https://doi.org/10.56975/ijcrt.v13i8.292475

IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Recent Advances In Management Of Basal Stem Rot Of Coconut In Coastal Agro Ecosystem Of Andhra Pradesh

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Abstract

Basal stem rot (*Ganoderma* wilt) disease caused by *Ganoderma* spp is the most destructive disease of coconut. Described detailed basal stem rot (BSR) disease symptoms on coconut palm. BSR pathogens *Ganoderma applanatum* (Pers) Pat and *G.lucidum* (Leys.) Karst was isolated from brackets and tissues of root and stem of coconut. Different management practices including cultural methods, chemical control and also biological control of the basal stem rot disease induced by *Ganoderma* spp, were reviewed in this chapter. Detailed investigations in the biological control of this disease were carried out. *In vitro* studies revealed that the native biocontrol agents *viz.*, *Trichoderma viride*, *T.harzianum* and *T.hamatum* were very effective in checking the radial growth of both the *Ganoderma* spp as well as in the production specific volatile and non-volatile metabolites that are antagonistic to the basal stem rot disease pathogens. All the three *Trichoderma* spp, were found to check the basal stem rot disease of coconut at field level effectively when applied at the rate of 50 gms of talc powder formulation in conjunction with 5 kg neem cake per palm/year. Based on the results, an integrated disease management with biological control as key component was formulated to combat the disease at field level. The formulated IDM strategy against BSR of coconut include application of 50g of talc powder formulation of *T.viride* along with 5 kg neem cake /tree/ annum for a continuous period of over three years besides other cultural practices.

https://doi.org/10.56975/ijcrt.v13i8.292475

Key words: Basal stem rot, *Ganoderma* spp., Fungicides, Biocontrol, *Trichoderma* spp & Coconut.

Introduction

Coconut, *Cocos nucifera* Linn. is known as "KALPAVRIKSHA" in view of its enormous contribution to the mankind. Every part of plant is having one or the other uses. *Ganoderma* spp. infects the coconut causes wilts or rots in palms (Plate-1&2). Basal stem rot or *Ganoderma* wilt is a major problem in Andhra Pradesh (Bhaskaran *et.al.*, 1984 a; Satyanarayana *et.al*., 1985; Wilson *et.al*., 1987; and Srinivasulu *et.al*., 2001a) This perennial palm though known for its adoptability to different soil conditions, moisture stress and vagaries of climate, is often subjected to attack by plant pathogens causing various diseases (Henry Louis, 2002). The biological control agent (BCA), *Trichoderma* sp., reduced illness in oil palm (Naher *et. al*.2018). Garrett (1955) reported that *Trichoderma viride* and *Streptomyces* spp were antagonistic to *G.lucidum*. Srinivasulu *et.al.*, (2002b) reported that *Trcihoderma* spp *viz.*, *Trichoderma viride* Per., *T.harzianum* Rifai, and *T.hamatum* (Bun.) Application of *Trichoderma viride* and *P.fluorescens* talk formulations at the rate of 200g each /palm in combination with 50kg FYM found effective against the disease (Karthikeyan *et.al.*, 2005). Although several researchers have reported various practices for managing basal stem rot disease, the results are inconsistent, and limited research has been conducted on the in vitro efficacy of *Ganoderma* species in coconut. Addressing this gap in the existing literature, the present investigation was undertaken.

