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Eco-friendly bioagent-based approach for managing biotic stress in brinjal

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Abstract

Plant-parasitic nematodes, particularly root-knot nematodes, are a major threat to global crop production, causing significant biotic stress. The high toxicity of chemical nematicides has raised concerns, highlighting the urgent need for safer, alternative control methods. Biological control using antagonistic bacteria or fungi offers a promising solution and can be integrated into nematode management strategies. A field experiment was conducted in a hotspot area to evaluate the effectiveness of various bioagents in managing *Meloidogyne incognita* nematodes on brinjal. The study involved treating brinjal seeds with bioagents and applying bioagents to the soil, comparing these treatments with an untreated control. Nematode infection in the root zone, plant growth parameters, nematode populations in soil and roots and brinjal fruit yield were recorded throughout the cropping period. These variables were monitored to assess the impact of bioagents treatments on crops health and productivity. Significant reduction in the nematode population and improved plant growth was recorded in *Purpureocillium lilacinum* treated plots. The present investigation highlights the potential of biocontrol agent *P. lilacinum*, in managing nematode infestations and enhancing productivity of brinjal crop.

Keywords

biocontrol agents; biotic stress; brinjal; *Purpureocillium lilacinum*; root knot nematode

Introduction

Plant-parasitic nematodes are major soil pathogens that cause significant root damage, posing a serious threat to global agricultural production. Among plant-parasitic nematodes, root-knot nematodes (*Meloidogyne* spp.) are particularly pervasive in tropical and subtropical regions, affecting more than 3000 plant species (1). Brinjal (*Solanum melongena* L.), also known as eggplant or aubergine, is a popular vegetable native of South Asia consumed worldwide (2). Daily consumption of brinjal serving of 100 g fruits provides 1.58 g protein, Phosphorus 30.32 mg, calcium 18 g and 27.25 kcal of energy (3). Despite its importance, brinjal production is severely impacted by various pests, particularly plant-parasitic nematodes, which pose a major challenge to sustainable cultivation. Among these, root-knot nematode, which are sedentary endoparasites, cause significant harm to many horticultural crops, especially vegetables in tropical and subtropical regions, leading to substantial yield losses

(4, 5). Three primary root-knot nematode species *M. incognita*, *M. javanica* and *M. arenaria* have been found to infest brinjal, resulting in yield reductions of 27% to 62% due to severe infections (6). The infection process starts when second-stage juveniles (J2) hatch from eggs laid by females on plant roots and penetrate the roots and establish feeding sites, leading to the characteristic root galls. In India, *M. incognita* causes an estimated 14.1% annual yield loss in various vegetable crops (7). Under severe infestations, losses reaching up to 90% under field conditions, depending on the initial nematode population density (8, 9).

Despite the significant threat posed by these nematodes, current control measures remain in adequate since cost of nematicide is high as well as environmental concerns. The widespread use of environmentally harmful nematicides is still a common method for managing plant-parasitic nematodes across numerous crops worldwide (10). Cultural practices like crop rotation, although widely used, are often ineffective when used alone. The use of resistant crop varieties is also limited, as many commercially grown crops lack the necessary resistance genes.

Furthermore, the indiscriminate use of chemical nematicides has harmful effects on human health, beneficial organisms and the environment. The phasing out of frontline nematicides has led to increased research into safer, cost-effective alternatives. Affected plants exhibit external symptoms such as stunted growth, leaf discoloration, wilting and premature death, although the severity of these symptoms depends on the extent of nematode infection. While nematicides have traditionally been effective in controlling root-knot nematodes, there is a growing emphasis on using bio-agents as an economically and environmentally sustainable method of nematode management. Beneficial microorganisms in talc formulations have been extensively studied for their potential to reduce nematode populations in various crops. In light of this, a study was conducted to assess the efficacy of biocontrol agents on biotic stress created by *M. incognita* infestation in brinjal.

