

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(9): 389-395
www.biochemjournal.com
Received: 26-07-2026
Accepted: 28-08-2026

Harish BR

Department of Plant Pathology,
Keladi Shivappa Nayaka
University of Agricultural and
Horticultural Sciences, Iruvakkki,
Shivamogga, Karnataka, India

B Gangadhara Naik

Department of Plant Pathology,
Keladi Shivappa Nayaka
University of Agricultural and
Horticultural Sciences, Iruvakkki,
Shivamogga, Karnataka, India

Ravikumar M

Department of Horticulture,
Keladi Shivappa Nayaka
University of Agricultural and
Horticultural Sciences, Iruvakkki,
Shivamogga, Karnataka, India

Sahana N Banakar

Department of Plant Pathology,
Keladi Shivappa Nayaka
University of Agricultural and
Horticultural Sciences, Iruvakkki,
Shivamogga, Karnataka, India

Divya M

Department of Agricultural
Microbiology, Keladi Shivappa
Nayaka University of
Agricultural and Horticultural
Sciences, Iruvakkki, Shivamogga,
Karnataka, India

Vijayalaxmi

Department of Plant Pathology,
Keladi Shivappa Nayaka
University of Agricultural and
Horticultural Sciences, Iruvakkki,
Shivamogga, Karnataka, India

Corresponding Author:**Harish BR**

Department of Plant Pathology,
Keladi Shivappa Nayaka
University of Agricultural and
Horticultural Sciences, Iruvakkki,
Shivamogga, Karnataka, India

Unveiling native fungal and bacterial bioinoculants from the arecanut rhizosphere ecosystem

Harish BR, B Gangadhara Naik, Ravikumar M, Sahana N Banakar, Divya M and Vijayalaxmi

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i9e.9997>

Abstract

Arecanut is an economically important plantation crop in India, with Karnataka contributing substantially to the national production. However, the crop is affected by several diseases that pose a major constraint to sustainable production. Biological control using beneficial microorganisms offers an environmentally safer approach to disease management, and the rhizosphere represents an important source of native microbial resources. The present study was undertaken to isolate native fungal and bacterial bioinoculants from arecanut rhizosphere soils collected from different arecanut-growing regions of Shivamogga district, Karnataka. A total of twelve rhizosphere soil samples were collected from twelve locations representing seven taluks of the district. Fungal and bacterial bioinoculants were isolated using serial dilution and selective media techniques. The isolation resulted in the recovery of twelve *Trichoderma* isolates and seven bacterial isolates from the sampled rhizosphere soils. The *Trichoderma* isolates were obtained from different arecanut-growing regions representing lateritic, red loamy and red sandy loam soils, while the bacterial isolates were recovered predominantly from lateritic and red loamy soils. The isolates were purified and maintained as pure cultures for further studies. The recovery of diverse fungal and bacterial isolates from different geographical locations and soil types demonstrated the presence of native microbial resources associated with the arecanut rhizosphere of Shivamogga district. The study provides a useful collection of indigenous fungal and bacterial bioinoculants that can serve as a resource for subsequent screening and evaluation of their potential for biological management of important arecanut pathogens.

Keywords: Arecanut, rhizosphere, bioinoculants, biological control

1. Introduction

Arecanut (*Areca catechu* L.) is an economically important plantation crop widely cultivated in tropical and subtropical regions of Asia. It plays an important role in the livelihood of farming communities and contributes substantially to the agricultural economy of India. India is the world's largest producer and consumer of arecanut (Chowdappa *et al.*, 2014) [3]. During 2024-25, the total area under arecanut cultivation in India was 1,040.27 thousand ha, with a production of 1,491.23 thousand MT. Karnataka is the leading arecanut-producing state, accounting for 741.18 thousand ha and 1,097.75 thousand MT of production, with a productivity of 1.5 MT/ha (Indiastat, 2025) [6]. Major arecanut-growing districts of Karnataka include Shivamogga, Chikkamagaluru, Tumakuru, Chitradurga, Davanagere, Uttara Kannada and Dakshina Kannada.

Despite its economic importance, arecanut production is affected by several biotic and abiotic constraints, among which diseases are of major significance. The crop is susceptible to diseases caused by diverse fungal, bacterial, viral and phytoplasmal pathogens, which can adversely affect plant growth and productivity (Reddy and Kumar, 2021) [13]. Important diseases of arecanut include fruit rot or Koleroga caused by *Phytophthora meadii*, basal stem rot caused by *Ganoderma* spp., bacterial leaf stripe caused by *Xanthomonas vasicola* pv. *arecae*, yellow leaf disease associated with *Candidatus* phytoplasma, and various leaf spot diseases caused by fungal pathogens including *Phyllosticta arecae*, *Colletotrichum* spp. and *Pestalotiopsis arecae*. The occurrence of several economically important pathogens makes disease management an important component of sustainable arecanut production.

