PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(1): 1–5
https://doi.org/10.14719/pst.4286

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Effect of coconut consortia on coconut basal stem rot disease

Kavitha K[1]*, Selvarani A[1], Nazreen Hassan S[1], Suresh S[1], Preetha G[2] & Suganya Kanna S[3]

[1]ICAR-Krishi Vigyan Kendra, Thirupathisaram 629 901, Kanyakumari District, Tamil Nadu, India

[2]Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu India

[3]Horticultural College and Research Institute, Periyakulam 625 604, Tamil Nadu, India

*Email: kavithak@tnau.ac.in

OPEN ACCESS

ARTICLE HISTORY
Received: 07 July 2024
Accepted: 01 October 2024
Available online
Version 1.0 : 30 December 2024
Version 2.0 : 06 January 2025
Version 3.0 : 27 January 2025

Check for updates

Additional information
Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

Copyright: © The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited (https://creativecommons.org/licenses/by/4.0/)

CITE THIS ARTICLE
Kavitha K, Selvarani A, Nazreen HS, Suresh S, Preetha G, Suganya KS. Effect of coconut consortia on coconut basal stem rot disease. Plant Science Today. 2025; 12(1): 1-5 . https:/doi.org/10.14719/pst.4286

Abstract

Coconut is an important plantation crop in India. Many diseases severely impact coconut trees in the current climate change scenario, declining the vigor and yield of palms and deteriorating the quality of nuts on the trees. Basal stem rot caused by *Ganoderma* spp. is one of the most destructive diseases of coconut. *Ganoderma* can endure an extended period in the soil as a soil-borne pathogen. Chlamydospores are formed under unfavourable conditions, helping the pathogen's survival and spread of the disease. Rain and irrigation water also contribute to the spread from one field to another. This study assessed coconut consortia's efficiency in combating the basal stem rot disease at the field level. The experimental trial was conducted at Tittuvillai village of Thovalai panchayat, Kanyakumari district, from 2021-2022 to 2023-2024 for three consecutive years with four treatments and seven replications. The palms exhibiting the typical symptom were selected and the experiment was started in 2021. A total of 28 palms displaying basal stem rot symptoms were randomly selected for the experiment. Four treatments were imposed, and the details of treatments include T1: Drenching of Coconut consortia (TNAU Cococon) @ 2 liters/palm along with application of mycorrhizae @ 100 g/palm at quarterly interval, T2: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm and root feeding with hexaconazole (0.2%) at quarterly interval, T3: Drenching of Bordeaux mixture 1% and T4: Control (Untreated). Among the four treatments, soil drenching of coconut consortia (TNAU Cococon) @ 2 liters/palm followed by root feeding with hexaconazole (0.2%) at quarterly intervals effectively reduced the disease index from 21.74 to 15.96 and enhanced nut yield from 67.14 to 90.00 nuts per palm per year in three years under field conditions.

Keywords

coconut; biocontrol; crop protection; plant diseases; microbial consortia

Introduction

In India, coconut is a crucial plantation crop. Due to the multiple commercial use of all plant parts, it is called "Kalpavriksha". Many diseases severely impact coconut trees in the current climate change scenario. These diseases not only decline the vigor and yield of palms but also deteriorate the quality of nuts on the trees. The most destructive fungal diseases that affect coconuts are leaf blight, grey leaf spot, bud rot, stem bleeding disease and basal stem rot.

Basal stem rot disease (*Ganoderma lucidum* and *G. applanatum*) is the most devastating disease, limiting coconut productivity in south India and causing severe yield loss. The incidence has been reported to reach up to 31% in coastal regions traditionally known for farming coconuts (1). Numerous palms, including avenue trees and forest trees, are affected by it. Coconut palms between 10 and 30 years are more susceptible to infection. The pathogen first infects the root system, making diagnosing early based on morphological signs impossible. The first noticeable sign of the disease is the exudation of viscous reddish-brown liquid from the basal parts of the stem. This is followed by discolouration of the stem, internal rotting that progresses to the point where bleeding occurs in the affected palm, yellowing of leaves, decrease in nut size and yield, sporophores being produced, shriveling of the stem and ultimately, the death of the tree.

