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Recent approaches on the management of Stem Bleeding Disease in Coconut

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ABSTRACT

Stem bleeding disease caused by *Thielaviopsis paradoxa* is an important disease of coconut in Andhra Pradesh. Among the chemical fungicides tested *in vitro*, the most effective in the order of merit were combi fungicide viz., Carbendazim 12% + Mancozeb 63% WP showed maximum inhibition of 91.11%, 95.19% and 97.41% at 100ppm, 250 ppm, and 500 ppm respectively. The second best treatment was Hexaconazole 5% + validamycin 2.5% SC which showed 89.26,93.70 and 96.30 followed by Azoxystrobin 11% + Tebuconazole 18.3% SC [77.78%, 77.78 and 88.52%]. Based on the *in vitro* studies, the best chemical fungicides were forwarded to evaluate under field conditions. The treatments were followed with quarterly schedule for a period of two years to observe its affects on the disease. After 27 months of quarterly treatment with Root feeding of Hexaconazole 5% + Validamycin-2.5% SC @4 ml in 100 ml water + soil drenching (@2ml/l^{-1}) 15 litre $palm^{-1}$ (at quarterly interval) has been recorded 42.00 % reduction over initial followed by the positive check with root feeding with Hexaconazole @4 ml in 100 ml of water $Palm^{-1}$) with 36.05 % reduction over initial. The next best treatment was Root feeding of Hexaconazole + Validamycin 4 ml in 100 ml of water $palm^{-1}$ showed 31.17 % reduction over initial. The treatment with Root feeding of Azoxystrobin 11% + Tebuconazole-18.3% SC @ 4 ml in 100 ml water + Soil drenching (@ 2ml/l^{-1}) 15 litre $palm^{-1}$ (at quarterly interval) recorded 24.75 % reduction over initial.

***Key words**: Stem bleeding, Coconut, Thielaviopsis paradoxa, Fungicide*

Introduction

Coconut palm (*Cocos nucifera*, L.) is an important plantation crop of India and often described as 'Kalpavriksha' because of the multifarious uses of every part of it in the commercial sector. Coconut plays vital role in rural horticulture economy with a total Production of 13411 tonnes in India and 1112 tonnes as share of 8.27% and ranks 4th in Andhra Pradesh with an area and production (1.15 lakh ha; 1378 million nuts) after Kerala, Karnataka and Tamil Nadu with a productivity of 11957 nuts/ ha 2021-22). In Andhra Pradesh, East Godavari (50,490 ha), West Godavari (21, 818 ha), Srikakulam (14,753 ha) and Visakhapatnam (7300 ha) districts occupy major area in forefront in coconut cultivation (Annonymous).

Stem bleeding disease of coconut caused by *Thielviopsis paradoxa* (De Seyness) Von Hohnel is a debilitating disease and is widely prevalent in all coconut growing areas of the country. The disease was first reported from Sri Lanka (Petch, 1906) and

later reported in India (Sundararaman, 1922) and other countries. In India, the disease is prevalent in almost all coconut growing states. The disease has been found to occur in all soil types, but more in laterite soils and sandy soils on seashore or backwater areas (Nambiar, 1994). The pathogen is a soil borne pathogen and enters the plant through growth cracks present on the stem and causes cortical decay. The disease is characterized by development of dark brown patches appearing at the basal portion of the trunk. A dark or reddish brown liquid exudates from the longitudinal cracks present on the stem bark. Subsequently, the liquid dries up and turns black, the tissues below the lesions become water soaked and get discoloured. The lesion spread upwards as the disease progresses. In the advanced stages, stem gets tapered and crown size gets reduced leading to gradual reduction in yield. The earliest recommendation for the control of the disease was chiselling of the affected tissues and application of hot coal tar. This did not always results in giving effective control of the disease (Nambier and Kalpana Sastry, 1988). Soil drenching with calixin 0.1% (Radhakrishnan, 1990) and root feeding with Bavistin 5% or Calixin 5% (Ramanujam *et al.,* 1993), have been found to reduce the disease to some extent. Biological control through the use of antagonistic microorganism and locally available botanicals for the development of integrated management strategy against the disease has emerged as available option (Alvindia and Natsuaki, 2009). *Trichoderma* spp., is considered to be antagonistic to many soil borne and plant pathogenic fungi (Prasad *et al*., 2002); Ramanujam *et al*., (2005) and Ranjana Chakrabarty *et al.,* 2013). Soil application of Neem cake to the affected palms was found to reduce the population of *T. paradoxa* and encourage the antagonistic population in soil (Sanal Kumar *et al*., 1993).

