields in the Jhansi district of Uttar Pradesh. It is descriptive and does not estimate district prevalence, yield loss, or treatment efficacy.

2. Objectives

(i) To document and characterize field-level canopy symptoms and geo-referenced decline patterns in affected brinjal (*Solanum melongena* L.) crops across selected locations in the Jhansi district of Uttar Pradesh.
(ii) To recover and evaluate endoparasitic nematode specimens using light microscopy to confirm genus-level identification based on female morphological body features (ovoid to pear-shaped form and projecting anterior neck).
(iii) To establish a diagnostic link between non-specific above-ground plant stress and below-ground *Meloidogyne* spp. infection while defining morphological identification limits and proposing a standardized confirmation workflow for future surveys.

3. Materials and Methods

3.1. Field observations

Brinjal stands across selected sites in the Jhansi district were visually examined for non-specific canopy stress indicators, including uneven growth, leaf yellowing, marginal scorching, wilting, shoot dieback, and complete plant collapse (Coyne et al., 2018). Symptomatic plants and their surrounding root zones were photographed using location-enabled devices to automatically capture precise geographical coordinates and timestamp metadata. Three specific field records were analyzed in this research article: two records (F1 and F2) originated from Nohatachhir on 13 March 2026 at 25.401206° N, 78.701347° E and 25.399730° N, 78.705003° E, respectively, while the third record (F3) was obtained at Dani Pura on 28 September 2026 at 25.346966° N, 78.728203° E. The coordinate metadata were extracted directly from image EXIF data and were used strictly to anchor the observations geographically, without inferring broader district-wide prevalence beyond the photographed sites.

The inclusion of photographic records from two distinct geographical locations across different months serves critical scientific objectives. Utilizing material from both Nohatachhir and Dani Pura demonstrates that the observed brinjal decline and its association with *Meloidogyne* spp. are not localized anomalies confined to a single field, but rather a recurring stress syndrome across distinct micro-environments within the region. Furthermore, capturing records in March at Nohatachhir and in September at Dani Pura provides insight into seasonal and phenological variations. The March observations capture early-to-mid season vegetative stress and rapid canopy collapse under rising spring temperatures, whereas the September observation documents root-zone conditions in mature, fruiting stands within continuously vegetated, weed-infested plots (Trudgill & Blok, 2001; Perry et al., 2009). This multi-site and temporal comparison allows for a broader evaluation of how root-knot nematode damage manifests across varying growth stages, cropping conditions, and environmental pressures.

Table 1: Location metadata and visible field symptoms associated with brinjal decline in Jhansi, Uttar Pradesh (2026).

Record	Locality and coordinates	Date and time	Visible feature
F1	Nohatachhir; 25.401206° N, 78.701347° E	13 Mar 2026, 11:33 IST	Severely desiccated canopy and whole-plant decline
F2	Nohatachhir; 25.399730° N, 78.705003° E	13 Mar 2026, 10:39 IST	Lower-leaf chlorosis, marginal necrosis and retained flowers
F3	Dani Pura; 25.346966° N, 78.728203° E	28 Sep 2026, 11:02 IST	Root-zone examination in a fruiting brinjal stand

3.2. Root zone examination and sample handling

Plants representing visible stress were selected for below-ground examination. Soil was opened near the stem without initially severing the main roots. Fine roots and adhering rhizosphere soil were collected from the active rooting zone and placed in labelled containers. A traceable sample record should include the site, plant condition, collection date and crop stage. Samples were protected from heating and desiccation during transport.

In the laboratory, roots were washed gently so that swellings and embedded females could be examined. Root pieces suspected of containing mature females were teased apart under low magnification. The recovered bodies were transferred to a clean aqueous mount for observation. The supplied micrographs represent material examined in the Department of Zoology, Bipin Bihari P.G. College, Jhansi.

3.3. Light microscopic examination

Recovered nematode specimens were observed under transmitted light microscopy to evaluate key diagnostic morphological characteristics. Genus-level identification as *Meloidogyne* was based primarily on the presence of swollen adult female body structures, characterized by a rounded to ovoid posterior region and a distinctly narrower, projecting anterior neck embedded within host tissues (Hunt & Handoo, 2009; Moens et al., 2009). Multiple microscopic fields were examined and photographed to verify structural consistency across specimens and to exclude artifacts or incidental soil biota (Coyne et al., 2018).

Because the provided light micrographs lacked a calibrated scale bar and documented objective magnification values, image pixels were not converted into quantitative morphometric measurements such as body length, maximum width, or stylet dimensions (Karssen, 2002). Furthermore, variations in dark internal regions and tissue opacity were interpreted as optical effects, plane-of-focus artifacts, or internal cellular contents rather than diagnostic species-level taxonomic characters (Blok & Powers, 2009).

