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Integrated Disease Management of Basal Stem Rot of Arecanut caused by *Ganoderma* spp. under Field conditions

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ABSTRACT: In the current experiment, an integrated disease management trial was conducted in the farmer's field infested with basal stem rot of arecanut from November 2019 to August 2021 at Arabilachi village, Bhadravathi Taluk Karnataka, by imposing eight treatments, T_1 to T_8. Among the treatments imposed, T_4 (Soil application of 10 liters of Hexaconazole 5% EC @ 2 ml/lit water/palm at half-yearly interval followed by soil application of *Trichoderma virens* enriched with 2 kg neem cake/ palm 15 days after chemical application) was found effective, where a slight increase in disease index (4.87 %) over the initial and maximum green nut yield (9.70 kg/palm in 2020 and 11.12 kg/palm in 2021) was recorded, which is followed by T_6 (Soil application of *T. virens* and *P. fluorescens* @100g each along with neem cake@ 2kg/palm yearly + Root feeding of 3 ml of Hexaconazole (5% EC) in 100 ml water at half-year interval) where 7.96 kg/palm in 2020 and 9.55 kg/palm in 2021 was observed. In contrast, the least green nut yield was recorded in control (T_8) with 7.03 kg/palm in 2020 and 5.58 kg/palm in 2021.

Keywords: Basal stem rot, Hexaconazole, *Trichoderma virens*, Disease index, and Green nut yield.

INTRODUCTION

Arecanut (*Areca catechu* L.) is a palm belonging to the family Arecaceae, grown in most parts of tropical Asia and East Africa. This palm is believed to be originated from the Philippines or Malaysia. The name Areca is taken up from the Malayan language, which means 'cluster of nuts'. It is one of the important cash crops grown primarily in Eastern and the Western Ghats, East and North East regions of India. Seed is the economic product of this areca palm. It is used for chewing purposes which, when chewed, is slightly addictive because of the alkaloids contained in it. According to the report given by the Directorate of arecanut and spices development-2021, India ranks first in arecanut production, and in India, Karnataka tops in the growing area, production, and productivity. This indicates the importance of arecanut as a cash crop in India and Karnataka. Among several biotic and abiotic stresses affecting arecanut palm, Basal Stem Rot (BSR) caused by *Ganoderma* spp. is one of the important disease-causing a major constrain in arecanut production. Due to this basal stem rot, losses of 5 to 11 per cent were noticed in maiden regions of Shivamogga, Chitradurga, Davanagere, and Chikmagalur districts of Karnataka (Narayanaswamy *et al.*, 2018). According to Naidu *et al.*, (1966), a death rate of five to eight per cent was observed in neglected gardens, but the mortality rate can reach as high as 94 per cent (Butler, 1906). Several fungicides *viz.*, Hexaconazole, Copper oxychloride, Bitertinol (Srinivasulu *et al.*, 2004), Difenconazole, and Propiconazole (Prathibha *et al.*, 2020) were reported to be effective in controlling the pathogen and some bioagents *viz.*, *Trichoderma* spp., *Pseudomonas fluorescens*, *Bacillus* spp. showed good anti-fungal efficacy against the pathogen (Menon, 1963).

Integrating bio-agents and fungicides will help control the disease and favor reducing the environmental pollution. According to Jayarajan *et al.*, (1987), neem cake plays a crucial role in reducing the disease severity of the *Ganoderma* wilt of coconut. Using this as one of the components in IDM practices is very effective. Srinivasulu *et al*., (2002) found that talc formulations of *Trichoderma hamatum* @ 50 g/palm combined with neem cake application @ 5 kg per palm potentially arrested the spread of *Ganoderma* wilt of coconut followed by *T.*

harzianum and *T. viride* fortified with neem cake @ 5 kg/palm. Chakrabarty *et al.,* (2013) conducted a field trial at CPCRI, Kahikunchi from 2005-07 with six treatments in basal stem rot infected arecanut palms to develop location-specific farmers friendly management practices, and they devised the treatments based on the result obtained *in vitro* experiment. Among the treatments tested, soil drenching with Calixin (0.3%) @ 10 l/palm at the quarterly interval was most effective, followed by neem cake application @ 2 kg/palm/year fortified with *T. viride* @ 100 g/palm/year in controlling the disease. Among several treatments devised, Narayanaswamy *et al.,* (2018) found root feeding of Tridemorph @ 2ml/100 ml water during January, April, and September + Neem cake application @ 2 kg per palm during the onset of monsoon + *T. harzianum* @ 100 g per palm during the beginning of monsoon as effective in reducing basal stem rot of arecanut. Thangeswari *et al.,* (2019) found treatment T_3 (Root feeding of Propiconazole @ 2ml + 100 ml water at quarterly interval) as effective in controlling the basal stem rot of coconut, where they observed only a 2.73 per cent increase in disease index against 17.4 per cent in control. Considering the economic importance of the disease and to come out with the best treatment at the field level, the following study had carried out.