Disease management in arecanut plantations commonly involves the use of chemical pesticides. However, repeated and indiscriminate use of chemical pesticides may result in

environmental contamination, pesticide residues and the development of resistance in plant pathogens (Pimentel and Burgess, 2014) [11]. These concerns have increased the need for environmentally safer and sustainable approaches to plant disease management. Biological control using beneficial microorganisms represents a promising alternative, as several microorganisms are capable of suppressing plant pathogens through mechanisms such as antibiosis, competition, mycoparasitism and induction of plant defence responses (Pal and Gardener, 2006) [9].

The rhizosphere is an important ecological niche that harbours a diverse population of microorganisms closely associated with plant roots. Beneficial microorganisms naturally occurring in the rhizosphere may possess greater adaptation to the prevailing soil and environmental conditions of their native habitat. Such indigenous microbial populations can serve as valuable sources of potential biological control agents. Fungi and bacteria belonging to genera such as *Trichoderma*, *Bacillus* and *Pseudomonas* are widely recognized for their potential in plant health promotion and suppression of plant pathogens (Compant *et al.*, 2010) [4]. Therefore, exploration of the rhizosphere microbiota of arecanut plantations may provide useful native microbial resources for developing biological disease management strategies.

Shivamogga district is one of the important arecanut-growing regions of Karnataka, with arecanut cultivation distributed across different agro-ecological conditions. However, the availability of native microbial resources associated with arecanut rhizosphere soils from different growing regions remains comparatively less explored. Isolation of indigenous fungal and bacterial bioagents from these soils can provide a diverse pool of microbial isolates for subsequent evaluation of their potential against important arecanut pathogens.

Therefore, the present study was undertaken to isolate native fungal and bacterial bioagents from the rhizosphere of arecanut palms collected from different arecanut-growing regions of Shivamogga district, Karnataka, as a source of potential microbial agents for the biological management of major arecanut pathogens.

2. Materials and Methods

2.1 Collection of Rhizosphere Soil Samples

Rhizosphere soil samples were collected from healthy and vigorously growing arecanut palms distributed across the seven taluks of Shivamogga district, Karnataka, viz., Shivamogga, Bhadravathi, Hosanagara, Thirthahalli, Shikaripura, Sorab and Sagara. Sampling was carried out by selecting gardens free from visible symptoms of major diseases. Approximately 250 g of rhizosphere soil adhering to the root zone (0-20 cm depth) of each selected palm was collected using a sterile hand trowel after carefully removing the surface soil. The collected samples were transferred into sterile polyethylene bags, properly labelled with location, date of collection and sample number and transported to the Department of Plant Pathology, College of Agriculture, Shivamogga. The samples were stored at 4±1 °C and processed within 24 hours for the isolation of fungal and bacterial bioinoculants.

2.2 Isolation of Fungal and Bacterial Bioinoculants by Serial Dilution Technique

Isolation of fungal and bacterial bioinoculants from rhizosphere soil samples was carried out by adopting the serial dilution plate technique described by Waksman

(1927) [15] with suitable modifications. Ten grams of each rhizosphere soil sample were transferred aseptically into a 250 mL conical flask containing 100 mL of sterile distilled water. The suspension was agitated on a vortex mixer for 15 minutes to obtain a uniform microbial suspension. Serial dilutions were prepared by transferring 1 mL of the suspension into 9 mL of sterile distilled water blanks to obtain dilutions ranging from 10⁻¹ to 10⁻⁶. Fresh sterile pipette tips were used at each dilution step to avoid contamination.

Different dilution levels were selected for the isolation of fungal and bacterial bioinoculants based on their population in the rhizosphere soil. For the isolation of bacterial bioinoculants (*Pseudomonas fluorescens*, *Bacillus* spp., Phosphate-solubilizing bacteria and Potassium-solubilizing bacteria), 0.1 mL aliquots from the 10⁻⁵ and 10⁻⁶ serial dilutions were aseptically spread on their respective selective media using the spread plate technique. For the isolation of fungal bioinoculants (*Trichoderma* spp.), 1 mL aliquots from the 10⁻³ and 10⁻⁴ serial dilutions were spread uniformly on *Trichoderma* Selective Medium (TSM). The inoculated plates were incubated under suitable conditions for the growth of the respective microorganisms.