Plate-1: Basal stem rot disease symptoms on coconut palm

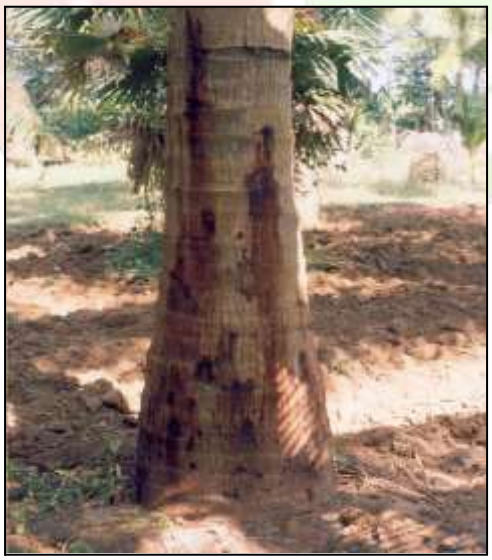

Plate-2: *Ganoderma* spp brackets

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Materials and Methods

Isolation and Identification of rhizosphere antagonistic mycoflora

Soil dilution and plate count method was used for isolation of antagonistic mycoflora from the rhizosphere of coconut palms. Soil samples were collected from different coconut gardens of coastal agro ecosystem of Andhra Pradesh. The collected samples were subjected to serial dilutions using sterile distilled water. A 0.5 ml aliquot of each sample, at 10–3 and 10–4 dilutions, was spread onto petri dishes containing Trichoderma-specific medium (TSM) (Elad and Chet, 1983). Two plates were prepared for each dilution. The plates were incubated at 28°C and examined after four days. The hyphal tip method was then used to obtain pure cultures of these organisms. The isolated antagonistic fungi were identified up to the level of genus or species by Rifai (1969).

Screening of antagonistic effect of *Trichoderma* spp (Gams *et.al.,* 1980)

Antagonistic effect of *Trichoderma* spp on *Ganoderma* spp under *in vitro* conditions

The native *Trichoderma* spp isolates were screened for antagonistic activity in vitro against *Ganoderma appalnatum* and *G. lucidum* on PDA using the dual culture technique. Discs (8mm in diameter) of 3-day-old agar cultures of both pathogen and the antagonistic fungi were placed at opposite ends of petri dish containing PDA. A control plate with only test fungus disc was simultaneously maintained. The petri-plates were incubated at 29 ± 1^{o}c for 7 days and the ability of the antagonist to inhibit the pathogen was recorded by periodic observation. The percent growth reduction was calculated.

Effect of volatile metabolites of *Trichoderma* spp on *Ganoderma* spp

Production and inhibitory effect of volatile antibiotics by the antagonists were tested against the test pathogen by using procedure given by Dennis and Webster (1971). The antagonists were grown on PDA for a period from 0 to 25 days and its effect on growth of *G.applanatum* and *G.lucidum* was tested by exposing inverted plates of freshly inoculated test pathogens to plates containing antagonistic cultures and sealing together by cello tape. The pathogen growth was measured after 4 days on incubation at 29 ± 1^{o}c and percent inhibition was calculated.

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Effect of non-volatile metabolites of *Trichoderma* spp on *Ganoderma* spp The antagonists that exhibited inhibition in the dual culture studies were cultured in potato dextrose broth to test the effect of their culture filtrates (non-volatile antibiotics) on the test pathogen, using the poisoned food technique (Khara and Hadwan, 1990). The culture filtrates were sterilized by autoclaving at 15 PSI for 15 minutes. The sterilized filtrate was then incorporated into the medium at various concentrations (10%, 20%, 50%, and 100%) to assess its effect on fungal growth and inhibition. The PDA medium mixed with the filtrate was poured (20 ml per plate) into sterilized petri dishes, which were then inoculated with fresh discs of the test pathogens, *G. applanatum* and *G. lucidum*. The percentage of inhibition was subsequently calculated.

Field efficacy of bioagents on Basal Stem Rot disease

Field experiments were conducted at multiple locations in Gannavaram, East Godavari district of Andhra Pradesh, where basal stem rot disease incidence was severe. Two field trials were carried out with two replicates each during the period of January –December 2019-20 and 2020-21 to evaluate the efficacy of fungicides and bioformulations of *Trichoderma* spp individually against basal stem rot disease. The disease index for basal stem rot was assessed.