Ganoderma can endure an extended period in the soil as a soil-borne disease. Chlamydospores are formed in unfavourable conditions, helping the pathogen's survival and spread of the disease. Rain and irrigation water also contribute to the spread from one field to another. Bio-control agents tend to be non-phytotoxic and ecologically safe as an alternative for managing deadly soil-borne diseases. Numerous studies have shown that *Trichoderma* spp. are helpful bio-control agents against various phytopathogens. The coconut pathogens *G. applanatum*, *G. lucidum* and *Thielaviopsis paradoxa* were successfully combated by the fungal bio-agents viz., *Trichoderma spp* (2). Application of neem cake in the soil at a rate of 5 kg per palm annually, along with *T. viride* at a rate of 250 g per palm per years and root feeding with hexaconazole at a rate of 1% per palm at quarterly intervals, effectively control the basal stem rot disease of coconut (3). An integrated management system that combined chemical and cultural control techniques for basal stem rot in coconuts significantly reduced the disease's ability to spread, improved plant vigor and nut yield and increased the colony-forming units of *Trichoderma viride* and *Pseudomonas flourescens* in the rhizosphere (4).

The application of cake formulation of *Trichoderma* was highly effective in managing stem bleeding disease in coconuts at the field level (5). *T. viride* Tv-16 isolate and *P. fluorescens*, Pf6 effectively inhibited the radial growth of the fungus *G. lucidum* (6). Management strategies were only shown to be successful when the disease was identified early. A single biocontrol agent's use may not be as consistent or effective in various situations. Combining more than two bioagents is essential to overcome these limitations, as they can work together and adapt to different environments (7). By changing the rhizosphere microbiota, the use of a consortium of strains of plant growth-promoting rhizobacteria, including *Bacillus cereus* AR156, *Bacillus subtilis* SM21 and *Serratia* sp. XY21, reduced sweet pepper disease (8). Seed bacterization using microbial consortia of *Pseudomonas aeruginosa* MBAA1, *Bacillus cereus* MBAA2, *Bacillus aeruginosa* MBAA1 and *Bacillus amyloliquefaciens* MBAA3 effectively controlled charcoal rot and stem rot in soybeans by production of ammonia, siderophore, and enzymes such as chitinase, cellulose and β-1,3 glucanase (9). Potato soft rot was efficiently suppressed by soaking tubers in a bacterial consortium consisting of *Serratia plymuthica* A294, *Enterobacter amnigenus* A167, *Rahnella aquatilis* H145, *Serratia rubidaea* H440 and *S. rubidaea* H469 by production of antibiotic compounds, biosurfactants and siderophores (10). KVK Kanyakumari conducted the current study to evaluate the effect of coconut consortia against basal stem rot disease by examining the effectiveness of a consortial formulation in farmer's fields through on-farm testing from 2021-2022 to 2023–2024. It is possible to increase the activity of biocontrol agents, particularly in response to changing environmental conditions, by combining different strains of microorganisms as consortia with multidirective mechanisms of disease suppression, such as antibiosis, competition or induction of plant resistance.

Materials and Methods

The trial was conducted at Tittuvillai village of Thovalai panchayat, Kanyakumari district, from 2021-2022 to 2023-2024 for three consecutive years. A total of 28 palms displaying basal stem rot symptoms were randomly selected for the experimental trial. Four treatments and seven replications were applied using a randomized block design.

T1: Drenching of Coconut consortia (TNAU Cococon) @ 2 liters/palm along with the application of mycorrhizae @ 100 g /palm at quarterly intervals.

T2: Drenching of Coconut consortia (TNAU Cococon) @ 2 liters/palm and root feeding with hexaconazole (0.2%) at quarterly interval

T3: Drenching of Bordeaux mixture 1%

T4: Control (Untreated)

Coconut consortia (TNAU Cococon) was obtained from the Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore. The disease index for all the palms was determined by calculating disease intensity using the formula (11).

Disease Index=23.6+17.7h+3.6r-0.6l

where, h- is the height of bleeding symptom on the stem (m), l is the number of functional leaves and r is the score for reduction in crown size on a 0 to 4 scale. Before enforcing the treatments, the initial disease index was recorded. Following the imposition of treatments, the disease index was documented regularly. The number of functional leaves and bleeding height were periodically observed. The disease index was analyzed at the ends of the first, second and third year and the nut yield for each treatment was recorded at harvest time.

Statistical Analysis

OP STAT software was used to analyze the data statistically.