2.2.1 Isolation of *Trichoderma* spp.

Isolation of *Trichoderma* spp. was carried out using *Trichoderma* Selective Medium (TSM). One millilitre aliquots from 10⁻³ and 10⁻⁴ serial dilutions were spread uniformly on sterilized Petri plates containing solidified TSM using a sterile L-shaped glass spreader. The inoculated plates were incubated at 28±2 °C for 96 hours in a Biological Oxygen Demand (BOD) incubator.

The plates were examined periodically for the appearance of colonies exhibiting typical characteristics of *Trichoderma*, such as rapid growth, compact colonies with white mycelia turning green due to profuse sporulation. Individual colonies were picked and purified by repeated hyphal tip transfer onto fresh Potato Dextrose Agar (PDA) plates. The purified cultures were maintained on PDA slants at 4 °C for further studies.

2.2.2 Isolation of *Pseudomonas fluorescens*

Isolation of fluorescent *Pseudomonas* spp. was carried out using King's B medium. One millilitre aliquots from the 10⁻⁵ and 10⁻⁶ serial dilutions were spread aseptically on sterilized King's B agar plates. The inoculated plates were incubated at 28±2 °C for 24-72 hours. Colonies exhibiting smooth, circular, creamy-white appearance were selected and further examined for fluorescence under ultraviolet light (365 nm) using a UV transilluminator. Colonies producing characteristic yellowish-green fluorescent pigment were selected as presumptive *Pseudomonas fluorescens* isolates. The selected colonies were purified by repeated streaking on fresh King's B agar plates until pure cultures were obtained. Pure cultures were maintained on King's B agar slants at 4 °C.

2.2.3 Isolation of *Bacillus* spp.

Isolation of *Bacillus* spp. was carried out on Luria-Bertani (LB) agar medium. Aliquots of 1 mL from 10⁻⁵ and 10⁻⁶ serial dilutions were spread uniformly on LB agar plates under aseptic conditions. The inoculated plates were incubated at 28±2 °C for 24-48 hours. Colonies exhibiting characteristic dull white, opaque, irregular, dry and rough morphology were selected. The colonies were purified by repeated streaking on fresh LB agar medium to obtain single

isolated colonies. Pure cultures were transferred to LB agar slants and preserved at 4 °C for further morphological, biochemical and molecular characterization.

2.2.4 Isolation of Phosphate-Solubilizing Bacteria (PSB)

Phosphate-solubilizing bacteria were isolated using Pikovskaya's agar medium. One millilitre aliquots from appropriate serial dilutions (10^{-5} and 10^{-6}) were spread on sterilized Pikovskaya's agar plates and incubated at 28 ± 2 °C for 48-72 hours. The plates were observed for the development of clear halo zones surrounding bacterial colonies due to phosphate solubilization. Colonies producing distinct solubilization zones were selected and purified by repeated streaking on fresh Pikovskaya's agar medium. Pure cultures were maintained on agar slants at 4 °C.

2.3 Purification of Bioinoculants

Individual fungal and bacterial colonies obtained after isolation were purified to obtain axenic cultures. Fungal isolates were purified by hyphal tip culture, whereas bacterial isolates were purified by repeated streak plate technique. Each purified isolate was examined microscopically to confirm purity before being utilized for subsequent experiments. Each isolate was assigned a unique

identification code based on the location of collection and the type of bioinoculant to facilitate further characterization and experimental evaluation.

2.4 Maintenance of Pure Cultures

Purified fungal isolates were maintained on Potato Dextrose Agar slants, whereas bacterial isolates were maintained on Nutrient Agar, King's B agar or Luria-Bertani agar slants depending upon the organism. The cultures were incubated at 28 ± 2 °C until sufficient growth was obtained and subsequently stored in a refrigerator at 4 °C. The cultures were sub-cultured at monthly intervals to maintain viability throughout the investigation.

3. Results

3.1 Collection of Rhizosphere Soil Samples

Rhizosphere soil samples were collected from healthy arecanut palms growing in different taluks of Shivamogga district, Karnataka, during the course of the investigation. A total of twelve soil samples were collected from twelve locations representing seven taluks, namely Bhadravati, Hosanagara, Sagara, Shikaripura, Shivamogga, Soraba and Thirthahalli. The details of the sampling locations, geographical coordinates, soil type and approximate age of the arecanut palms are presented in Table 1.