The pathogenic fungus *Thielaviopsis paradoxa* or *T. punctulata* causes Black scorch disease in date palm (De Beer et al 2014) and they are soil- borne wound pathogens that can attack the different parts (leaves, inflorescence, heart, trunk or bud) of the date trees causing rot (Abbas *et al*., 2003 , Al-Raisi *et al*., 2011).

IDM practices used to develop a combination of specific chemicals with bio-agents and botanicals with an aim to reduce the non-availability of bioagents and botanicals at specific period of time sand which are also environmental friendly. Since the pathogen is soil borne, it is essential to adopt systemic and combi fungicides for effective disease management. The present study was carried out to evaluate the effective fungicides suppressing the growth of the fungus *in vitro* and subsequent field level evaluation against the disease.

Materials and Methods

The trial was conducted in Degalavaripalem village of erstwhile East Godavari district, Andhra Pradesh for three years from 2019 - 2022 under ICAR-All India Co-ordinate Research Project on Palms, Dr. YSRHU-Horticultural Research Station, Ambajipeta centre, situated at 16.4° N latitude and 81.5° E longitudes and at an altitude of 34 m above mean sea level. The soils are of the coastal alluvial type with pH 7.8 with impeded drainage. The mean maximum temperature ranged from 26.7° - 36.8 °C, and the minimum temperature ranged from 22.7 °C - 44.5 °C. The average rainfall and relative humidity during experimentation varied between 1000 - 1250 mm and 65 to 90 %, respectively. Three acres of East Coast Tall coconut palms of more than 20 years age affected by stem bleeding were selected. Total 32 palms were selected for the treatment imposition with four palms per replication in Randomized Block Design for the management of the stem bleeding disease under natural infestation conditions at farmers' field.

Isolation of coconut pathogens

The disease symptom of stem bleeding caused by *Thielaviopsis paradoxa* is depicted in Plate 1-3. The stem portion of the infected palm where bleeding symptoms were conspicuous was chiselled out and surface sterilized with 0.1 % sodium hypochlorite

Plate 1. Stem bleeding infection at bottom portion of the stem

Plate 2. Stem bleeding infection at top portion of the stem

Plate 3. Initiation of stem bleeding at bottom potion of stem

followed by 3 washes in sterilized distilled water (SDW) and then the stem bits were placed on Potato Dextrose Agar (PDA) media plates for *Thielaviopsis paradoxa*. The plates were then incubated for three days at 29 ± 1°c and the test pathogen were isolated by purification (Plate 4-5). Before applying the treatments, the initial disease index of all the palms was worked out during September 2014 using the formula (Mathew *et al*., 1989).

DI = 1.8 l + 4.3 t where,

l is the lesion size expressed in 1000 cm^2

t is the score for tapering (ranging from 0 to 4)

Subsequently, the disease index was recorded at the end of the first, second and third year. Nut yield of the palms was also recorded before and every year after imposing the treatments. The yield data of three years from 2019-2022 were used to draw conclusions. The data was analyzed statistically as per the procedure given by Gomez and Gomez (1984).

Plate 4. *Thielaviopsis paradoxa* pure culture at four days

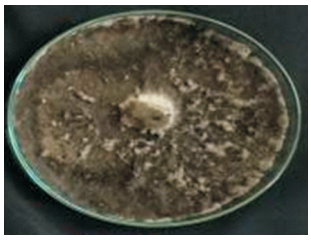

Plate 5. Pure culture *Thielaviopsis paradoxa* at 8 days

In vitro evaluation of fungicides

Management of stem bleeding disease in coconut was conducted with systemic and combi fungicides namely Ibrufenophos 48% EC (Kitazin), Famaxadone 16.6% + Cymaxanil 22.1% SC (Equation Pro), Hexaconazole 4% + Carbendazim 16% SC (Sofia), Azoxystrobin 11% + Tebuconazole 18.3%SC, Cyazafamid 34.5%SC (Ranman), Thifluzamide 24% SC (Pulsor), Carbendazim 12% + Mancozeb 63% WP, Hexaconazole 5% SC + Validamycin 25% SC, Hexaconazole 4 % + Zineb 68% (Avatar), Mancozeb 75% WP, and standard check Hexaconazole 5% SC using food poison technique (Table 1). The radial