Materials and Methods

The nematode *M. incognita*, originally isolated from nematode infested tomato plants, was used as the experimental inoculum for this study. This culture was maintained on the roots of a nematode-susceptible variety of tomato plants (*Solanum lycopersicum* L.) in a greenhouse. Since. nematodes are the living organism, should be cultured in the roots of susceptible plants. The experiment was conducted in the nematode infested plots available at Department of Nematology, Anbil Dharmalingam Agricultural College and Research Institute, Navalurkuttapattu, Trichy, during 2022-2023 in randomized block design with 12 treatments, each replicated 3 times.

The commercially available talc-based formulation of *Purpureocillium lilacinum* was obtained from the Department of Nematology, while *Trichoderma viride, Bacillus subtilis, Trichoderma harzianum* and *Pochonia chlamydosporia* were sourced from the Department of Plant Pathology at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. The treatments were applied as follows: T_1: Seed treatment with *P. chlamydosporia* (10 g/kg), T_2: Seed treatment with *P. lilacinum* (10 g/kg), T_3: Seed treatment with *T. harzianum* (10 g/kg), T_4: Seed treatment with *T. viride* (10 g/kg), T_5: Seed treatment with *B. subtilis* (10 g/kg), T_6: Soil application of *P. chlamydosporia* (2.5 kg/ha,T_7: Soil application of *T. harzianum* (2.5 kg/ha), T_8: Soil application of *P. lilacinum* (2.5 kg/ha), T_9: Soil application of *T. viride* (2.5 kg/ha), T_{10}: Soil application of *B. subtilis* (2.5 kg/ha), T_{11}: Soil application of Carbofuran 3G (33 kg/ha) and T_{12}: Untreated control. Brinjal seeds (var. CO2) were treated with bioagents as per the above said treatment schedule and sown in the nursery. Well-established seedlings were transplanted in plots. Soil treatments mean application of bioagents in the soil before transplanting according to the treatment plan. The experiment was concluded with crop duration of 150 days after planting. At termination, the effect of the treatments on brinjal plant growth parameters and nematode population buildup was assessed. Biometric measurements were taken, including shoot length (cm), fresh and dry shoot weight (g), root length (cm), fresh and dry root weight (g). At the time of termination of experiment the final nematode population per 200 cc of soil was estimated using Cobb's sieving and decanting method (11) and the Modified Baermann funnel technique (12). Additional parameters such as number of adult females per gram of root, the number of egg masses per root, the number of eggs per egg mass and the root gall index recorded. Brinjal fruit yield was also recorded during the harvest per plot. All data were tabulated and statistically analysed using the analysis of variance (ANOVA) test according to the randomized block design methodology (13) and using the IRRISTAT software version 92 that was created by the biometric Unit of the International Rice Research Institute, Philippines.

Results and Discussion

All biocontrol agents significantly enhanced plant growth parameters and reduced nematode populations in both the soil and roots, compared to the untreated control, with *P. lilacinum* showing the most pronounced effects. The use of *P. lilacinum*, *T. viride* and *B. subtilis* resulted in improvements in length and weight of shoot, dry shoot weight, fruit yield, length and weight of root in a treatment-dependent manner. Among the treatments, the soil application of *P. lilacinum* at 2.5 kg/ha recorded the most significant improvements in plant growth parameters and fruit yield (34.87 t/ha). This improvement represented increases of 45.27% to 90.40% over untreated control, with seed treatment using *P. lilacinum* ranking second in efficacy (Table 1).

In terms of nematode suppression (Table 2), *P. lilacinum* application resulted in the highest reduction of root-knot nematode adult females, egg masses per gram of root, eggs per egg mass and nematode population in soil. The lowest root-knot index (1.0) according to the gall index (0 to 5 scale) based on the percentage of the root system with galls was also observed in the soil application of *P. lilacinum*, followed by soil application of Carbofuran (1.46) and *T. harzianum* (1.73). Similar results were found in a study (14), where biocontrol agents like *Pseudomonas fluorescens, P. lilacinus, Verticillium chlamydosporium, B. subtilis* and