Table 1: Details of soil samples collected from the arecanut palm rhizosphere of Shivamogga district

Taluk	Place of collection	Latitude (° N)	Longitude (° E)	Soil type	Approximate age of palm (years)
Bhadravati	Komaranahalli	13.972139	75.744008	Red loamy soil	13
	Veerapura	13.972355	75.744057	Red loamy soil	20
Hosanagara	Kargadi	13.865572	75.059085	Lateritic soil	22
	Haniya	13.854826	75.063122	Lateritic soil	25
Sagara	Tyagarthi	14.161082	75.063435	Lateritic soil	16
	Achapura	14.069180	75.232840	Lateritic soil	10
Shikaripura	Harogi	14.42254	75.181984	Red loamy soil	24
Shivamogga	Holaluru	14.072795	75.542368	Red loamy soil	17
	Kumsi	14.040457	75.406662	Red loamy soil	21
Soraba	Nadahalli	14.364634	75.08290	Lateritic soil	35
Thirthahalli	Kudumallige	13.724393	75.288555	Lateritic soil	15
	Basavani	13.727547	75.302118	Lateritic soil	18

Among the locations surveyed, two sampling sites each were selected from Bhadravati (Komaranahalli and Veerapura), Hosanagara (Kargadi and Haniya), Sagara (Tyagarthi and Achapura), Shivamogga (Holaluru and Kumsi) and Thirthahalli (Kudumallige and Basavani), while

one location each was selected from Shikaripura (Harogi) and Soraba (Nadahalli). The geographical coordinates of the sampling sites ranged from 13.724393° N to 14.42254° N latitude and 75.035593° E to 75.744057° E longitude (Fig.1).

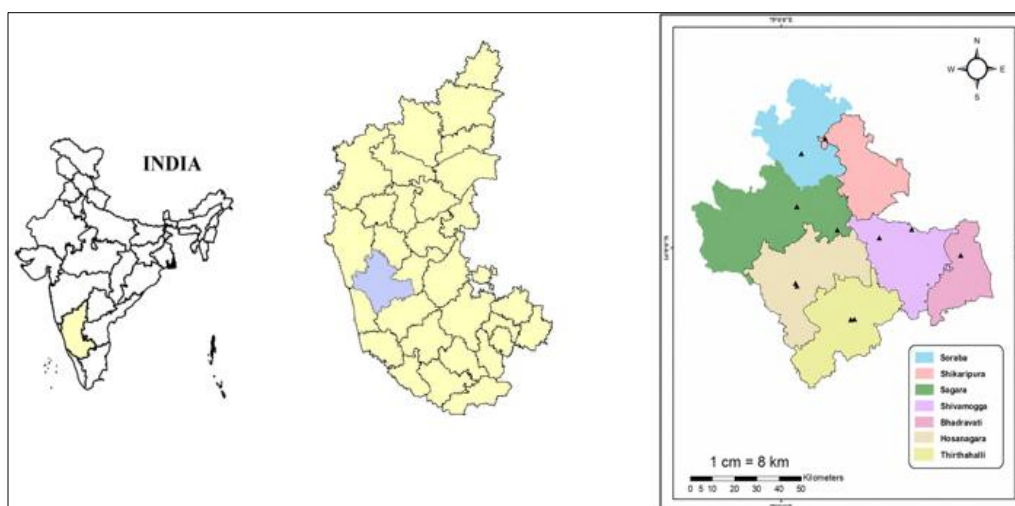


Fig 1: Map showing the locations of arecanut rhizosphere soil sample collection in Shivamogga district

The collected rhizosphere soil samples represented two major soil types, namely red loamy soil and lateritic soil. The approximate age of the sampled arecanut palms varied from 10 to 35 years, indicating that the samples were collected from well-established plantations distributed across different agro-ecological regions of Shivamogga district.

3.2 Isolation of *Trichoderma* spp.

Rhizosphere soil samples collected from different arecanut-

growing regions of Shivamogga district were processed for the isolation of native *Trichoderma* spp. (Plate 1). A total of twelve *Trichoderma* isolates were recovered from the collected rhizosphere soil samples. The isolates were designated as Tr1 to Tr12 based on the location of collection. The details of the isolates, including their place of origin, geographical coordinates and soil type, are presented in Table 2.