MATERIALS AND METHODS

The current study was conducted in the farmer's garden at Arabilachi, Bhadravathi Taluk of Shivamogga district of Karnataka, situated at 13.933826° North latitude 75.757113° East longitude from November 2019 to August 2021. Eight treatments were imposed, and the treatments included the use of *Trichoderma virens*, *Pseudomonas fluorescens*, Neem cake, Hexaconazole, Captan, and the treatment details are given in Table 1. Twelve plants were chosen for each treatment randomly, and the disease index was calculated before the treatment imposition using the formula given by Acharya *et al.,* (2014). Readings such as disease index and green nut yield were recorded at regular intervals.

Experimental design and details.

Crop	Variety	Design	Treatments	No. of palms per treatment
Arecanut	Local	RCBD	8	12

Observations recorded

Pre-treatment Per cent Disease Index

Post-treatment Per cent Disease Index and nut yield

Disease Index is calculated using the formula given by Acharya *et al.,* (2014)

Disease Index (DI) = {(1.705 × fruiting body) + (0.572 × tapering of stem) + (0.145 × dl to tl ratio) + (0.350 × reduction in leaf size)} × 18.057.

Table 1: Details of treatment imposition.

Treatment	Details
T_1	Soil application of *T. virens* (100g) along with 2 kg neem cake per palm per year
T_2	Soil application of *P. fluorescens* (100g) along with 2 kg neem cake per palm per year
T_3	Soil application of *T. virens* (100g) + *P. fluorescens* (100g) along with 2 kg neem cake per palm per year.
T_4	Soil application of 10 liters of Hexaconazole 5% EC @ 2 ml/l water/palm at half-year interval followed by soil application of *T. virens* enriched with 2 kg neem cake/palm 15 days after chemical application.
T_5	Root feeding of Hexaconazole 5% EC @ 3 ml in 100 ml water twice yearly
T_6	Soil application of *T. virens* and *P. fluorescens* @100g each along with neem cake@ 2kg/palm yearly + Root feeding of 3 ml of Hexaconazole (5% EC) in 100 ml water at half-year interval.
T_7	Drenching around the plant basin with 75-100 gm of captan in 25 lots of water at half-year interval (Check).
T_8	Untreated Control.

A visual score of 0 to 4 was given for tapering of stem and reduction in leaf. Dl to tl ratio means drooped leaves to total leaves ratio. Grade '0' was given when there was no reduction in leaf size and 4 when there was a 50 per cent or more reduction in leaf size by visual observation compared to healthy palm in the same garden. Similarly, a '0' grade was marked for no tapering, and depending upon the severity of the tapering, 1-4 grades were given. A visual score of 4 was given to those palms where the girth of the trunk apex was almost half that of the girth at one-meter height, and girths in between them were given a score of 1 to 3. The presence of fruiting bodies and oozing was noted against each palm. A score of 0 or 1 was assigned depending upon the presence or absence of fruiting bodies/oozing in the affected arecanut palm.

RESULTS AND DISCUSSION

The disease index and green nuts yield was calculated at ten to eleven-month intervals. The details of the disease index before and after treatment imposition are presented in Table 2. Before treatment imposition (November 2019), the highest disease index (22.32 %) was observed in T_6, followed by T_3, whereas the lowest disease (17.15 %) was indexed in those plants utilized for T_5. During the first

observation (September-2020), the lowest disease index (20.59 %) was observed in palms that received T_4 treatment (Soil application of 10 liters of Hexaconazole 5% EC @ 2 ml/lit water/palm at half-year interval followed by soil application of *T. virens* enriched with 2 kg neem cake/palm 15 days after chemical application), followed by palms that received T_5 treatment (21.82 %) (Root feeding of Hexaconazole @ 3 ml in 100 ml water at half-year intervals). The highest disease index was noticed in control (T_8), with a disease index of 30.09 per cent.

Table 2: Disease index before and after treatment imposition.

Treatment	Disease index (%)[#] (November 2019)	Disease index (%) (September 2020)	Disease index (%) (August 2021)	Increase over initial	% reduction over control
T_1	17.21 (24.50[*])	24.53 (29.65)	31.78 (34.30)	14.57	24.06
T_2	18.15 (25.21)	25.83 (30.32)	32.81 (34.88)	14.66	21.60
T_3	21.04 (27.30)	26.27 (30.79)	32.02 (34.45)	10.98	23.48
T_4	18.27 (22.14)	20.59 (23.65)	23.14 (25.28)	4.87	44.70
T_5	17.15 (22.31)	21.82 (25.51)	26.42 (29.93)	9.27	36.86
T_6	22.32 (27.87)	26.97 (31.04)	31.55 (33.98)	9.23	32.64
T_7	21.07 (27.09)	26.54 (30.79)	31.95 (34.30)	10.88	23.65
T_8	20.17 (26.67)	30.09 (33.27)	41.85 (40.32)	21.68	—
SEm ±	1.89	2.09	1.99		
C.D @ 5%	NA	5.91	5.62		

[#] Mean of twelve palms,[*] Figures in parenthesis are arcsine transformed values

The final disease index was calculated during August 2021. The results revealed that the lowest disease index (23.14 %) was noticed in T_4 (Soil application of 10 liters of Hexaconazole 5 % EC @ 2 ml/lit water/palm at half-year interval followed by soil application of *T. virens* enriched with 2 kg neem cake/palm 15 days after chemical application) followed by T_5 (26.42 %). In contrast, the highest disease index (41.85 %) was observed in control.