Results and Discussion

The result of the effect of coconut consortia on basal stem rot disease in coconut is presented in Table 1. Before treatment imposition, all the plants showed a disease index in the range of 21.74 to 22.32 and there was no significant difference among the palms concerning disease index before treatment imposition. Among the four treatments, during 2021-22, Treatment (T2) with drenching of Coconut consortia followed by root feeding with hexaconazole with recommended dose of fertilizers reduced the lowest disease index of 17.95 whereas treatment T1 involving drenching of coconut consortia along

Table 1. Effect of Coconut consortia on basal stem rot disease index in coconut (2021-22 to 2023-24)

Treatments	Ganoderma Disease Index			
	Before treatment imposition	2021-22	2022-23	2023-24
T1: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm along with application of mycorrhizae @ 100 g /palm at quarterly interval	21.87	20.21	20.10	19.67
T2: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm and root feeding with hexaconazole (0.2%) at quarterly interval	21.74	17.95	16.34	15.96
T3: Drenching of Bordeaux mixture 1%	21.86	21.10	25.95	28.73
T4: Control (Untreated)	22.32	27.05	29.57	31.26
CD (0.05)	NS	5.959	4.346	3.703
SEM		1.990	1.452	1.237

with VAM and recommended dose of fertilizers recorded disease index of 20.21. Treatment T3 involving drenching Bordeaux mixture 1% recorded a disease index of 21.10, whereas the untreated control recorded a disease index 27.05. There is no significant difference among the treatments T2, T1 and T3 and they are on par concerning disease index, but a considerable difference was observed with T4.

During 2022-23, Treatment (T2) further reduced the disease index to 16.34, whereas Treatment T1 recorded a disease index 20.10. There is no significant difference among the disease index in treatment T2 and T1, but a significant difference was observed with T3 and T4. Treatment T3 recorded a disease index of 25.95, whereas the untreated control recorded a disease index of 29.57. During the third year, 2023-24, a disease index of 15.96 was recorded in Treatment (T2) and a significant difference was observed with T1, which recorded a disease index of 19.67. Treatment T3 recorded a disease index of 28.73, whereas the untreated control recorded a disease index 31.26.

The results of coconut consortia's effect on coconut nut yield are shown in Table 2. Nut yield per palm was recorded before treatment imposition in all the plants. The results revealed that the yield per palm was in the range of 67.14 to 68.57 and there was no significant difference among the palms with regard to yield before treatment imposition. Among the four treatments, during the first year (2021-22), Treatment (T2) recorded a higher nut yield of 80.71 nuts / palm/year and is on par with treatment T1 with a nut yield of 78.57 nuts/palm/year. Treatment T3 recorded a nut yield of 69.29 nuts/palm/year, whereas the untreated control recorded a yield of 65.00 nuts /palm/year. The treatment, T3 and T4, are on par with each other.

During the second year (2022-23), Treatment (T2) increased the nut yield per palm to 87.86 nuts /palm/year, whereas treatment T1 recorded a nut yield of 82.86 nuts / palm/year. The treatments T1 and T2 are on par with each other. Treatment T3 yielded 72.14 nuts /palm/year, whereas the untreated control recorded 57.14 nuts/palm/year. During the third year, 2023-24, the nut yield per palm was further increased to 90.00 nuts /palm/year in Treatment T2, followed by T1, which recorded a nut yield of 84.29 nuts /palm/year. Treatment T3 recorded 72.14 nuts /palm/year yield, whereas the untreated control recorded 51.43 nuts /palm/year.

Pooled analysis on observations from all four treatments performed from 2021-22 to 2023-24 on *Ganoderma* wilt disease index and yield is presented in Table 3. The pooled analysis data clearly showed that T2 treatment, with a drenching of Coconut consortia followed by root feeding with hexaconazole with a recommended dose of fertilizers, showed the lowest disease index of basal stem rot of 16.75±0.36 with a higher nut yield of 86.46±1.70 followed by T1 treatment involving drenching of coconut consortia along with VAM and recommended dose of fertilizers and T3 Treatment involving drenching of Bordeaux mixture 1% recorded disease index of 19.38±0.47 and 25.26±1.26 and nut yield of 82.07±1.34 and 71.63±1.04 respectively.

Table 2. Effect of Coconut Consortia on nut yield in coconut (2021-22 to 2023-24)

Treatments	Nut yield palm^{-1} year^{-1}			
	Before treatment imposition	2021-22	2022-23	2023-24
T1: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm along with application of mycorrhizae @ 100 g /palm at quarterly interval	68.57	78.57	82.86	84.29
T2: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm and root feeding with hexaconazole (0.2%) at quarterly interval	67.14	80.71	87.86	90.00
T3: Drenching of Bordeaux mixture 1%	68.57	69.29	72.14	72.14
T4: Control (Untreated)	68.57	65.00	57.14	51.43
CD (0.05)	**NS**	6.44	7.23	8.70
SEM		2.15	2.41	2.91