Table 2: *Trichoderma* isolates isolated from the rhizosphere of arecanut palm of Shivamogga district, Karnataka

Isolate Code	Taluk	Village	Latitude (° N)	Longitude (° E)	Soil type
Tr1	Bhadravati	Komaranahalli	13.972139	75.744008	Red loamy soil
Tr2	Shivamogga	Holaluru	14.072795	75.542368	Red loamy soil
Tr3	Shikaripura	Harogi	14.42254	75.18198	Red loamy soil
Tr4	Sagara	Tyagarthi	14.161082	75.063435	Lateritic soil
Tr5	Bhadravati	Veerapura	13.972355	75.744057	Red loamy soil
Tr6	Shivamogga	Kumsi	14.040457	75.406662	Red loamy soil
Tr7	Thirthahalli	Basavani	13.727547	75.302118	Lateritic soil
Tr8	Sagara	Achapura	14.069180	75.232840	Lateritic soil
Tr9	Hosanagara	Kargadi	13.865572	75.059085	Lateritic soil
Tr10	Thirthahalli	Kudumallige	13.724393	75.288555	Lateritic soil
Tr11	Hosanagara	Haniya	13.854826	75.063122	Lateritic soil
Tr12	Shikaripura	Harogi	14.42254° N	75.18198° E	Red loamy soil

Tr1-*Trichoderma* isolate 1

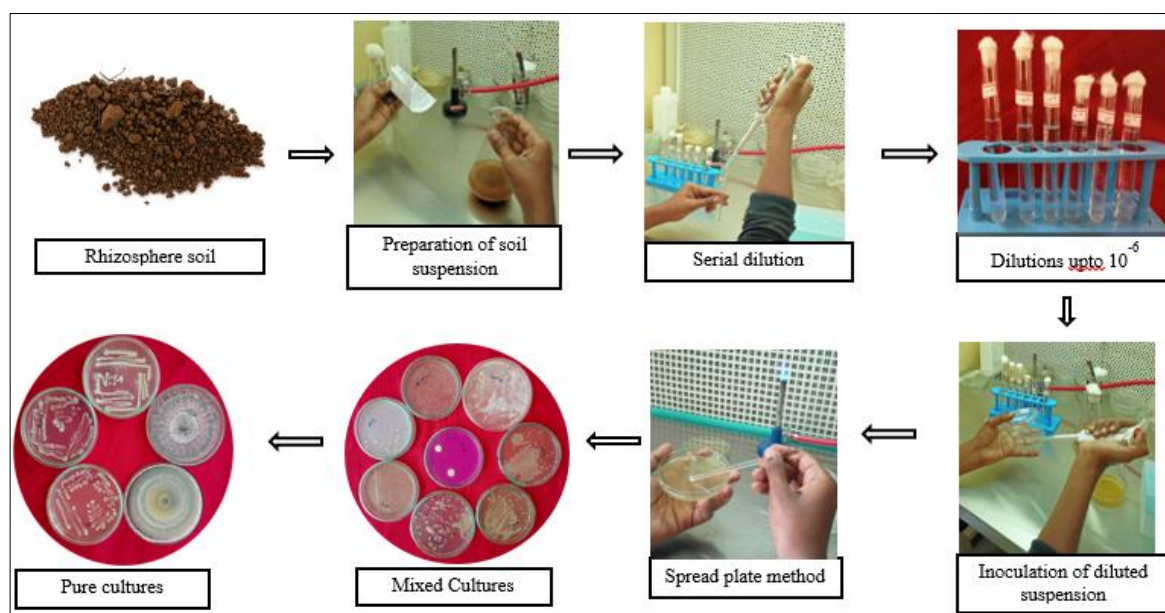


Plate 1: Isolation of bioinoculants from collected soil samples

Among the twelve isolates, two isolates each were obtained from different villages of Bhadravati, Shivamogga, Sagara, Hosanagara and Thirthahalli taluks, while Shikaripura taluk contributed two isolates from the same village (Harogi). The isolates originated from seven taluks were represented diverse agro-climatic conditions of Shivamogga district, thereby providing a broad collection of native *Trichoderma* isolates for further characterization and evaluation.

The majority of the *Trichoderma* isolates were recovered from lateritic soils, whereas the remaining isolates were obtained from red loamy soil and red sandy loam/red loamy loam soils. The geographical distribution of the isolates extended from 13.724393° N to 14.42254° N latitude and 75.035593° E to 75.744057° E longitude, indicating that

native *Trichoderma* populations were distributed across different arecanut-growing ecosystems of the district. The isolated cultures were purified and maintained for further studies.

