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Eco-friendly management of pseudostem rot of small cardamom in hill zone of Karnataka

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Abstract
Small cardamom is the important spices crop and it is indigenous to the southern stretch of evergreen forests of Western Ghats. The incidence of pseudostem rot is gradually increasing in majority of cardamom growing areas. Eco-friendly approaches are the best management strategies for the successful management of the disease. The effect of bio-agents, consortium and neem cake was studied against pseudostem rot of cardamom. The result revealed that, minimum tiller infection (3.93 %) was recorded in T_5 (Carbendazim @ 0.20 %) which was statistically on par with T_4 (*T. harzianum* @ 50 g with 1 kg neem cake + *Pseudomonas fluorescens* @ 2.00 %) (5.52 %). Foliar spray of Carbendazim @ 0.20 % recorded maximum capsule yield 747.91 g/plant which was on par with T5 (716.47 g/plant).

Keywords: Small cardamom, pseudostem rot, *Fusarium oxysporum* and bio-agent.

Introduction
Small cardamom (*Elettaria cardamomum* Maton) is popularly known as "Queen of Spices"; and in India, it is mainly cultivated in the southern states of Kerala, Karnataka and Tamil Nadu. The cardamom of commerce is the dried fruit (capsule) of the plant. It is used as spice for various food preparations, in confectionaries, making perfumes and in several ayurvedic preparations. It possesses medicinal properties like carminative, stimulant, tonic, diuretic, digestive, expectorant, cardiotonic and used in several pharmaceutical preparations. It contains flavour compounds such as a-terpinyl acetate, 1-8 cineule, and linalool (Madhusoodanan *et al*., 2002) [6].

The small cardamom crop is affected by various diseases and pests, thus causing severe crop loss. Pseudostem rot diseases caused by *Fusarium oxysporum* Schlecht., affecting various plant parts, is one of the major concerns in several cardamom-growing tract of Karnataka and Kerala (Joseph *et al*., 2006) [2]. The pathogen is found to be associated with root rot, rhizome rot, panicle wilt and pseudostem rot and occurs in various intensities. Pseudostem rot disease is generally seen during the post- monsoon period and may last up to summer months. The symptoms of the diseases are round to oval shaped brown lesions develops on the pseudostem and at the base of the petiole. These lesions later elongate and as infection proceeds deeper layer of the pseudostem gets discoloured. The lesion portion at the pseudostem is splits off or tear resulting in the breaking and falling of tillers. Due to this kind of symptoms, it is also called as Stem lodging disease (Vijayan *et al*., 2008) [15]. The effective management of the disease is necessary for successful cultivation of cardamom. Hence, the present investigation was carried out manage pseudostem rot disease through eco-friendly manner by utilization of bio-control agents.

Materials and Methods
Experimental details
The experiment was carried out at Zonal Agricultural and Horticultural Research Station (ZAHRS), Mudigere in 2017-18, 2018-19 and 2019-20. The experiment was carried out in existing cardamom plantation and repeated for three years. The treatments comprises of six treatments with four replications which were imposed on Randomized Complete Block Design (RCBD). For each replication, 12 plants were selected. *Trichoderma harzianum* and bioagent consortium (*Pseudomonas fluorescens* IISR-6 + *P. fluorescens* IISR-859) were collected from Indian Institute of Spice Research, Calicut. The treatment details are presented here under.

Treatment details

Treatment No.	Details
T1	*Pseudomonas fluorescens*-Spray @ 2.00 %
T2	Consortium of bacteria (*Pseudomonas fluorescens* IISR6 + *P. fluorescens* IISR-859) –Spray @ 2.00 %
T3	*T. harzianum* (50g with 1 kg Neem cake)-Soil application + Consortium of bacteria – Spray @ 2.00 %
T4	*T. harzianum* (50g with 1kg Neem cake)-Soil application + *Pseudomonas fluorescens*- Spray @ 2.00 %
T5	Carbendazim (Bavistin)-Spray @ 0.20 %
T6	Untreated Check

Statistical analysis

Statistical analysis was carried out as per the procedures given by Panse and Sukhatme (1985) [8]. Actual data in percentage were converted to angular transformed values, before analysis.

Results and Discussion

Biological control of diseases of crop plants has become an integral part of disease management systems in recent years. Biological control offers promising solutions to pesticidal hazards, environmental pollution, pesticide residues in crops and to ever increasing cost of plant protection operations. The term biological control is used to denote the use of one species of organism to control or eliminate another organism which is harmful to the crop plants or animals. Bioagents used to control plant diseases are potential inhibitors or suppressors of pathogens and they bring about effective disease control (Liptton, 1984) [5].