Table 3. Pooled analysis on field evaluation of Coconut consortia against Basal stem rot disease index and nut yield over three years (2021-22 to 2023-24)

Treatments	Ganoderma Disease index	Nut yield palm^{-1} year^{-1}
T1: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm along with application of mycorrhizae @ 100 g /palm at quarterly interval	19.38±0.47	82.07±1.34
T2: Drenching of Coconut consortia (TNAU Cococon) @ 2 litres/palm and root feeding with hexaconazole (0.2%) at quarterly interval	16.75±0.36	86.46±1.70
T3: Drenching of Bordeaux mixture 1%	25.26±1.26	71.63±1.04
T4: Control (Untreated)	29.29±1.68	58.10±0.99

Means of pooled data of Ganoderma disease index ± Standard errors and Nut yield palm-1 year-1± Standard errors are shown.

Endophytic bacteria are internal colonizers with a greater capacity to compete within vascular networks, limiting Ganoderma's access to nutrients and space during its growth. Endophytic bacteria are introduced to the roots to manage plant disease. This modifies the native bacterial communities of the roots and increases their ability to suppress soil-borne diseases. As a result, their use should be preferred over other biological control agents. The Coconut Consortia (TNAU cocoon) is a mixture of seven isolates of *Bacillus* sp. involved in nutrient mobilization and immune booster development. Drenching coconut consortia (Cococon) followed by root feeding with hexaconazole at quarterly intervals was more effective when the application was carried out at earlier stages of disease development. Ganoderma wilt was shown to be significantly suppressed by an IDM package comprising a combination of *T. viride* and neem cake (12). The stage of disease development, availability of suitable bioagents and appropriate agronomic practices all influenced the treatment effect.

Consortial strains of plant growth-promoting rhizobacteria *viz., B. cereus*, *B. subtilis* and *Serratia* sp. as seedling treatment significantly reduced sweet pepper *Phytophthora* blight disease (8). Seed treatment with microbial consortia of *Pseudomonas aeruginosa*, *B. cereus*, *B. aeruginosa* and *B. amyloliquefaciens* effectively controlled charcoal rot and stem rot in soybeans (9). Potato soft rot was efficiently suppressed by soaking tubers in bacterial consortium consisting of *Serratia plymuthica*, *Enterobacter amnigenus*, *Rahnella aquatilis*, *Serratia rubidaea* and *S. rubidaea* (10).

According to earlier studies, combining two biocontrol agents increased disease control suppression. The disease index was successfully lowered under field conditions over three years by applying a talc-based formulation to the soil containing *T. reesei*, *P. fluorescens* and neem cake (13). Using multiple biocontrol agents is a dependable way to reduce variability and boost biological control reliability. Compared to individual treatment, the soil application of endophytic bacteria with FYM significantly prevented the bleeding symptoms in coconut palms and increased nut yield (14). Palms treated with a mixture of two antagonists (*P. fluorescens* + *T. viride*) suppressed *Ganoderma* disease development in coconut (15). Root feeding of tebuconazole followed by soil drenching with Bordeaux mixture and application of Neem cake enriched with *T. viride* and *P. fluorescens* lowered the disease index with maximum nut yield (16).

Conclusion

The integrated disease management package comprising of drenching of coconut consortia (TNAU Cococon) @ 2 liters/ palm followed by root feeding with hexaconazole (0.2%) at quarterly intervals with the recommended dose of fertilizers effectively managed the basal stem rot disease of coconut as revealed by the decline in disease index with an increase in yield from first year onwards. The application of Coconut consortia (TNAU Cococon) in the soil facilitates an increase in the soil population of the organism and enhances nutrient mobilization, which ultimately improves production and productivity. Research on the relationships between coconut consortia and their hosts is vital since many strains have been involved in biological plant protection, with a focus on inducing natural defenses in plants. The availability of biocontrol products through microbial consortia is expected to rise in the future, yet the details of the registration process continue to be unclear.

Acknowledgements

The Research was supported by ICAR-ATARI, Zone X, CRIDA campus, Hyderabad.

Authors' contributions

KK, SA and NHS conducted the research deign participated in data collection and drafted the manuscript; KK, PG and SKS performed the statistical data analysis; KK and SS involved in preparation and alignment of data. All authors read and approved the final manuscript.