3.3 Isolation of Bacterial Bioinoculants

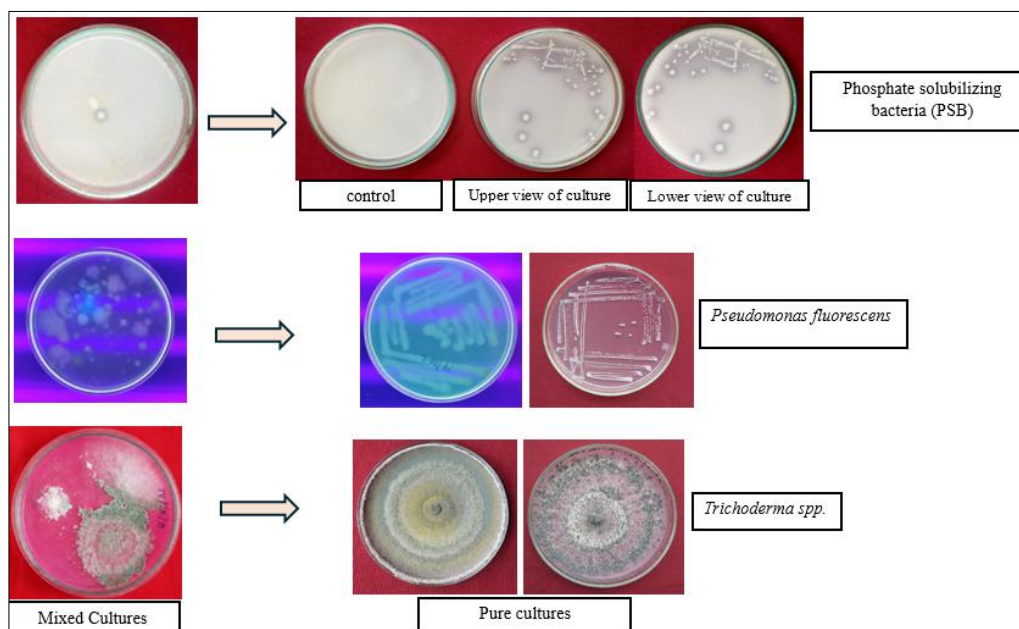
Rhizosphere soil samples collected from different arecanut-growing regions of Shivamogga district were utilized for the isolation of native bacterial bioinoculants.

A total of seven bacterial isolates were obtained from the rhizosphere soil samples and designated as B1 to B7 based on the place of collection. The collection details of the bacterial isolates, including taluk, village, geographical coordinates and soil type, are presented in Table 3 (Plate 2).

Table 3: Bacterial isolates from the arecanut rhizosphere of Shivamogga district

Isolate Code	Taluk	Village	Latitude (° N)	Longitude (° E)	Soil type
B1	Bhadravati	Komaranahalli	13.972139	75.744008	Red loamy soil
B2	Bhadravati	Veerapura	13.972355	75.744057	Red loamy soil
B3	Hosanagara	Haniya	13.854826	75.063122	Lateritic soil
B4	Shivamogga	Holaluru	14.072795	75.542368	Red loamy soil
B5	Sagara	Achapura	14.069180	75.232840	Lateritic soil
B6	Thirthahalli	Kudumallige	13.724393	75.288555	Lateritic soil
B7	Hosanagara	Kargadi	13.865572	75.059085	Lateritic soil

B1-Bacterial bioinoculant 1

**Plate 2:** Isolation of native rhizosphere bioinoculants showing colony development of phosphate-solubilizing bacteria (PSB), fluorescence of *Pseudomonas fluorescens* under UV illumination and cultural growth of *Trichoderma* spp.

The bacterial isolates were recovered from five taluks of Shivamogga district, namely Bhadravati, Hosanagara, Shivamogga, Sagara and Thirthahalli. Among these, Bhadravati and Hosanagara contributed two isolates each, whereas Shivamogga, Sagara and Thirthahalli contributed one isolate each. The isolates represented a wide geographical distribution, with sampling locations extending from 13.724393° N to 14.072795° N latitude and 75.035593° E to 75.744057° E longitude.

The bacterial bioinoculants were isolated from red loamy soil and lateritic soil, which are the predominant soil types of the arecanut-growing regions surveyed. The purified bacterial isolates were maintained under laboratory conditions and subsequently utilized for further studies.

