Acta Scientific Microbiology (ISSN: 2581-3226)

Volume 8 Issue 2 February 2025

Research Article

Biocontrol Potential of *Pochonia chlamydosporia* Against *Meloidogyne incognita* in Okra

Joshi Chinmay[1], Zala Viren[1], Pandya Amit[1], Zala Harpal[1], Zala Vibhakshi[1], Zala Prakasha[1] and Trivedi Nidhi S[2]*

[1]Ami Agri Bioscience Pvt ltd, Ahmedabad, Gujarat, India

[2]BioAgro Innovators LLP, Gandhinagar, Gujarat, India

***Corresponding Author:** Trivedi Nidhi S, BioAgro Innovators LLP, Gandhinagar, Gujarat, India.

Received: December 11, 2024

Published: January 04, 2025

Abstract

This study evaluates the efficacy of the biocontrol agent Ami *Pochonia chlamydosporia* in managing root-knot nematodes (*Meloidogyne incognita*) in okra (*Abelmoschus esculentus*) cultivation at the Ami Experimental Farm in Ahmedabad, Gujarat, over a year. The analysis used a randomized block design and comprised two treatments: one with *P. chlamydosporia*, a seed treatment and soil amendment at 1 kg per acre, and a control group with no treatment. The results showed that the treated plants had substantially enhanced growth parameters, with average heights of 156.34 cm versus 101.65 cm in the control, root lengths increasing from 24.23 cm to 47.16 cm, dry shoot weights increasing from 13.11 g to 21.53 g, and dry root weights increasing from 2.25 g to 7.43 g. Furthermore, Ami *P. chlamydosporia* decreased the root-knot index from 5.45 to 1.45 and nematode populations by 52.34%, from 371.34 to 219.18. The treatment also increased yield by 30.05%, to 5.09 t/ha, compared to 4.12 t/ha in the control. The Incremental Cost-Benefit Ratio (ICBR) of 1.91 demonstrates considerable financial benefits; promoting the conclusion that *P. chlamydosporia* is a viable and sustainable approach to reducing root-knot nematodes in okra, increasing crop yields, and maintaining soil health.

Keywords: Okra; *Meloidogyne incognita*; Ami *P. chlamydosporia*; Nematodes

Abbreviation

ICBR: Incremental Cost-Benefit Ratio; ITCC: Indian Type Culture Collection; LSD: Least Significant Difference; RKI: Root Knot Index; FYM: Farm Yard Manure

Introduction

Okra (*Abelmoschus esculentus*) is a common summer vegetable crop grown across tropical and subtropical areas [1]. It is rich in vitamin C and widely used in sauces and soups [2]. Okra is also a source of dietary fibre, vitamins A and B6, thiamine, niacin, and minerals, making it a vital component of healthy diets in various countries [3]. Despite its importance, okra cultivation faces several challenges, including insect, bacterial, fungal, viral, and worm infestations [4]. Sustainable pest control measures are critical to ensure this economically valuable crop remains productive [5].

Root-knot nematodes (*Meloidogyne spp.*) are among the most destructive and economically harmful pests worldwide [6]. They damage a wide range of crops worldwide, having a particularly severe impact in tropical and subtropical climates [7]. In highly contaminated crops, these worms can cause yield losses of up to 80% [8]. *Meloidogyne incognita*, a root-knot worm, causes considerable harm to okra, including leaf browning, slowed development, decreased crop production, and reduction of photosynthetic pigments, affecting total productivity [9].

Although synthetic nematicides have been used to control nematodes, their high cost, environmental problems, and potential health risks have led to demand for environmentally sustainable alternatives [10]. A potential approach is to utilize biopesticides, including biological control agents like *Pochonia chlamydosporia*, *Trichoderma harzianum*, and *Paecilomyces lilacinus* [11]. These fungi have shown remarkable resistance to root-knot nematodes, decreasing nematode populations in both greenhouse and field conditions [12].