3.4. Diagnostic comparison and identification limits

The morphological features of the recovered specimens were evaluated against established diagnostic descriptions of *Meloidogyne* available in the UC Davis Nemaplex database and the authoritative taxonomy framework provided by Hunt and Handoo (2009). While the presence of a swollen female body with a narrow, projecting anterior neck is characteristic of the genus *Meloidogyne*, general body outline alone is insufficient to differentiate among closely related species due to significant morphological overlap (Karssen, 2002; Blok & Powers, 2009).

Although recent regional surveys by Sen and Pandey (2026) confirmed the occurrence of *Meloidogyne incognita* on *Solanum melongena* across the Bundelkhand region—including blocks within Jhansi—their findings provide broad epidemiological context rather than direct specimen-level confirmation for the material examined in this study. In the absence of definitive diagnostic criteria such as perineal pattern morphology, juvenile morphometrics, or species-specific molecular assays (e.g., PCR markers), no specific species designation is assigned to the current specimens, and they are conservatively reported as *Meloidogyne* spp. (Zijlstra et al., 2000; Coyne et al., 2018).

4. Results

4.1. Expression of field decline

The field images showed marked variation in symptom severity rather than a single uniform syndrome. At Nohatachhir, one plant had extensive leaf collapse, dry curled laminae and loss of functional canopy. Adjacent green vegetation emphasized the localized nature of the decline (Figure 1A). A second plant retained young foliage and a flower, but the lower leaves had broad yellow areas, brown marginal injury and scattered necrotic patches (Figure 1). These observations are compatible with impaired root function but are not exclusive to nematode infection.

At Dani Pura, the stand remained in production and bore fruit, yet root-zone examination was undertaken within a weedy, continuously vegetated plot (Figure 1). The coexistence of crop plants and alternative vegetation is epidemiologically relevant because many weeds can maintain root-knot nematodes between crop cycles. The photograph documents the sampling context rather than proving that any particular weed was a host.



Figure 1: Field collection at different locations.

4.2 Microscopic appearance of recovered females

The microscopic fields contained multiple swollen nematode bodies. Individual specimens ranged visually from ovoid to distinctly pear-shaped. Several had a broad posterior body and a clearly narrowed neck ending in a rounded anterior region (Figures 2). The repeated appearance of this form in separate fields reduced the likelihood that the observation represented a single damaged fragment or an incidental soil organism.

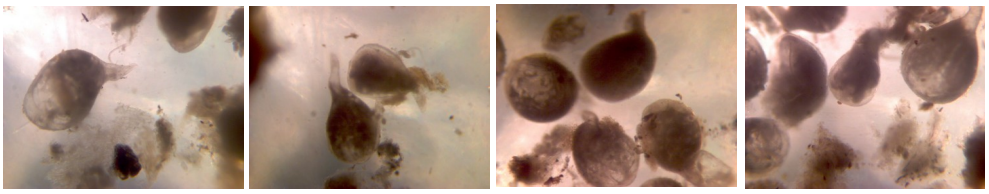


Figure 2: Light-microscopic views of swollen adult females with tapered necks recovered from symptomatic brinjal.

Other fields showed groups of rounded and pyriform bodies with differing orientation, focus and internal opacity (Figures 2). Some individuals were partly obscured by debris or overlapped by adjacent material. These variations are expected in temporary, unstained mounts and explain why outline alone cannot be used to separate *Meloidogyne* species.

4.3. Interpretation of diagnostic evidence

The field symptoms prompted root-zone examination but were not diagnostic of nematode infection. Microscopic body forms were consistent with adult female *Meloidogyne* and are reported as *Meloidogyne* spp. Species identity remains unresolved. The observations do not exclude other causes of plant decline, establish a mixed or single-species population, or quantify infection frequency or yield effects.

5. Discussion

The primary contribution of this research article is demonstrating a logical diagnostic progression—transitioning from non-specific field symptomology to a biologically coherent laboratory observation. Above-ground symptoms such as leaf chlorosis, marginal necrosis, wilting, and canopy collapse are highly ambiguous and can be induced by abiotic factors including drought stress, waterlogging, or nutrient imbalances, as well as biotic factors such as fungal or bacterial vascular pathogens (Coyne et al., 2018). Had diagnostic efforts concluded solely with above-ground field photographs, root-knot nematode infestation could only have been hypothesized as one of several potential etiologies. Recovering swollen adult female specimens directly from root tissues substantially reinforced the diagnosis, as this sedentary life stage is biologically adapted to establishing permanent feeding sites within host roots and exhibits a distinct, diagnostically reliable body plan at the genus level (Moens et al., 2009; Perry et al., 2009).