4. Discussion

4.1 Collection of Rhizosphere Soil Samples

A total of twelve rhizosphere soil samples were collected from twelve locations representing seven taluks of Shivamogga district, namely Bhadravati, Hosanagara, Sagara, Shikaripura, Shivamogga, Soraba and Thirthahalli, from arecanut palms aged between 10 and 35 years. The sampled sites, spread across a latitudinal range of 13.72° N to 14.42° N and a longitudinal range of 75.04° E to 75.74° E, which represented predominantly red loamy and lateritic soil types of the arecanut-growing tracts of the district. Restricting the sample collection from the well-established, visually healthy palms from the leaf spot infected gardens has ensured that, the microbial populations recovered were

drawn from a rhizosphere that had co-evolved with the crop over an extended period, thereby increasing the likelihood of isolating bioinoculants that are ecologically compatible with arecanut and adapted to the region's specific edaphic and climatic conditions.

A comparable rhizosphere-sampling approach was followed by Mohan *et al.* (2019) ^[8], who collected rhizosphere soil from the active root zone of arecanut palms across the Wayanad district of Kerala for metagenomic analysis. Paulraj *et al.* (2021) ^[10], who characterized the bacterial diversity of arecanut rhizosphere soils in the Yellow Leaf Disease-endemic tract of Dakshina Kannada district using 16S rRNA amplicon sequencing and reported the dominance of Proteobacteria, Bacteroidetes, Firmicutes and Actinobacteria. The diversity of soil types and locations covered in the present collection is therefore in agreement with the general understanding that the arecanut rhizosphere harbours a rich and geographically variable microbial community and sampling across multiple taluks and soil types, as adopted here, is essential for capturing this diversity prior to bioinoculant isolation.

4.2 Isolation of *Trichoderma* Isolates

A total of twelve native *Trichoderma* isolates (Tr1 to Tr12) were recovered from the rhizosphere soil samples, with two isolates obtained from each of five taluks and two isolates from a single village in Shikaripura. The majority of the isolates originated from lateritic soils, with the remainder recovered from red loamy soil, indicating the richness of

lateritic soil, despite its comparatively lower organic matter and nutrient status, supported a fairly rich native *Trichoderma* population in the arecanut rhizosphere. This pattern may be attributed to the inherent acidity and high iron/aluminium-oxide content of lateritic soil, which is known to act as a natural ecological filter favouring stress-tolerant, spore-forming and antagonistic genera such as *Trichoderma* and *Bacillus* over less tolerant taxa, relative to the comparatively less acidic red loamy soil (Zhang *et al.*, 2022)^[16].

This finding is in conformity with the observations of Chakrabarty and Sarma (2017)^[1], who isolated *Trichoderma* spp. from the rhizosphere of healthy arecanut palms across different districts of Assam using the serial dilution plate technique on *Trichoderma*-selective medium, whereas Sharma and Singh (2014)^[14], recovered thirty *Trichoderma* isolates from rhizosphere soils across six districts of Uttarakhand. The recovery of twelve distinct isolates from a relatively compact geographic area in the present study, spread across varying soil types, is consistent with the widely reported ubiquity and ecological plasticity of *Trichoderma* in cultivated soils and reinforces the rationale for surveying multiple locations rather than relying on a single sampling site when prospecting for native antagonists.

4.3 Isolation of Bacterial Bioinoculants

Seven native bacterial isolates (B1 to B7) were recovered from five of the seven taluks surveyed, with Bhadravati and Hosanagara each contributing two isolates and the remaining taluks contributing one isolate each. The bacterial bioinoculants were obtained predominantly from red loamy and lateritic soils, mirroring the soil-type distribution recorded for the *Trichoderma* isolates and suggesting that these two dominant soil types of the district are jointly favourable for the persistence of both fungal and bacterial antagonists in the arecanut rhizosphere. This is consistent with reports that lateritic soils, being comparatively richer in organic matter and more acidic, are naturally enriched in beneficial genera such as *Bacillus*, which often exhibit higher phosphatase activity under such conditions (Chen *et al.*, 2026)^[2].

The comparatively lower number of bacterial isolates relative to *Trichoderma* isolates recovered in the present study may be attributed to the selective nature of the isolation media employed and the inherently slower colony development of many rhizobacteria relative to fast-growing fungal antagonists on general isolation media. Similar rhizosphere bacterial isolation efforts on plantation crops have been reported by Gupta *et al.* (2014)^[5], who recovered 1,512 morphologically distinct heterotrophic bacterial isolates from the rhizosphere of coconut, cocoa and arecanut across different agro-ecological regions of India and selected three promising isolates, including CPCRI-3 from arecanut, for further characterization.