Results and Discussion

Isolation and Identification of antagonistic rhizosphere mycoflora

Trichoderma spp were isolated from rhizosphere of healthy coconut palms existing in different soils of Coastal Agro Ecosystem of Andhra Pradesh. The isolated antagonistic mycoflora were identified up to genus and species level as the case may be on the basis of growth, color, phialides characters produced by them on PDA. The identified *Trichoderma* spp are *T.viride* Pers. Fr, T.*harzianum* Rifai, *T.hamatum* (Bon.) Bain., *T.longibrachiatum* Rifai, *T.virens* Miller and *T.polysporum* Rifai.(Plate-3)

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Plate-3: Native *Trichoderma* spp

Antagonistic effect of *Trichoderma* spp on *Ganoderma* spp under *in vitro* conditions

It is evident from the data that six species of native isolated *Trichoderma viz., T.viride, T.harzianum, T.hamatum, T.longibrachiatum, T.virens* and *T.polysporum* were screened for their antagonistic activity on *Ganoderma applanatum* and *G.lucidum* by dual culture technique. In dual culture technique, all six isolated native *Trichoderma* spp were found inhibitory to the mycelial growth of *G.applanatum* and *G.lucidum* on PDA under *in vitro* conditions (Table-1). The percent inhibition by *Trichoderma* spp on *Ganoderma* spp ranged between 58.18% to 84.62% (Plate-4,5,6&7). The maximum per cent inhibition of mycelial growth of *Ganoderma* spp by *T.harzianum* (81.81% to 84.61%) followed by *T.hamatum* (72.72 to 76.92), *T.longibrachiatum* (69.10 to 75.38), *T.virens* (65.45 to 67.69), *T.viride* (63.63 to 84.62) and *T.polysporum* (58.18 to 61.54) (Table-1). Biological control agents (BCAs) are becoming more popular as a potential replacement for chemical fungicides for controlling BSR in oil palm fields (Sujarit *et.al*. 2020). Earlier workers reported that *T.harzianum* and *T.viride* found to be antagonistic to *G.lucidum* (Bhaskaran, 1990) Badalyan *et.al.,* (2004) reported that *Ganoderma* spp showed the highest competitive ability against mycoparasitic fungi *viz., T.harzianum, T.pseudokonigii & T.viride*. *Trichoderma* strains are among the most studied fungal biocontrol agents and are successfully used as biopesticides and biofertilizers in greenhouse and field plant production (Haraman *et al*., 2004).

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https://doi.org/10.56975/ijcrt.v13i8.292475

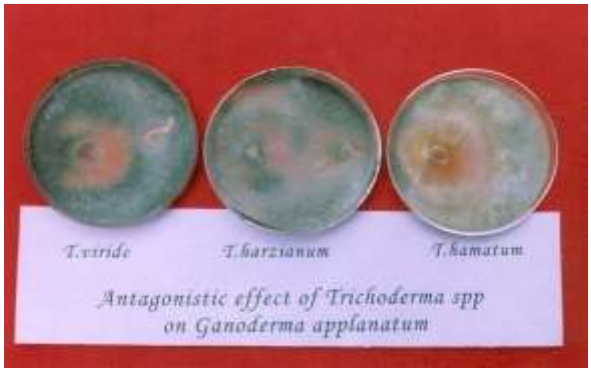

Plate-4 & 5: Antagonistic effect of *Trichoderma* spp on *G.applanatum*

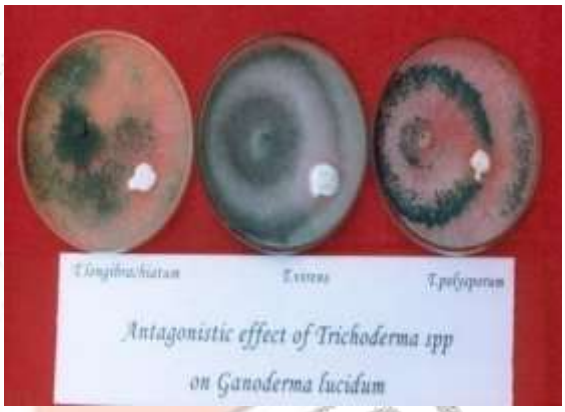

Plate-6 & 7: Antagonistic effect of *Trichoderma* spp on *G.lucidum*

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Table-1: Antagonistic effect of *Trichoderma* spp on *Ganoderma* spp under *in vitro* conditions