Table 1. List of Contact/systemic/ combi fungicide used in the experiment

Tr. No	Fungicide	Contact/systemic/ combi fungicide	Brand name	Manufacturer
T1	Ibrufenophos 48%	Systemic fungicide	Kitazin	P I Industries limited
T2	Famaxadone16.6%+ Cymaxanil 22.1% SC	Combi - Systemic and contact fungicide	Equation Pro	Dupont
T3	Hexaconazole 4% + Carbendazim 16% SC	Combi - Systemic fungicide	Sofia	Insecticides india limited
T4	Hexaconazole 5% EC	Systemic fungicide	Contaf	Tata Rallis India Ltd
T5	Azoxystrobin 11% + Tebuconazole 18.3% SC	Combi - Systemic fungicide	Custodia	ADAMA Ltd.
T6	Cyazafamid34.5% SC	Systemic fungicide	Ranman	United Phosphorus Limited
T7	Thifluzamide 24% SC	Systemic fungicide	Pulsor	Insecticides india limited
T8	Carbendazim 12% + Mancozeb 63% WP	Combi - Systemic and contact fungicide	SAAF	United Phosphorus Limited
T9	Hexaconazole 5% SC + Validamycin 25% SC	Combi - Systemic fungicide	Validex	Agri science company
T10	Hexaconazole 4 % + Zineb 68%	Systemic fungicide	Avatar	Indofil Industries Ltd.
T11	Mancozeb 75% WP	Contac fungicide	Indofil M-45	Indofil Industries Ltd.
T12	Control-Untreated	-	-	

growth of the test fungal colony recorded on 6th day when maximum growth was observed in untreated control plates. The percent inhibition of the mycelia growth over control was calculated using formula given by Vincent (1947).

$$I = \frac{C - T}{C} \times 100$$

I = % inhibition of mycelia growth
C= radial growth of fungus in control
T = radial growth of fungus in treatment
Statistical analysis was followed with Number of treatments: 11, Number of replications: 3 and Design : CRD

Evaluations of identified systemic fungicides against stem bleeding disease under field conditions

Based on the *in vitro* studies, the effective combi systemic fungicides viz., Azoxystrobin 11% + Tebuconazole 18.30% SC and Hexaconazole 5% + Validamycin 2.5% SC were selected for evaluation against stem bleeding disease of coconut at farmer's coconut garden at Dagalavaripalem village of East Godavari district. Pre data was recorded on disease index of stem bleeding disease. The positive control has been maintained with root feeding of Hexaconazole 5% SC (4 ml in 100 ml of water/Palm) to compare the efficacy of the testing fungicides. The treatments have been given at quarterly intervals.

T1. Root feeding of Azoxystrobin 11% + Tebuconazole-18.3% SC @ 4 ml in 100 ml water (at quarterly interval)
T2. Soil drenching of Azoxystrobin 11% + Tebuconazole-18.3% SC (@ 2ml/l^{-1}) 15 litre/ palm (at quarterly interval)
T3. Root feeding of Azoxystrobin 11% + Tebuconazole-18.3% SC @ 4 ml in 100 ml water + Soil drenching (@ 2ml/l^{-1}) 15 litre/palm (at quarterly interval)
T4. Root feeding of Hexaconazole 5% + Validamycin-2.5% SC @4 ml in 100 ml water (at quarterly interval)
T5. Soil drenching Hexaconazole 5% + Validamycin-2.5% SC (@2ml/l^{-1}) 15 litre/ palm (at quarterly interval)

Table 2. *In vitro* evaluation of fungicides against stem bleeding disease causing pathogen *T.paradoxa* in coconut

S. No	Treatments	Mycelial growth (mm) of *T.paradoxa*			Percent inhibition over control		
		100 ppm	250 ppm	500 ppm	100 ppm	250 ppm	500 ppm
T_1	Ibrufenophos 48 % EC (Kitazin)	87.33 (69.21)	86.33 (68.32)	88.33 (70.07)	2.96	4.07	1.85
T_2	Famaxadone 16.6% + Cymaxanil 22.1% SC (Equation Pro)	65.67 (54.24)	41.67 (40.19)	17.67 (24.80)	27.04	53.70	80.37
T_3	Hexaconazole 4 % + Carbendazim 16 % SC (Sofia)	38.00 (43.25)	33.00 (44.58)	27.33 (48.69)	67.78	73.33	80.00
T_4	Hexaconazole 5 % EC(Contaf)	29 (38.05)	24 (35.05)	18 (31.51)	57.78	63.33	69.63
T_5	Azoxystrobin 11 % + Tebuconazole 18.3 % SC (Custodia)	20.00 (26.56)	20.00 (26.56)	10.33 (18.72)	77.78	77.78	88.52
T_6	Cyazafamid34.5 %SC(Ranman)	87.67 (69.49)	87.33 (69.17)	88.67 (70.35)	2.59	2.96	1.48
T_7	Thifluzamide 24%SC(Pulsor)	86.33 (68.36)	87.00 (68.88)	85.67 (67.88)	4.07	3.33	4.81
T_8	Carbendazim 12% + Mancozeb 63% WP	8.00 (16.41)	4.33 (11.90)	2.33 (8.46)	91.11	95.19	97.41
T_9	Hexaconazole 5% SC + Validamycin 25% sc	9.67 (18.08)	5.67 (13.63)	3.33 (10.34)	89.26	93.70	96.30
T_{10}	Hexaconazole 4 % + Zineb 68% (Avatar)	70.00 (56.84)	59.33 (50.41)	41.67 (40.10)	22.22	34.07	53.70
T_{11}	Mancozeb 75% WPIndofil M-45	40.00 (39.23)	26.67 (31.00)	26.67 (31.00)	55.56	70.37	70.37
T_{12}	Control	90.00 (71.57)	90.00 (71.57)	90.00 (71.57)	0.00	0.00	0.00
	SEm+	1.36	1.48	1.90			
	CD (P≤0.01)	5.40	5.86	7.51			