The symptom contrast observed between adjacent brinjal plants at Nohatachhir highlights the spatial dynamics of nematode damage. Severe collapse in one plant alongside localized lower-leaf yellowing in an adjacent plant likely reflects variations in initial nematode population density, infection age, root architecture, soil moisture heterogeneity, plant vigour, or secondary pathogen interactions (Trudgill & Blok, 2001). Plant-parasitic nematodes, including *Meloidogyne* species, characteristically display aggregated spatial distribution patterns, resulting in localized patches of decline within otherwise healthy, green crop stands. Consequently, visual symptom severity cannot serve as a direct proxy for soil or root nematode densities. Future district-wide surveys must adopt structured, systematic sampling frameworks that evaluate both symptomatic and asymptomatic plants to avoid diagnostic selection bias.

While microscopic examination confirmed typical *Meloidogyne* body forms, general female outlines provide only provisional genus-level identification. Closely related *Meloidogyne* species frequently exhibit overlapping body shapes, and specimen orientation or coverslip pressure during mounting can further distort external morphology (Karssen, 2002). Definitive species identification necessitates detailed analysis of fine morphological characters—such as perineal pattern

architecture, second-stage juvenile morphometrics, and stylet structure—complemented by isoenzyme phenotype profiling or sequence-characterized amplified region (SCAR) PCR assays (Zijlstra et al., 2000; Hunt & Handoo, 2009; Blok & Powers, 2009). Furthermore, the absence of calibrated scale bars in light micrographs prevents valid morphometric ratio calculations, and visual specimen numbers within a microscopic field should not be interpreted as population density estimates. Quantitative nematological assessments require standard extraction protocols using calibrated root masses or soil volumes, coupled with replicate counts and defined extraction efficiency metrics (Hussey & Barker, 1973; Whitehead & Hemming, 1965).

Finally, integrated pest management (IPM) strategies should strictly follow accurate pathogen confirmation rather than empirical, symptom-based pesticide applications. Sustainable management of *Meloidogyne* spp. in brinjal production relies on combining preventive and bio-intensive cultural practices, including nematode-free nursery transplants, farm sanitation, weed host suppression, crop rotation with non-hosts or poor hosts, soil solarization, and application of quality-controlled biocontrol agents or organic soil amendments (Bridge & Page, 1980; Coyne et al., 2018). Chemical nematicides, where approved and registered, should be applied strictly according to label specifications, with efficacy evaluated against standardized parameters such as root galling indices, final population densities, and marketable crop yields.

6. Implications for Brinjal Health Management

The images suggest that a field may contain plants at very different stages of decline. Monitoring should therefore begin before complete canopy collapse. Growers and field workers can flag patches with persistent midday wilt, yellowing that does not respond normally to nutrition, reduced shoot growth or repeated failure of individual plants. A small number of carefully excavated root systems can then be checked for galling before laboratory samples are collected.

Where *Meloidogyne* is confirmed, the objective is to reduce multiplication over successive crops. Nursery media and transplants should be protected from infested soil. Root residues and host weeds should be managed, and crop sequences should be selected using the confirmed host status of the local population. Any proposed biological treatment should be tested with an untreated control and adequate replication. A visually greener crop is not sufficient evidence of nematode suppression unless root galling and population density also decline.

7. Conclusion

Field evaluations of brinjal (Solanum melongena L.) stands in Nohatachhir and Dani Pura, Jhansi, revealed pronounced canopy decline characterized by lower-leaf chlorosis, marginal necrosis, and severe desiccation. Subsequent root-zone extraction and transmitted light microscopy confirmed the presence of swollen, ovoid to pear-shaped endoparasitic females with distinct, projecting anterior necks embedded in host root tissues. These morphological features support Meloidogyne spp. as a likely biological contributor to the observed brinjal decline in the Bundelkhand region.

Because general female body contours exhibit structural overlap among closely related taxa, the specimens are designated as *Meloidogyne* spp. pending definitive species-level identification via perineal pattern analysis, juvenile morphometrics, or PCR-based molecular assays. This research demonstrates a vital diagnostic progression, bridging ambiguous above-ground crop stress with biologically coherent below-ground parasitism. The findings emphasize that canopy observations alone are insufficient for field diagnosis and underscore the necessity of integrating root-zone examinations into routine plant health monitoring. Implementing standardized diagnostic workflows, establishing calibrated extraction protocols, and combining eco-friendly management strategies, such as resistant cultivars, crop rotation, soil solarization, and biocontrol agents will be essential to accurately map infestation dynamics and sustainably mitigate root-knot nematode damage across Uttar Pradesh.

8. Declarations

Conflict of interest: Authors declare no conflict of interest.

Ethics statement: The reported observations concerned crop plants and plant-parasitic nematodes. Authors were taken prior permission and consent from farmers for sample collection.

Author contributions: Anand Kumar Singh collected the field data, conducted the laboratory examinations, prepared the visual materials, and authored the original manuscript draft, while Manvendra Singh Sengar conceptualized and designed the study, established the research methodology, supervised the investigation, and critically reviewed and edited the final manuscript.

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