Antagonistic Fungi (*Trichoderma* spp)		*G.applanatum*		*G.lucidum*		Mode of action		Remarks
		Mycelial growth (mm)	Percent inhibition	Mycelial growth (mm)	Percent inhibition	Mycopa-ra sitism (+ or -)	Anti-biosis (+ or -)	
1.	*T.viride*	20.0	63.63[d]	10.0	84.62[a]	–	+	Yellow halo disappeared after six days
2.	*T.harzianum*	10.0	81.81[a]	10.0	84.61[a]	+	–	Complete mycoparasitism
3.	*T.hamatum*	15.0	72.72[b]	15.0	76.92[a]	+	–	Prtial mycoparasitism
4.	*T.longibrachiatum*	17.0	69.10[c]	16.0	75.38[a]	–	+	Inhibition zone observed
5.	*T.virens*	19.0	65.45[d]	21.0	67.69[c]	+	–	Complete mycoparasitism
6.	*T.polysporum*	23.0	58.18[e]	25.0	61.54[d]	+	–	Complete mycoparasitism
7.	Control	55	--	65	--	--	--	--

+ Present: - Absent

*Numbers in each column followed by the different letter are significantly different. Values represent the means of 6 replicates.

https://doi.org/10.56975/ijcrt.v13i8.292475

Effect of volatile metabolites of *Trichoderma spp* on *G.applanatum*

Production and inhibitory effect of volatile metabolites of native *Trichoderma* spp viz., *T.viride, T.harzianum, T.hamatum, T.longibrachiatum, T.virens and T.polysporum* were tested against Ganoderma applanatum on PDA under in vitro conditions and the results are presented in Table-2. The mycelial growth of *G.applanatum* was suppressed when exposed to zero day old cultures followed by 15 day old cultures of all the six species of *Trichoderma*. The mycelial growth ranged from 7.0 to 11.5 mm and 9.5 to 10.5 mm in zero and 15 day old cultures respectively. Among the *Trichoderma s*pp, the highest percent inhibition was 50, 32.14 and 28.57% in case of *T.polysporum* at zero, 15 and 25 day old cultures respectively followed by *T.longibrachiatum* (39.28, 42.87 and 25%) and *T.hamatum* (35.72, 25.00 and 17%) at three stages of exposure (Table-2).

Table-2: Effect of volatile metabolites of *Trichoderma* spp on G.*applanatum* under *in vitro* conditions

Antagonistic fungi (*Trichoderma* spp)	Mycelial growth of *Ganoderma applanatum* Age of antagonist (days)					
	0		15		25	
	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition	Mycelial growth	Percent Inhibition
T.viride	11.5	17.85^{e}	10.5	25.00^{d}	11.0	21.42^{c}
T.harzianum	7.5	46.42^{b}	10.0	28.57^{c}	12.0	14.28^{e}
T.hamatum	9.0	35.72^{d}	10.5	25.00d	11.5	17.85^{d}
T.longibrachiatum	8.5	39.28^{c}	8.0	42.87^{a}	10.5	25.00^{b}
T.virens	9.5	32.14^{d}	10.0	28.57^{c}	12.0	14.28^{e}
T.polysporum	7.0	50.00^{a}	9.5	32.14^{b}	10.0	28.57^{a}
Control	14	--	14	--	14	--

* Numbers in each column followed by the different letters are significantly different. Values represent the means of 6 replicates

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Effect of volatile metabolites of *Trichoderma* spp on *G. lucidum*