Different bio-control agents and consortium were evaluated against pseudostem rot of small cardamom. The positive check, fungicide-Carbendazim (0.20%) and negative check, untreated control were maintained. In 2017-18, among the biological treatments evaluated, T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) treatment showed the minimum tiller infection of 5.57 % followed by T_1-*P. fluorescens* spray (7.58 %). The positive check, treatment T_5-Carbendazim @ 0.20% found to be superior with lowest per cent tiller infection (3.41 %) compared to all the treatments. The negative check, untreated control showed the highest percent tiller infection (12.16 %) (Table 1). In 2018-19, among the biological treatments evaluated, T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) treatment showed the lower tiller infection of 5.52 % followed by T_1-*P. fluorescens* spray (6.00 %) and T_3 (*T. harzianum* with Neem cake + consortium of bacteria-spray) (7.25 %). The positive check, treatment T_5-Carbendazim @ 0.20% found to be superior with lowest per cent tiller infection (3.00 %) compared to all the treatments. The negative check, untreated control showed the highest percent tiller infection (11.00 %) (Table 1).

In 2019-20, among the biological treatments evaluated, T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) treatment showed the lower tiller infection of 6.48 % followed by T_3 (*T. harzianum* with Neem cake + consortium of bacteria-spray) (10.59 %). The positive check, treatment T_5-Carbendazim @ 0.20% found to be superior with lowest per cent tiller infection (5.38 %) compared to all the treatments. The negative check, untreated control showed the highest percent tiller infection (13.48 %) (Table 1). The pooled analysis revealed that, T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) treatment showed the lower tiller infection of 4.50 % followed by T_1-*P. fluorescens* spray (8.21 %) and T_3 (*T. harzianum* with Neem cake + consortium of bacteria-spray) (8.98 %). %). The positive check, treatment T_5-Carbendazim @ 0.20% found to be superior with lowest per cent tiller infection (3.93 %) compared to all the treatments. The negative check, untreated control showed the highest percent tiller infection (12.21 %) (Table 1).

Table 1: Effect of bio-control agents against pseudostem rot of cardamom

Treatment	Per cent Tiller infection			
	2017-18	2018-19	2019-20	Pooled
T_1= *Pseudomonas fluorescens* (2% solution)- spray	7.58 (15.97)*	6.00 (14.17)	11.04 (19.37)	8.21 (16.64)
T_2= Consortium of bacteria (2% solution)- spray	9.02 (17.47)	8.50 (16.94)	12.12 (20.35)	9.88 (18.31)
T_3= *T. harzianum* (50g with 1 kg Neem cake)+ consortium of bacteria-spray	9.09 (17.54)	7.25 (15.61)	10.59 (18.94)	8.98 (17.43)
T_4= *T. harzianum* (50g with 1kg Neem cake)+ *Pseudomonas fluorescens* (2%)-spray	5.57 (13.65)	4.50 (12.24)	6.48 (14.62)	5.52 (13.58)
T_5= Carbendazim (0.2%)- spray	3.41 (10.64)*	3.00 (9.97)	5.38 (13.27)	3.93 (11.43)
T_6= Control	12.16 (20.40)	11.00 (19.36)	13.48 (21.51)	12.21 (20.45)
S.Em±	0.29	0.51	0.93	0.33
CD @ 5%	0.91	1.60	2.82	1.01
CV %	7.67	14.05	10.37	9.56

*Arc sine transformed values

The influence of bio-control agents and fungicide on yield of small cardamom was also studied. In 2017-18, among the different treatments, T_5-Carbendazim (0.20%) recorded the maximum yield (698.00 g/plant) which was statistically on par with T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) (676.25 g/plant) followed by T_1-*P. fluorescens* spray (633.52 g/plant). The negative check, untreated control showed the lower yield (428.75 g/plant) (Table 2). In 2018-19, among the different treatments, T_5-Carbendazim (0.20%) recorded the maximum yield (740.23 g/plant) which was statistically on par with T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) (710.42 g/plant) followed by T_1-*P. fluorescens* spray (640.12 g/plant). The negative check, untreated control showed the lower yield (405.28 g/plant) (Table 2).