Among the fungus, *Pochonia chlamydosporia* (Zare and Gams), formerly known as *Verticillium chlamydosporium* (Goddard), is a potential biocontrol agent [13]. This fungus effectively parasitizes nematode eggs and exposed females, producing chlamydosporia that serve as long-lasting propagules that are essential for soil formation [14]. It has demonstrated potential as an efficient bio pesticide for controlling nematodes in okra and other vegetable crops, providing an ecologically friendly and cost-effective approach for managing root-knot nematode infestations [15]. *Pochonia chlamydosporia* has been shown in several studies to effectively manage *Meloidogyne incognita* and promote growth in a variety of crops [16].

Furthermore, *Pochonia chlamydosporia* functions as a root endophyte, promoting the development of several host plant species while increasing its resistance against various pathogens [17]. It has been shown to significantly improve plant growth by enhancing the uptake of nutrients and root development [18]. In other studies, *Pochonia chlamydosporia* at 3% w/w was applied to the soil and resulted in optimal plant growth, with 42 cm of shoot length, 9.4 g of shoot weight, 36 cm of root length, and 2.7 g of root weight, obtained. The effectiveness of *P. chlamydosporia* in promoting plant growth in pot conditions is demonstrated by these data, which showed recovery rates of 80.9%, 74.1%, 73.9%, and 80% in comparison to the control [19]. The current study aims to determine the field efficacy of Ami *Pochonia chlamydosporia* in preventing *Meloidogyne incognita* infestations in okra.

Materials and Methods

Experimental field

The experiment was carried out from 2021 to 2022 at the Ami Experimental Farm in Ahmedabad, Gujarat.

Experiment crop

A research study on okra (*Abelmoschus esculentus*) was conducted from 2021 to 2022 to evaluate the efficacy of Ami *Pochonia chlamydosporia* in preventing *Meloidogyne incognita* infestations. *Pochonia chlamydosporia*, obtained specifically from the Indian Type Culture Collection (ITCC), is known for the ability to reduce nematode populations in farming conditions.

Experimetal design

A field experiment was conducted in sick plots to evaluate the efficiency of Ami *Pochonia chlamydosporia* powder formulation in reducing *Meloidogyne incognita* (root-knot nematode) infested okra (*Abelmoschus esculentus*). The study used a randomized block design, with two treatments and four replications. Treatment 1 (T1), which included seed treatment with *P. chlamydosporia* at a dose of 1 kg per acre, followed by soil application, while Treatment 2 (T2) served as the untreated control. The experimental plots were produced in a nematode-infested environment with an initial nematode population of 206 per 200 cc of soil. Okra seeds were treated and partially dried in the shade before being sowed in 3.0 x 2.0 m plots. Ninety days after sowing, data on plant growth parameters (shoot length, root length, dry weight, and yield) were collected, as well as nematode parameters (number of galls per plant, final nematode population in soil and roots, and root-knot index (1-5 scale). In addition, five grams of infected roots from each replication were stained with Acid Fuchsin in Lacto phenol solution to determine the ultimate nematode population in the roots [20]. The data were analyzed using Fisher's analysis of variance at a 5% significance level, and significant differences between treatments were found using the least significant difference (LSD) value.

Result and Discussion

Assessing the Effects of Bio-Agent (Ami *Pochonia chlamydosporia*) on *Meloidogyne incognita*-Affected Okra Growth.

Plant height (cm)

Plant height increased substantially when Ami *Pochonia chlamydosporia* was applied to the soil at a dosage of 1 kilogram per acre in a powder formulation. In particular, the untreated control group observed only 101.65 ± 0.9 cm, whereas the treated okra plants achieved an average height of 156.34 ± 2.3 cm, an increase of 39.12% shown in table 1. In further studies, the use of 6000 chlamydospores per gram of soil resulted in a plant height of 98.5 cm when *Pochonia chlamydosporia* was evaluated for suppressing *Meloidogyne incognita* in tomato crops [21].