Table 1. Effect of bio-control agents on plant growth of brinjal

Treatments	Shoot length (cm)	Fresh shoot weight (g)	Dry shoot weight (g)	Fruit yield (t/ha)	Root length (cm)	Fresh root weight (g)	Dry root weight (g)
T_1- Seed treatment of *Pochonia chlamydosporia* (10 g/kg of seeds)	47.26	19.74	10.09	29.51	13.88	11.76	7.06
T_2-Seed treatment of *Purpureocillium lilacinum* (10 g/kg of seeds)	60.27	24.15	13.17	32.84	19.12	17.18	10.32
T_3- Seed treatment of *Trichoderma harzianum* (10 g/kg of seeds)	42.35	19.13	9.88	27.31	10.15	10.02	8.02
T_4-Seed treatment of *Trichoderma viride* (10 g/kg of seeds)	55.33	23.33	12.86	32.84	18.24	17.05	9.58
T_5-Seed treatment of *Bacillus subtilis* (10 g/kg of seeds)	51.05	21.44	11.62	30.90	15.11	14.85	8.88
T_6- Soil application of *Pochonia chlamydosporia* (2.5 kg/ha)	50.15	21.13	11.26	30.33	14.32	15.12	8.95
T_7- Soil application of *Trichoderma harzianum* (2.5 kg/ha)	45.32	18.22	10.65	28.67	13.24	13.10	8.10
T_8-Soil application of *Purpureocillium lilacinum* (2.5 kg/ha)	65.35	27.32	16.23	34.87	21.46	19.27	11.36
T_9-Soil application of *Trichoderma viride* (2.5 kg/ha)	57.23	24.16	13.25	33.66	19.14	18.12	10.07
T_{10}-Soil application of *Bacillus subtilis* (2.5 kg/ha)	53.27	22.16	12.13	32.07	17.12	16.24	9.02
T_{11}-Soil application of Carbofuran 3G (33 kg/ha)	62.47	25.13	14.82	34.27	20.07	17.87	10.12
T_{12}- Untreated control	37.16	15.12	9.50	20.34	12.52	10.12	7.82
CD (P=0.05)	5.18	2.52	2.24	2.68	4.07	2.16	1.86

Table 2. Effect of bio-control agents on nematodes in brinjal

Treatments	No. of females per g of root	No. of egg masses per g of root	No. of eggs / egg mass	Nematode population in 200 cc soil	Root Knot Index
T_1- Seed treatment of *Pochonia chlamydosporia* (10 g/kg of seeds)	23.05	18.16	177.22	197.50	4.52
T_2-Seed treatment of *Purpureocillium lilacinum* (10 g/kg of seeds)	15.13	9.22	146.22	155.08	3.17
T_3- Seed treatment of *Trichoderma harzianum* (10 g/kg of seeds)	21.10	19.16	174.32	186.44	4.52
T_4-Seed treatment of *Trichoderma viride* (10 g/kg of seeds)	28.33	22.20	166.30	177.25	4.05
T_5-Seed treatment of *Bacillus subtilis* (10 g/kg of seeds)	24.66	22.10	154.44	166.12	3.66
T_6- Soil application of *Pochonia chlamydosporia* (2.5 kg/ha)	17.12	15.20	140.26	146.32	3.05
T_7- Soil application of *Trichoderma harzianum* (2.5 kg/ha)	18.07	17.24	114.24	127.12	1.73
T_8-Soil application of *Purpureocillium lilacinum* (2.5 kg/ha)	10.42	7.32	98.14	87.25	1.00
T_9-Soil application of *Trichoderma viride* (2.5 kg/ha)	23.24	17.12	132.33	136.66	2.32
T_{10}-Soil application of *Bacillus subtilis* (2.5 kg/ha)	15.62	20.12	137.20	141.20	2.82
T_{11}-Soil application of Carbofuran 3G (33 kg/ha)	16.24	8.44	112.24	102.16	1.46
T_{12}- Untreated control	25.33	23.26	332.27	314.16	5.00
CD (P=0.05)	4.26	3.12	7.23	8.10	2.10

T. viride were effective in managing root-knot nematodes in bhendi. These biocontrol agents were shown to effectively reduce nematode populations in both soil and roots, primarily due to their nematicidal activity (15, 16).