Inhibition by volatile metabolites of all the six species of *Trichoderma* was tested on *G.lucidum* on PDA under in vitro conditions (Table-3). The zero, 15 and 25 day old cultures of all the six species of *Trichoderma* were found to be inhibitory to mycelial growth of *G.lucidum.* The maximum mycelial growth inhibition was recorded when exposed to zero day old cultures than 15 & 25 day old culture of all the six species of *Trichoderma*. Among the *Trichoderma* spp, the maximum percent inhibition was recorded with *T.viride* 67.66, 59.45 and 40.54% at zero day, 15 day and 25 day old cultures respectively in *G.lucidum* and followed by *T.longibrachiatum* (67.56, 51.35 and 32.43%) and *T.hamatum* at three stages of exposure (Table-3). The percent inhibition ranged 27.02 – 67.56 in *T.harzianum, T.virens* and *T.polysporum* at three stages of exposure. Antagonism of *Trichoderma* spp is mediated by specific or non-specific metabolites of microbial origin viz., lytic enzymes, volatile compounds or other toxic substances (Narasimha Rao & Kulakarni 2003). *Trichoderma* strains viz., T22 produced secondary metabolite azaphilone against *R.solani, Pythium ultimum, G. graminis var. tritici* and T39 produced butenolide against *R.solani in vitro* (Vinale et al., 2006).

Table-3: Effect of volatile metabolites of *Trichoderma* spp on *G.lucidum* under in vitro conditions

Antagonistic fungi (*Trichoderma* spp) Mycelial growth	***Mycelial growth of Ganoderma lucidum* Age of antagonist (days)**					
	0		**15**		**25**	
		Percent inhibition	**Mycelial growth**	**Percent inhibition**	**Mycelial growth**	**Percent inhibition**
T.viride	6.0	67.56[a]	7.5	59.45[a]	11.0	40.54[a]
T.harzianum	6.5	64.86[b]	12.5	32.43[e]	13.5	27.02[c]
T.hamatum	6.0	67.56[a]	10.0	45.94[c]	12.0	35.13[b]
T.longibrachiatum	6.0	67.56[a]	9.0	51.35[b]	12.5	32.43[b]
T.virens	7.0	62.16[b]	10.0	45.94[c]	11.5	37.83[b]
T.polysporum	6.0	67.56[a]	11.0	40.54[d]	13.0	29.72[c]
Control	**18.5**	--	**18.5**	--	**18.5**	--

* Numbers in each column followed by the different letter are significantly different. Values represent the means of 6 replicates

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Effect of non-volatile metabolites of *Trichoderma* spp on *G.applanatum* under *in vitro* conditions

The culture filtrates of all the six species of *Trichoderma viz., T.viride, T.harzianum, T.hamatum, T.longibrachiatum, T.virens* and *T.polysporum* at 10, 20, 50 and 100% concentrations were suppressive to the mycelial growth of *G.applanatum* on PDA under *in vitro* conditions (Table-4). The maximum mycelial growth inhibition was recorded at 100% culture filtrates of all six species of *Trichoderma*. The mycelial growth ranged from 6 to 11.50 mm in *G.applanatum.* Among the six species of *Trichoderma* screened, the maximum percent inhibition in mycelial growth of *G.applanatum* was recorded with culture filtrate of *T.viride* (57.14%) followed by *T.polysporum* (41.07%), *T.virens* (30.35) and *T.hamatum* (30.35) at 100% concentration (Table-4).

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Table-4: Effect of non-volatile metabolites of *Trichoderma* spp on *G.applanatum* under *in vitro* conditions

Mycelial growth of Ganoderma applanatum

Antagonsit fungi (*Trichoderma* spp)	Culture filtrate concentration of antagonist (%)							
	10		20		50		100	
	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition
T.viride	13.00	7.14^{c}	10.00	28.57^{a}	8.00	42.85^{a}	6.00	57.14^{a}
T.harzianum	11.50	17.85^{b}	12.50	10.71^{e}	11.00	21.42^{c}	11.50	17.85^{d}
T.hamatum	11.25	19.64^{b}	12.50	10.71^{e}	13.25	5.35^{d}	9.75	30.35^{c}
T.longibrachiatum	10.75	23.21^{a}	12.00	14.28^{d}	12.75	8.92^{d}	10.00	28.57^{c}
T.virens	11.25	19.64^{b}	11.50	17.85^{c}	11.00	21.42^{c}	9.75	30.35^{c}
T.polysporum	11.50	17.85^{b}	11.00	21.42^{b}	9.00	35.71^{b}	8.25	41.07^{b}
Control	**14**	**--**	**14**	**--**	**14**	**--**	**14**	**--**