Table 1: Effect of bio-agent on plant growth parameters in okra infected by *Meloidogyne incognita.*

Treatments	Plant Height (cm)	% Increase	Root Length (cm)	% Increase	Dry Shoot wt. (g)	% Increase	Dry root wt. (g)	% Increase
T1	156.34± 2.3	39.12	47.16 ±1.01	64.14	21.53 ±0.47	54.23	7.43 ±0.12	67.89
T2- Control	101.65± 0.9		24.23 ±0.92		13.11 ±0.11		2.25 ±0.10	

Root length (cm)

Okra root length was notably increased by using the bioagent Ami *Pochonia chlamydosporia* in powder form at a dose of one kilogram per acre. Compared to the control group, which reported just 24.23 ± 0.92 cm, the treated plants showed a considerable increase of 64.14%, with an average root length of 47.16 ± 1.01 cm displayed in Table 1. In a similar research, okra infected with *M. incognita* showed a root length of 28.3 cm after treatment with *P. chlamydosporia* [22]. Furthermore, chili plants infected with *M. incognita showed* a root length of 29.95 cm after treatment with *P. chlamydosporia* at a rate of 4 g/kg of soil [23].

Dry shoot weight (gm)

The dry shoot weight of the okra plants increased notably when Ami *Pochonia chlamydosporia* powder was applied at a dose of one kilogram per acre. The treated plants obtained an exceptional dry shoot weight of 21.53 ± 0.47 g, showing a considerable increase of 54.23%, compared to the untreated control group's average of 13.11 ± 0.11 g depicted in Table 1. Another study found that treating okra plants with the biocontrol agent *Pochonia chlamydosporia at* a concentration of 8×10^3 resulted in the highest increase in shoot dry weights [24]. The application of *Pochonia chlamydosporia* culture filtrate showed remarkable effectiveness, permitting cucumber plants infected with *Meloidogyne incognita* to produce a dry shoot weight of 48.3 g [25].

Dry root weight (gm)

The dry root weight of the okra plants was considerably enhanced by the application of Ami *Pochonia chlamydosporia* at a dose of one kilogram per acre. When compared to the control group, which obtained just 2.25 ± 0.10 g, the treated group (T1) had an average dry root weight of 7.43 ± 0.12 g, a substantial rise of 67.89% demonstrated in Table 1. In another study, applying the biocontrol agent *Pochonia chlamydosporia* resulted in a dry root weight of 12.5 g [26]. The application of *Pochonia chlamydosporia* at a seed treatment dosage of 12 g/kg led to a root weight of 28.25 g for bitter gourds infected with *Meloidogyne incognita* [27].

Evaluating the Efficacy of Bio-Agent (Ami *Pochonia chlamydosporia*) Against *Meloidogyne incognita* in Okra.

Final nematode population

The Ami *Pochonia chlamydosporia* treatment substantially decreased the final nematode population in the treated group (T1), with an average of 219.18 ± 11.56. This is a 52.34% decrease from the control group, which had a final nematode population of 371.34 ± 17.12. Ami *Pochonia chlamydosporia* treatment T1 with 5g root considerably decreased the final nematode population in the treated group, with an average of 46.34 ± 4.10. This is a 41.4% decrease from the control group, which had a population of 100.43 ± 9.11 shown in table 2.

Table 2: Effect of bio-agent on *M. incognita* growth parameters in okra.

Treatments	Final Nematode Population				RKI	Yield (t/ha)	% increase over check	ICBR
	200 cc Soil	% decrease over check	5g Root	% decrease over check				
T1	219.18 ± **11.56**	52.34	46.34 ± 4.10	41.4	1.45	5.09	30.05	1.91
T2-Control	371.34 ± **17.12**		100.43 ± 09.11		5.45	4.12		

In a different study, the addition of *Pochonia chlamydosporia* treatment at a rate of 25 g/m^2 had a significant effect on the populations of *Meloidogyne incognita* in the soil and roots. In particular, the treatment produced a nematode population of 41 in 5 g of root tissue, but the nematode population in 100 cm^3 of soil decreased to 79 [28]. The nematode population in bitter gourd roots (5 gm.) was considerably decreased to 10.00 (3.15) by applying 2.5 kg of *Pochonia chlamydosporia* (cfu 2×10^6) per hectare along with 2.5 tons of FYM. This is a 76.56% decrease when compared to untreated controls. Furthermore, there was an 84.69% decrease in the nematode population in the soil (200 cc), which reduced to 50.00 (6.97) [29].

Root knot index (RKI)

The RKI for treated plants was 1.45, indicating a significant reduction in nematode activity. In comparison, the control group had an RKI of 5.45 illustrated in table 2.