Using fungal and bacterial antagonists to manage nematode infestations in crops is a sustainable and eco-friendly approach. However, biological control methods are often most effective when integrated with other management practices. Regular monitoring and assessing nematode populations are crucial for determining the appropriate control measures. By adopting biological control strategies, growers can manage *M. incognita* infestations in brinjal effectively, reducing yield losses while minimizing the use of chemical nematicides.

The primary mechanism by which *P. lilacinum* controls parasitic nematodes is through egg parasitism (17, 18), where the fungus targets and invades the gelatinous matrix surrounding nematode eggs (19). Eggs at earlier developmental stages are more vulnerable to infection by nematophagous fungi (20). In contrast, *T. viride*, a common soil fungus, effectively controls nematodes by colonizing the surfaces and cortex of plant roots (21, 22). Applying *Trichoderma* species reduces root galling, promotes plant growth and improves plant tolerance to nematodes. In addition, *P. fluorescens* enhances plant growth in tomatoes by increasing soil phosphorus content or producing more indole acetic acid than untreated control plants (23).

In this study, applying *P. lilacinum* to the soil was found to be more effective than seed treatment, likely because it established itself better in the plant rhizosphere. The observed improvements in plant growth and yield could be attributed to the release of growth-promoting compounds by the biocontrol agent or the production of toxic substances that inhibit nematodes and suppress harmful microorganisms. The reduction in nematode galls and egg masses might be due to the bio-agent's strong ability to colonize the rhizosphere, limiting nematode feeding sites. Additionally, the decrease in root galls indicates that many juvenile nematodes were unable to penetrate the plant roots. Overall, using fungal antagonists like *P. lilacinum* holds significant potential for controlling *M. incognita* infestations in brinjal.

Conclusion

The current study highlighted the effectiveness of various fungal and bacterial antagonists in controlling root-knot nematode (*M. incognita*) infestations in brinjal plants, leading to improved plant growth and yield outcomes. Among the treatments, soil application of *P. lilacinum* at 2.5 kg/ha emerged as the most effective, achieving the highest reductions in nematode damage and associated plant stress. This treatment not only protected brinjal crops by reducing nematode populations but also enhanced plant growth parameters such as shoot length, root weight and fruit weight, while contributing to the resilience of the agro-ecosystem. Our findings suggest that *P. lilacinum* offers a sustainable and eco-friendly strategy for managing root-knot nematodes in brinjal cultivation, with potential applicability to other vegetable crops. Further research on its integration with other management practices could enhance its efficacy and adoption.

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Authors' contributions

JJ carried out the experiment, took observations and analysed the data. TS guided the research by formulating the research concept, helped in the final manuscript writing. RV contributed by statistical analysis and interpretation of the findings. SG designed and coordinated the experiment and performed summarizing and revising the manuscript. GM participated in the sequence alignment and drafted the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