The present effort made for the isolation of seven bacterial bioinoculants, though smaller in number, is consistent with the general trend in these studies of recovering a broad initial pool of isolates that is subsequently narrowed down through morphological, biochemical and functional screening, an similar approach was also adopted by Khattak *et al.* (2025)^[7], who screened 42 rhizobacterial isolates from eggplant rhizosphere to identify a single superior antagonist against *Verticillium dahliae*.

5. Conclusion

The present study successfully isolated native fungal and bacterial bioinoculants from the rhizosphere of arecanut palms across different arecanut-growing regions of Shivamogga district, Karnataka. Rhizosphere soil samples collected from 12 locations representing seven taluks provided a diverse source of native microbial resources. A total of 12 *Trichoderma* isolates and seven bacterial isolates were recovered using selective media and serial dilution techniques. The isolates were obtained from predominantly lateritic and red loamy soils, indicating the occurrence of potentially useful microbial populations across different soil types and geographical regions of the district. The study demonstrates that arecanut rhizosphere soils of Shivamogga harbour diverse native fungal and bacterial bioinoculants and can serve as a valuable source for further screening and evaluation of promising microbial agents for biological management of arecanut diseases.

6. Acknowledgments

The work was undertaken as part of the M.Sc. research programme at Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, College of Agriculture, Navile, Shivamogga. I sincerely acknowledge the valuable guidance and support extended by the members of the advisory committee and express my gratitude to my seniors and friends for their constant encouragement and cooperation throughout my M.Sc. degree programme.

References

1. Chakrabarty R, Sarma TC. *In vitro* evaluation of bio-control agents and fungicides against *Ganoderma lucidum* causing basal stem rot of arecanut. Indian Phytopathol. 2017;70(3):336-340.
2. Chen K, Lin X, Wei X, Yin Y, Ye M, Yang S. Divergence in the tomato rhizosphere microbial community structure driven by three soil types. Microbiol Spectr. 2026;14(5).
3. Chowdappa P, Mohan Kumar SP, Hegde RK. Arecanut production and productivity enhancement strategies in India. Indian J Arecanut Spices Med Plants. 2014;16(3):5-11.
4. Compant S, Clement C, Sessitsch A. Plant growth-promoting bacteria in the rhizo- and endosphere of plants: their role, colonization, mechanisms involved and prospects for utilization. Soil Biol Biochem. 2010;42(5):669-678.
5. Gupta A, Gopal M, Thomas GV, Manikandan V, Gajewski J, Thomas G, *et al.* Whole genome sequencing and analysis of plant growth promoting bacteria isolated from the rhizosphere of plantation crops coconut, cocoa and arecanut. PLoS One. 2014;9(8).
6. Indiastat. Selected state/season-wise area, production and productivity of arecanut in India (2024-2025). 2025.
7. Khattak AA, Chen X, AbdAlamer IS, Tomah AA, Hussein RA, Al Farraj DA, *et al.* Isolation and characterization of *Bacillus velezensis*: investigating its mechanisms as an effective biocontrol agent against

- Verticillium* wilt in eggplants. *Front Sustain Food Syst.* 2025;9:1581883.
8. Mohan M, Girija D, Surendra Gopal K, Sureshkumar P. Microbial insight into rhizosphere of arecanut palms of Wayanad using metagenomics. *J Plant Crops.* 2019;47(3):189-196.
 9. Pal KK, Gardener BM. Biological control of plant pathogens. *Plant Health Instr.* 2006.
 10. Paulraj S, Bhat R, Rajesh MK, Ramesh SV, Priya UK, Pandian RTP, *et al.* Data of 16S rRNA gene amplicon-based metagenomic signatures of arecanut rhizosphere soils in Yellow Leaf Disease (YLD) endemic region of India. *Data Brief.* 2021;38:107443.
 11. Pimentel D. Environmental and economic costs of the application of pesticides primarily in the United States. *Environ Dev Sustain.* 2005;7(2):229-252.
 12. Reddy MA, Kumar CA. Disease scenario in arecanut and their management strategies. *Plant Health Prog.* 2021;22(2):125-134.
 13. Sharma KK, Singh US. Cultural and morphological characterization of rhizospheric isolates of fungal antagonist *Trichoderma*. *J Appl Nat Sci.* 2014;6(2):451-456.
 14. Waksman SA. Principles of soil microbiology. Baltimore: Williams & Wilkins; 1927. 897 p.
 15. Zhang N, Ma Z, Li D, Ni H, Sun B, Liang Y. Soil pH filters the association patterns of aluminum-tolerant microorganisms in rice paddies. *mSystems.* 2022;7(1).