Yield t/ha

The application of *Ami Pochonia chlamydosporia* resulted in an okra production of 5.09 t/ha, representing a 30.05% increases over the control yield of 4.12 t/ha presented in table 2. In another study, *Pochonia chlamydosporia*, applied at 5.0 g/plant, substantially reduced the effects of *Meloidogyne incognita*, leading to a considerable improvement in cucumber development. Plants that received treatment showed healthier roots and produced 2.508 kg of yield per plant [30].

Incremental cost-benefit ratio

The treatment with Ami *Pochonia chlamydosporia* had an Incremental Cost-Benefit Ratio (ICBR) of 1.91, demonstrating substantial financial benefits indicated in table 2. In another experiment, 2.5 tons of vermicompost per hectare in combination with a 2 x 10^6 CFU concentration of *Pochonia chlamydosporia* substantially reduced the infestation of *Meloidogyne incognita* in bitter gourd. The results showed that plant health improved substantially. At 1.72, the Incremental Cost-Benefit Ratio (ICBR) was determined [31].

Conclusion

This study shows notable increases in plant growth, yield, and decreases in nematode populations, demonstrating Ami *Pochonia chlamydosporia* effectiveness as a promising biocontrol agent against *Meloidogyne incognita* in okra cultivation. The positive Incremental Cost-Benefit Ratio implies that integrating *P. chlamydosporia* can improve financial outcomes for farmers, promoting sustainable agricultural practices. It is an adaptable method that may be used in a variety of agricultural conditions, not just okra. It can also be applied to other crops that are impacted by root-knot nematodes. Further studies have focused on the enduring consequences on soil health, ideal methods for implementation, and potential beneficial effects of using additional eco-friendly approaches.

Bibliography

1. Sarkar Mangaldeep., *et al*. "Present Status of Okra (Abelmoschus Esculentus (L.) Moench.) Diseases and their Management Strategies". *Diseases of Horticultural Crops: Diagnosis and Management*. Apple Academic Press, (2022): 325-343.
2. Das Soma., *et al*. "Okra and its various applications in drug delivery, food technology, health care and pharmacological aspects-a review". *Journal of Pharmaceutical Sciences and Research* 11.6 (2019): 2139-2147.
3. Adelakun Oluyemisi Elizabeth and Olusegun James Oyelade. "Potential use of okra seed (Abelmoschus esculentus moench) flour for food fortification and effects of processing". *Flour and Breads and their Fortification in Health and Disease Prevention*. Academic Press, (2011): 205-212.
4. Ofuya Thomas I., *et al*. "A review of insect pest management in vegetable crop production in Nigeria". *Insects* 14.2 (2023): 111.
5. Shah F and Wu W. "Soil and crop management strategies to ensure higher crop productivity within sustainable environments". Sustainability 11.5 (2019): 1485.
6. Azlay Latifa., *et al*. "Biological management of root-knot nematodes (Meloidogyne spp.): a review". *Organic Agriculture* 13.1 (2023): 99-117.
7. Nurul Hafiza AAR., *et al*. "Occurrence and control of root knot nematode in crops: a review". (2016): 1649-1654.
8. Shilpa N., *et al*. "A status-quo review on management of root knot nematode in tomato". *The Journal of Horticultural Science and Biotechnology* 97.4 (2022): 403-416.

9. Asimakis Elias., *et al*. "Algae and their metabolites as potential bio-pesticides". *Microorganisms* 10.2 (2022): 307.

10. Abd-Elgawad Mahfouz MM. "Optimizing safe approaches to manage plant-parasitic nematodes". *Plants* 10.9 (2021): 1911.

11. Ahmad Gufran., *et al*. "Eco-friendly approaches for the alleviation of root-knot nematodes". *Plant Growth-Promoting Microbes for Sustainable Biotic and Abiotic Stress Management* (2021): 557-575.

12. Naz Ishrat., *et al*. "Biological control of root knot nematode, *Meloidogyne incognita*, in vitro, greenhouse and field in cucumber". *Biological Control* 152 (2021): 104429.

13. Bengtsson Torbjörn. "Biological control of root-knot nematodes (*Meloidogyne spp*.) by the fungus Pochonia chlamydosporia". (2015).