In T_4 treated palms, a slight increase in disease index (4.87 %) was recorded over the initial, followed by T_6 (9.23 %). Whereas, in T_8, the highest increase in disease index (21.68 %) was observed over the initial observation. Compared to control, T_4 palms showed 44.70 per cent of disease reduction, followed by T_5 (36.86 %).

During both the years of observation (2020 and 2021), maximum green nut yield was recorded in T_4 (9.70 kg/palm in 2020 and 11.12 kg/palm in 2021) and is significantly superior over all other treatments tested, followed by T_6 (7.96 kg/palm in 2020, 9.55 kg/palm in 2021). However, the least green nut yield was recorded in control (T_8) with 7.03 kg/palm in 2020 and 5.58 kg/palm in 2021. All the details are presented in Table 3.

Table 3: Disease index and green nut yield before and after treatment imposition.

Treatment	Initial disease index (%)[#] (Nov - 2019)	Disease index (%)[#] (Sep - 2020)	Disease index (%)[#] (Aug - 2021)	Green nut yield (kg/Palm)[#] (2020)	Green nut yield (kg/Palm)[#] (2021)
T_1	17.21 (24.50[*])	24.53 (29.65)	31.78 (34.30)	7.86	8.63
T_2	18.15 (25.21)	25.83 (30.32)	32.81 (34.88)	7.84	8.22
T_3	21.04 (27.30)	26.27 (30.79)	32.02 (34.45)	8.33	8.93
T_4	18.27 (22.14)	20.59 (23.65)	23.14 (25.28)	9.70	11.12
T_5	17.15 (22.31)	21.82 (25.51)	26.42 (29.93)	8.41	9.22
T_6	22.32 (27.87)	26.97 (31.04)	31.55 (33.98)	8.87	9.55
T_7	21.07 (27.09)	26.54 (30.79)	31.95 (34.30)	7.87	8.55
T_8	20.17 (26.67)	30.09 (33.27)	41.85 (40.32)	7.03	5.58
SEm ±	1.89	2.09	1.99	0.21	0.21
C.D @ 5%	NA	5.91	5.62	0.60	0.59

[#] Mean of twelve palms, [*] Figures in parenthesis are arcsine transformed values

An increase in disease index was observed in all the treatments tested, but the rate of increase differed from one treatment to another. A slight rise in disease index and the highest percentage of disease reduction over control was observed in palms treated with Soil application of 10 liters of Hexaconazole 5 % EC @ 2 ml/lit water/palm at half-year interval followed by soil application of *T. virens* enriched with 2 kg neem cake/ palm 15 days after chemical application.

Overexploitation of chemicals has led to severe environmental pollution, death of beneficial microbes, and resistance to pathogens. This necessitated the integration of different cultural, biological, and chemical methods. Biocontrol-based IDM is the best option for controlling this disease (Narayanaswamy *et al.,* 2018). Current results are in agreement with Prathibha *et al.,* (2020), who found that soil application of 1% Hexaconazole 5% EC + *T. harzianum* enriched neem cake @ 5 kg/palm at four months interval was effective in reducing the disease index from 32.2 to 17.1 per cent after three years in coconut. In contrast, Narayanaswamy *et al.,* (2018)

found root feeding of Tridemorph @ 2 ml/100 ml water thrice per year + Neem cake application @ 2 kg per palm + *T. harzianum* @ 100 g per palm during the onset of monsoon effective in controlling the basal stem rot of arecanut. Chakrabrathy *et al.*, (2013) reported soil drenching with Calixin (0.3 %) @ 10l/palm at the quarterly interval as most effective in controlling the basal stem rot.

Soil application of 125g of *Trichoderma reesei* and *Pseudomonas fluorescens* + 5 kg of Neem cake/ palm/year effectively controlled the *Ganoderma* wilt of coconut. Increased yield and decrease in disease index were observed in the treated palms (Neeraja *et al.*, 2018). As a part of their integrated disease management program, Snehalatharani *et al.*, (2016) devised sixteen treatments for the control of basal stem rot of coconut, and they came out with one effective treatment (Application of 50 g of *T. viride* along with 5 kg of neem cake at the yearly interval) for controlling the disease. Application of 125 g of *Trichoderma reesi* + 125 g of *Pseudomonas* spp. + 5 kg neem cake per coconut palm per year helped in controlling basal stem rot and increase in nut yield of coconut (Hubballi *et al.*, 2019).

CONCLUSION

Basal stem rot disease causes substantial economic damage, especially in the case of ill-drained, neglected, and old orchards. Even though several bioagents and fungicides were proved to be effective against *Ganoderma* spp. by several workers, integration of bioagents such as *Trichoderma* spp., *Pseudomonas fluorescens*, Neem cake, and fungicides like Hexaconazole will help in the reduction of disease index and increase in yield. Integrated disease management studies need to be continued in the same garden for two to three years to get the exact information about the efficacy of the effective treatment.

Conflict of Interest. None.

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