References

1. Abad P, Favery B, Rosso MN, Castagnone SP. Root knot nematode parasitism and host response: Molecular basis of a sophisticated interaction. Mol Plant Pathol. 2003;4:217–24. https://doi.org/10.1046/j.13643703.2003.00170.x
2. Rangarajan AK, Purushothaman R, Pérez-Ruiz M. Disease classification in aubergine with local symptomatic region using deep learning models. Biosyst Eng. 2021;209:139–53. https://doi.org/10.1016/j.biosystemseng.2021.06.014
3. Hasan MR, Bai H. Profitability of brinjal production in three districts of Bangladesh. J of Eco-fri Agril. 2016;9:55–59.
4. Sahebani N, Hadavi N. Biological control of the root-knot nematode *Meloidogyne javanica* by *Trichoderma harzianum*. Soil Biol Biochem. 2008;40(8):2016–20. https://doi.org/10.1016/j.soilbio.2008.03.011
5. Kiewnick S, Sikora RA. Biological control of root knot nematode, *Meloidogyne incognita* by *Paecilomyces lilacinum* strain 251. Biol Control. 2006;38(2):179–87. https://doi.org/10.1016/j.biocontrol.2005.12.006
6. Darekar KS, Mhase NL. Assessment of yield losses due to root-knot nematode, in tomato, brinjal and bitter gourd. Int Nematol Newsl. 1988;5:7–9.
7. Jain RK, Mathur KN, Singh RV. Estimation of losses due to plant parasitic nematodes on different crops in India. Indian J Nematol. 2007;37:219–21.
8. Bhatti DS, Jain RK. Estimation of loss in okra, tomato and brinjal yield due to *Meloidogyne incognita*. Indian J Nematol. 1977;7:37-41.
9. Jain RK, Gupta DC. A note on the screening of some chemicals as seed treatment for control of root-knot nematode (*Meloidogyne javanica*) infesting okra. Haryana J Hort Sci. 1986;15:288–90.
10. Atkinson HJ, Grawin PE, Mcpherson MJ. Engineering plants for nematode resistance. Annu Rev Phytopathol. 2003;41:615–39. https://doi.org/10.1146/annurev.phyto.41.052002.095737
11. Cobb NA. Estimating the nematode population of soil. United States, Department of Agriculture. 1918; Circular No.1–48.
12. Schindler AF. A simple substitute for a Baermann funnel. Plant dis Res. 1961;45:747–48.
13. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Edition, John Wiley and Sons, New York. 1984; p 680.
14. Senthilkumar T, Vinothini S, Kalaivani M. Assessment of potential of bio-agents on root knot nematode *Meloidogyne incognita* in bhendi. Int J Curr Microbiol App Sci. 2018;7(8):2528–31. https://doi.org/10.20546/ijcmas.2018.708.257
15. Keuken O, Sikora RA. Biological control of root knot nematode, *Meloidogyne incognita* with the rhizosphere bacteria *Bacillus subtiles* and bacterial production of toxic metabolites. Nematologica. 1995;41:315.
16. Senthilkumar T. Assessment on potential of bacterial biocontrol agents on plant parasitic nematodes in banana. J Entomol Zool Stud. 2020;8(4s):26–27. https://www.entomoljournal.com/special--issue?year=2020&vol=8&issue=4S&ArticleId=7578
17. Chen SY, Chen FJ. Fungal parasitism of *Heterodera glycines* eggs as influenced by egg age and pre-colonization of cysts by other fungi. J Nematol. 2003;35:271–77. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2620643/pdf/271.pdf
18. Senthilkumar T. Evaluation of ecofriendly management technique against root knot nematode *Meloidogyne incognita* in tuberose. Biol Forum. 2021;13(3b):192–94.
19. Meyer SLF, Wergin WP. Colonization of soybean cyst nematode females, cysts and gelatinous matrices by the fungus *Verticillium lecanii*. J Nematol. 1998;30(4):436–50.
20. Khan A, Williams KL, Nevalainen HKM. Control of plant-parasitic nematodes by *Paecilomyces lilacinus* and *Monacrosporium lysipagum* in pot trials. Biocontrol. 2006;51:643–58. https://doi.org/10.1007/s10526-005-4241-y
21. Senthilkumar T, Rajendran G. Biological-management of root-knot nematode *Meloidogyne incognita* using *Pseudomonas fluorescens* and *Trichoderma viride* in grapevine. South Ind Hor. 2005;53(1/6):231–35.
22. Sharon E I, Chet A, Viterbo M, Bar-Eyal H, Nagan GJ, Samuels, Spiegel Y. Improved attachment and parasitism of *Trichoderma* on *Meloidogyne javanicain vitro*. Eur J Plant Pathol. 2009;123(3):291–99. https://doi.org/10.1007/s10658-008-9366-2
23. Khan MZ, Akhtar ME, Mahmood-ul-Hassan M, Mahmood MM, Safdar MN. Potato tuber yield and quality as affected by rates and sources of potassium fertilizer. J Plant Nutr. 2012;35:664–77. https://doi.org/10.1080/01904167.2012.653072