14. Moosavi Mohammad Reza and Rasoul Zare. "Fungi as biological control agents of plant-parasitic nematodes". *Plant Defence: Biological Control* (2020): 333-384.

15. Khan Mujeebur Rahman., *et al*. "Root–Knot Nematodes in Vegetables and Ornamentals and Their Management by Novel Biological and Biotechnological Tools". *Novel Biological and Biotechnological Applications in Plant Nematode Management*. Singapore: Springer Nature Singapore, (2023): 261-288.

16. Bontempo Amanda Ferreira., *et al*. "Dose-response effect of Pochonia chlamydosporia against Meloidogyne incognita on carrot under field conditions". *Revista Caatinga* 30 (2017): 258-262.

17. Ciancio Aurelio., *et al*. "Formulation of Pochonia chlamydosporia for plant and nematode management". *Bioformulations: for sustainable agriculture* (2016): 177-197.

18. Mingot-Ureta Cristina., *et al*. "Isolates of the nematophagous fungus Pochonia chlamydosporia are endophytic in banana roots and promote plant growth". *Agronomy* 10.9 (2020): 1299.

19. Dhawan S C and Satyandra Singh. "Biomanagement of root-knot nematode, Meloidogyne incognita by egg parasitic fungus, (Pochonia chlamydosporia) on Okra". *Vegetable Science* 38.02 (2011): 128-134.

20. Khan Mujeebur Rahman and Ziaul Haque. "Methods of assay and detection of nematodes in plant and soil". *Nematode Diseases of Crops and their Sustainable Management*. Academic Press, (2023): 27-54.

21. Uddin Muhammad Nazir., *et al*. "Evaluation of Pochonia chlamydosporia (Goddard) isolates for suppression of Meloidogyne incognita, root-knot nematode of tomato". *Journal of Agricultural Science* 11.5 (2019): 70.

22. Dhawan S C and Satyandra Singh. "Biomanagement of root-knot nematode, Meloidogyne incognita by egg parasitic fungus, (*Pochonia chlamydosporia*) on Okra". *Vegetable Science* 38.02 (2011): 128-134.

23. Chandrawat B S., *et al*. "Bio-agents: A source for initiation of defence enzymes in chilli infected with root-knot nematode, Meloidogyne incognita". *Journal of Entomology and Zoology Studies* 8.6 (2020): 1684-1688.

24. Mukhtar Tariq., *et al*. "Biocontrol potential of Pasteuria penetrans, Pochonia chlamydosporia, Paecilomyces lilacinus and Trichoderma harzianum against Meloidogyne incognita in okra". *Phytopathologia Mediterranea* (2013): 66-76.

25. Naz Ishrat., *et al*. "Biological control of root knot nematode, Meloidogyne incognita, in vitro, greenhouse and field in cucumber". *Biological Control* 152 (2021): 104429.

26. Khan Mujeebur Rahman., *et al*. "Management of root-knot disease in eggplant through the application of biocontrol fungi and dry neem leaves". *Turkish Journal of Biology* 36.2 (2012): 161-169.

27. Bhati S S., *et al*. "Bio-agents: An effective method for suppression of root-knot nematode, Meloidogyne incognita infecting bitter gourd (*Momordica charantia L*.) As seed treatment". *Journal of Entomology and Zoology Studies* 7.5 (2019): 1197-1201.

28. Rao MS., *et al*. "Bio-intensive management of root-knot nematodes on bell pepper using Pochonia chlamydosporia and Pseudomonas fluorescens". *Nematologia Mediterranea* (2004).

29. Nisha M S., *et al*. "Management of root-knot nematode, Meloidogyne incognita (Kofoid and White) Chitwood in bitter-gourd using bioagents and organic amendment". (2017).

30. Bhati S S., *et al*. "Impact of bio-agents against meloidogyne incognita infecting cucumber in poly-house". *Biological Forum– An International Journal* 14.2 (2022).

31. Mondal S., *et al*. "Efficacy of some bioagents in managing root-knot nematode, Meloidogyne incognita in Bittergourd". *Indian Journal of Plant Protection* 48.1-2 (2020).