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https://doi.org/10.56975/ijcrt.v13i8.292475

Effect of non-volatile metabolites of *Trichoderma* spp on *G.lucidum* under *in vitro* condition

Production of non-volatile metabolites of all the six species of *Trichoderma viz., T.viride, T.harzianum, T.hamatum, T.longibrachiatum, T.virens* and *T.polysporum* at 10, 20, 50 and 100% concentrations were tested on *G.lucidum* on PDA under *in vitro* conditions (Table-5). The culture filtrates of all six species of *Trichoderma* were suppressive to the mycelial growth of *G.lucidum*. The maximum mycelial growth inhibition was recorded at 100% culture filtrate of all the six species of *Trichoderma* and the mycelial growth being ranged from 8 – 14.25 mm in *G.lucidum.* The highest percent inhibition was observed with *T.viride* (36.75%) followed by *T.polysporum* (40.54) and *T.longibrachiatum* (25.67) at 100% concentration culture filtrate. The percent inhibition ranged from 6.75 to 25.67% in *T.harzianum, T.hamatum* and *T.virens* at 10, 20, 50 and 100% culture filtrate (Table-5).

A positive correlation was observed between an increase in the concentration of the culture filters of all six *Trichoderma* spp and the per cent inhibition in mycelial growth of test pathogens. Similar correlations were obtained between the increase in concentration of the culture filtrate of *T.harzianum* and inhibition of *Pythium aphanidernatum a*nd *P.myriothium* on tobacco by Devaki *et.al.* (1992). Several works reported the inhibitory effects of non-volatile substances produced by *Trichoderma* spp on several soil borne plant pathogens (Dennis and Webster, 1971, Upadhya and Muckhopadhya, 1983; Mathur and Bhatnagar, 1994*).*

https://doi.org/10.56975/ijcrt.v13i8.292475

Table-5: Effect of non-volatile metabolites of *Trichoderma* spp on *G.lucidum* under *in vitro* conditions

Mycelial growth of *Ganoderma lucidum*

Antagonsit fungi (*Trichoderma* spp)	Culture filtrate concentration of antagonist (%)							
	10		20		50		100	
	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition	Mycelial growth	Percent inhibition
T.viride	14.75	20.27^{c}	8.00	56.75^{a}	8.00	56.75^{a}	8.00	56.75^{a}
T.harzianum	17.25	6.75^{e}	17.76	4.00^{e}	15.75	14.86^{b}	15.50	16.21^{d}
T.hamatum	15.75	14.86^{d}	16.50	10.81^{d}	18.00	13.51^{b}	15.00	18.91^{d}
T.longibrachiatum	14.00	24.32^{b}	15.50	16.21^{c}	17.00	8.10^{c}	13.75	25.67^{c}
T.virens	13.75	25.67^{b}	15.00	18.91^{b}	16.75	9.45^{c}	14.25	22.97^{c}
T.polysporum	12.50	32.43^{a}	14.50	21.62^{b}	17.25	6.75^{c}	11.00	40.54^{b}
Control	**18.50**	**--**	**18.50**	**--**	**18.50**	**--**	**18.50**	**--**

* Numbers in each column followed by the different letter are significantly different. Values represent the means of 6 replicates.

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Field efficacy of fungicides on BSR

Field experiments were conducted during the years 2019-20 and 2020-21 to evaluate the efficacy of fungicide Tridemoph along with neem cake to manage the basal stem rot disease in coconut. The data indicated that root feeding with 2 percent Hexaconazole + 5kg neem cake/palm/year reduced mean disease index to maximum extent (25.55) followed by 1 percent Hexaconazole + 5kg neem cake (32.41). Control palm recorded mean disease index of 48.80 (Table-6). Second year data confirms the results achieved during the first year, though the disease spread as more. Hexaconazole and dazomet were successfully delivered to *G. boninense* cells using a nano delivery system that used chitosan nanoparticles as the carrier for the fungicides. Low phytotoxicity and high activity against the pathogen were displayed by the nano delivery system in oil palm (Malutin *et.al.* 2019a; Malutin *et.al.* 2019b). Bhaskaran and Ramanathan(1982); Bhaskaran *et.al.*, (1984b) reported that drenching the soil with 40 lt of 1 percent bordeaux mixture and stem injection of Aureofungin Sol 2 g + 1 g copper sulphate in 100 ml of water thrice at quarterly intervals significantly reduced the disease intensity and increased the yield of nuts. Neem cake extract, banana rhizome extract and *Tephrosia purpurea* root extract gave 100, 86 and 54 per cent inhibition of *Ganoderma applanatum* respectively (Bhasakaran *et.al.*, 1988b).