Compliance with ethical standards

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

Ethical issues: None

References

1. Bhaskaran R, Ramanathan T. Occurrence and spread of Thanjavur wilt disease of coconut. Indian Coconut Journal. 1984;15(6):12-14.
2. Srinivasulu B, Nagamalleswari Y, Aruna K, Lakshmi MV, Kumar KVK, KrishnaSri M. Scanning electron microscopy confirmation of mycoparasitism exhibited by *Trichoderma* spp. on coconut pathogens, *G. applanatum, G. lucidum* and *T. paradoxa.* Current Trends in Biotechnology and Pharmacy. 2008;2:562-67.
3. Meena B, Jeyalakshmi V. Integrated management of basal stem rot disease of coconut. Journal of Plantation Crops. 2006;34(3):504-05. https://doi.org/10.19071/jpc.2016.v44.i1.3017
4. Rajappan K, Vaithilingam R. Efficacy of integrated disease management technologies in the management of basal stem rot disease in coconut. Indian Coconut J. 2009;52(5):18-22.
5. Neeraja B, Snehalatharani A, Chalapathi Rao NBV, Ramanandam G. Studies on different formulations of the bioagent *Trichoderma* in the management of stem bleeding disease in coconut. Journal of Plantation Crops. 2020;48(1):55-59.
6. Ranjana C, Sarma TC. *In vitro* evaluation of bio-control agents and fungicides against *Ganoderma lucidum* causing basal stem rot of arecanut. Indian Phytopath. 2017;70(3):336-40. https://epubs.icar.org.in/ejournal/index.php/IPPJ/article/view/74240
7. Atef NM. *Bacillus subtilits* and *Trichoderma harzianum* as wheat inoculants for biocontrol of *Rhizoctonia solani*. Aust J Basic Appl Sci. 2008;2(4):1411-17. https://ajbasweb.com/old/ajbas/2008/1411-1417.pdf
8. Zhang LN, Wang DC, Hu Q, Dai XQ, Xie YS, Li Q. Consortium of plant growth-promoting rhizobacteria strains suppresses sweet pepper disease by altering the rhizosphere microbiota. Front Microbiol. 2019;10:1668. https://doi.org/10.3389%2Ffmicb.2019.01668
9. Thakkar A, Saraf M. Development of microbial consortia as a biocontrol agent for effective management of fungal diseases in *Glycine max* L. Arch Phytopathol Plant Prot. 2014;48:459-74. https://doi.org/10.1080/03235408.2014.893638
10. Maciag T, Krzyzanowska DM, Jafra S, Siwinska J, Czajkowski R. The great five-an artificial bacterial consortium with antagonistic

activity towards *Pectobacterium* spp. and *Dickeya* spp.: formulation, shelf life and the ability to prevent soft rot of potato in storage. *Appl Microbiol Biotechnol.* 2020;104:4547-61. https://doi.org/10.1007/s00253-020-10550-x

11. Bhaskaran R, Rethinam P, Nambiar KKN. Thanjavur wilt of coconut. Journal of Plantation Crops. 1989;17(2):69-79.
12. Snehalatharani A, Chalapathi Rao NBV, Ramanandam G, Maheswarappa HP, et al. Bio-control based integrated disease management of basal stem rot disease of coconut. Journal of Plantation Crops. 2016;44(1):62-66. https://doi.org/10.19071/jpc.2016.v44.i1.3017
13. Neeraja B, Snehalaltha Rani A, Chalapathi Rao NBV, Bhagavan BVK. Early detection and integrated disease management against coconut basal stem rot disease. IOP Conf Ser: Earth Environ Sci; 2023.1179:012004. https://iopscience.iop.org/article/10.1088/1755-1315/1179/1/012004/meta
14. Rajendran L, Karthikeyan G, Raguchander T, Samiyappan R. Effect of endophytic bacteria *Bacillus subtilis* EPC 5 on basal stem rot disease spread and nut yield in coconut plantations. Journal of Applied Horticulture. 2018;20(3):207-12. https://horticultureresearch.net/jah/2018_20_3_207_212.PDF
15. Karthikeyan M, Radhika K, Bhaskaran R, Mathiyazhagan S, Velazhahan R. Rapid detection of *Ganoderma lucidum* and assessment of inhibition effect of various control measures by immunoassay and PCR. African J Biotechnol. 2009;8(10):2202-08. https://www.ajol.info/index.php/ajb/article/view/60556
16. Palanna KB, Narendrappa T. Integrated disease management of *Ganoderma* wilt of coconut in dry tracts of Southern Karnataka. Mysore J Agric Sci. 2016;50(2):416-20. https://www.uasbangalore.edu.in/images/2016-2st-Issue/56.pdf