In 2019-20, among the different treatments, T_5-Carbendazim (0.20%) recorded the maximum yield (805.50 g/plant) which was statistically on par with T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas*

fluorescens) (762.75 g/plant) followed by T_1-*P. fluorescens* spray (621.91 g/plant). The negative check, untreated control showed the lower yield (427.94 g/plant) (Table 2). The pooled analysis revealed that, T_5-Carbendazim (0.20%) recorded the maximum yield (747.91 g/plant) which was statistically on par with T_4 (Soil application of *Trichoderma harzianum* with neem cake + *Pseudomonas fluorescens*) (716.47 g/plant) followed by T_1-*P. fluorescens* spray (631.85 g/plant) (Table 2). The results on the efficacy of bio-control agents may vary from one geographical region to another. It is mainly due to adaptability of the bio-agent strain to the particular environment. Hence, many researchers exploit the indigenous/native bio-control agent for the successful disease management. The performance of the bio-agent strain is mainly depending on the adaptability of the strain to the local environment. It should be competes with various antagonists and micro biota in the soil of the particular geographical region.

Table 2: Influence of bio-control agents on yield of small cardamom

Treatment	Yield (g/plant)			
	2017-18	2018-19	2019-20	Pooled
T_1= *Pseudomonas fluorescens* (2% solution)- spray	633.52	640.12	621.91	631.85
T_2= Consortium of bacteria (2% solution)- spray	581.25	600.67	565.75	582.56
T_3= *T. harzianum* (50g with 1 kg Neem cake) + consortium of bacteria-spray	530.00	575.25	677.01	594.09
T_4= *T. harzianum* (50g with 1kg Neem cake) + *Pseudomonas fluorescens* (2%)-spray	676.25	710.42	762.75	716.47
T_5= Carbendazim (0.2%)- spray	698.00	740.23	805.50	747.91
T_6= Control	428.75	405.28	427.94	420.66
S.Em±	12.51	15.51	22.07	16.66
CD @ 5%	37.86	47.59	66.51	50.23
CV %	4.25	5.16	6.86	5.41

The report on management of pseudostem rot as sole disease was limited. Since, *Fusarium oxysporum* is the one of the pathogen in rhizome or clump rot complex, most of the studies are carried out for the management of rhizome of cardamom. But, *Fusarium oxysporum* also causes pseudostem rot in cardamom and its symptoms mainly confined to above ground part i.e., pseudostem region. Hence, in addition to soil application of bio-agent or fungicides, foliar application is also got prime importance. Attempts of management of rhizome-rot through *Trichoderma* spp. (*T. viride* and *T. harzianum*) were made by many researchers (Thomas *et al*. 1991; Joseph *et al*. 1993) [12, 3]. Sivakumar *et al*. (2012) [11] revealed that rhizome bacterization and soil application of bacterial consortium (*P. fluorescens* Pf51 and *Bacillus subtilis* Bs45) could effectively control rhizome rot of cardamom. Devasahayam *et al*. (2015a) [1] utilized the *T. harzianum* (10^8 cfu/g) multiplied in mixture of decomposed coffee compost and cowdung @ 50g / clump during May – June and August – September to manage the disease. Decreased incidence of rhizome rot and increase in yield of cardamom for the basal application of *T. harzianum*, *P. fluorescens* and *B. subtilis* from cardamom growing region of Tamil Nadu was also reported (Gopakumar *et al*. 2006) [2].

Peeran *et al*. (2018) [9] reported that endophytes *Tulasnella* sp. (*Alpinia galanga* isolate) showed an inhibition of *Rhizoctonia solani* and *F. oxysporum* while *Phoma* sp. (an isolate from Appangala-1) showed inhibition of *Pythium vexans*. Endophyte treated plants also showed higher activities of defence related enzymes like peroxidase and polyphenol oxidase. Thomas and Vijayan (2002) [13] showed that four biocontrol agents namely T. *viride*, *T. harzianum*, *B. subtilis* and *P. fluorescens* effectively inhibited the causal organism *F. oxysporum* and reduced the severity of the disease. Vijayan *et al*. (2012) [14] also reported that basal application of *T. harzianum*, along with spraying and drenching of *P. fluorescens* provided a significant control of symptoms (root tip rot and leaf yellowing, pseudostem rot and panicle wilt) associated with *Fusarium* rot disease and reduced the population of *F. oxysporum* to the minimal. Maya *et al*. (2012) [7] stated that basal application of *T. harzianum* @ 50g with one kg neem cake and aerial spray with either *P. fluorescens* or consortium containing *P. fluorescens* strains IISR 6 and IISR 859 @ 2% was an effective management strategy against pseudostem rot.

Conclusion

The soil application of *T. harzianum* @ 50 g with 1 kg neem cake followed by spraying of *Pseudomonas fluorescens* or consortium @ 2.00 % concentration effectively reduced the pseudostem rot disease in hill zone of Karnataka.

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