Field efficacy of native *Trichoderma* spp on basal stem rot

Field experiments were conducted during the year 2019-20 and 2020-21 to evaluate the efficacy of native *Trichoderma* spp and their combination with neem cake / FYM against the disease. Perusal of data (Table-7) indicates that among the three native biocontrol agents, *T.hamatum* (50 g) + Neem cake (5 kg)/palm/year was found highly effective in arresting the spread of basal stem rot disease. The mean disease index being 11.98 followed by *T.harzianum* (50g) + neem cake and *T.viride* (50g) + 5kg neem cake with mean disease index of 14.14 and 14.52 respectively as against 66.1 in untreated control. It was also observed that the biocontrol agent performed better only when used in combination with neem cake than either alone or in combination with FYM.

https://doi.org/10.56975/ijcrt.v13i8.292475

Table-6: Efficacy of Fungicides and neem cake on BSR

Mean disease index

	Treatments per palm per year	2019-20	2020-21	Mean
T_1	Root feeding with 100ml 2% of Tridemorph per palm at quarterly interval	31.53	36.61	34.07
T_2	T_1 +5kg neem cake	32.41	34.67	33.54
T_3	Root feeding with 100ml 1%of Tridemorph per palm at quarterly	37.31	39.40	38.36
T_4	T_3 +5kg neem cake	25.55	26.61	26.08
T_5	5 kg neem cake	32.65	31.70	34.54
T_6	Control	48.80	49.69	49.25
	CD (p=0.05)	**2.2**	**2.1**	**2.13**

Table-7: Efficacy of native biocontrol agents on basal stem rot disease

Mean disease index

	Treatments per palm	2019-20	2020-21	Mean
T_1	*Trichoderma viride* (50 g)	41.2	46.3	43.8
T_2	*Trichoderma harzianum* (50 g)	42.1	46.9	44.5
T_3	*Trichoderma hamatum* (50 g)	43.5	48.2	45.8
T_4	*T.viride* (50 g) + Neem cake (5 kg)	13.9	15.1	14.5
T_5	*T.harzianum* (50 g) + NC (5 kg)	13.5	14.8	14.1
T_6	*T.hamatum* (50 g) + NC (5 kg)	11.3	12.7	12.0
T_7	*T.viride* (50 g) + FYM (100 kg)	22.8	23.2	23.0
T_8	*T.harzianum* (50 g) + FYM (100 g)	28.7	26.1	27.4
T_9	*T.hamatum* (50 g) + FYM (100 kg)	21.3	22.2	21.7
T_{10}	Neem cake (5 kg)	15.9	17.4	16.6
T_{11}	FYM (100 kg)	37.5	33.0	35.3
T_{12}	Control	58.0	75.2	66.6
	CD (p=0.05)	**3.2**	**3.1**	**3.3**

https://doi.org/10.56975/ijcrt.v13i8.292475

Conclusion

Since no single control method is fully effective in halting the spread of this disease, an integrated disease management approach is essential for controlling BSR. Current management strategies include the use of chemical fungicides, cultural practices, biological techniques, and fertilizer applications. The combination of the *Trichoderma* spp and neem cake form an ideal combination in suppressing the spread of the basal stem rot disease of coconut effectively and holds promise in the development of an integrated approach to manage the disease. This finding highlights the field efficacy of native *Trichoderma* spp against basal stem rot, as this strategy happens to be a low cost, farmer feasible and ecofriendly technology to manage basal stem rot disease of coconut.

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