T6. Root feeding of Hexaconazole 5% + Validamycin-2.5% SC @4 ml in 100 ml water + soil drenching (@2ml/litre) 15 litre/palm (at quarterly interval)
T7. Root feeding of Hexaconazole@ 3ml +100 ml water at three months interval (Positive check)
T8. Control

Statistical analysis was followed OP STAT with Number of treatments: 8, Number of replications: 4 Design: RBD

Results and Discussion

in vitro evaluation of combi systemic and contact fungicides against *Thielviopsis paradoxa*

In vitro evaluation of contact,systemic and combi fungicides viz., Ibrufenophos 48% EC (Kitazin), Famaxadone 16.6% + Cymaxanil 22.1 % SC (Equation Pro) Hexaconazole 4% + Carbendazim 16 % SC (Sofia), Hexaconazole 5 % EC , Azoxystrobin 11% + Tebuconazole 18.3 %SC , Cyazafamid 34.5 %SC (Ranman), Thifluzamide 24 % SC (Pulsor), Carbendazim 12% + Mancozeb 63 % WP, Hexaconazole 5% SC + Validamycin 25% sc, Hexaconazole 4 % + Zineb 68 % (Avatar) and Mancozeb 75 % WP were tested against *Theilaviopsis paradoxa* at 100 ppm, 250 ppm, 500 ppm.

The data (Table 2) indicated that among the chemical fungicides tested, the most effective treatments are in the order of merit wherein combi fungicide viz., (T8). Carbendazim 12% + Mancozeb 63% WP showed maximum inhibition of 91.11%, 95.19% and 97.41%at 100ppm, 250 ppm, and 500 ppm respectively. The second best treatment was Hexaconazole 5% + Validamycin 2.5 %SC which showed 89.26,93.70 and 96.30 followed by Azoxystrobin 11% + Tebuconazole 18.3 %SC(77.78 %, 77.78 and 88.52%), Famaxadone16.6 %+ Cymaxanil 22.1% SC (27.04 %, 53.70 % and 80.37 %). Mancozeb 75% WP (55.56 %,70.37 % and 70.37%) and Hexaconazole 4 %SC + Zineb 68% WG (22.22 %, 34.07 % and 53.70 %). None of the other chemicals viz., Ibrufenophos 48% EC, Cyazafamid 34.5 %SC, and Thifluzamide 24 %SC showed the inhibition over the pathogen *Theilaviopsis paradoxa* (Plate 6-11).

Field evaluation of identified combi fungicides

Based on the *in vitro* studies, the best chemical fungicides were forwarded to evaluate under field conditions. The treatments were followed with quar-

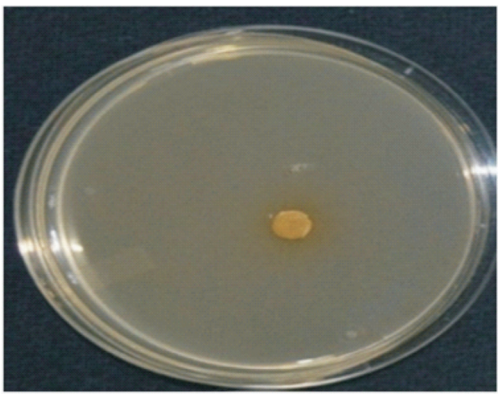

Plate 6. Hexaconazole 5% + validamycin 2.5% SC t 500 ppm

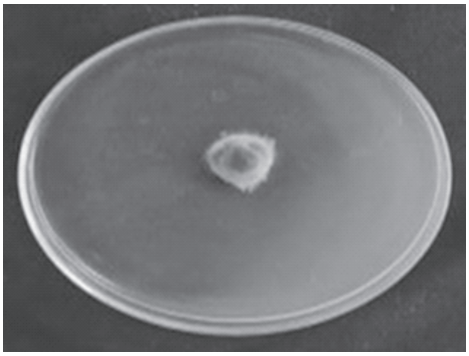

Plate 7. Azoxystrobin 11%+ Tebuconazole18.3% SC W/W at 500 ppm

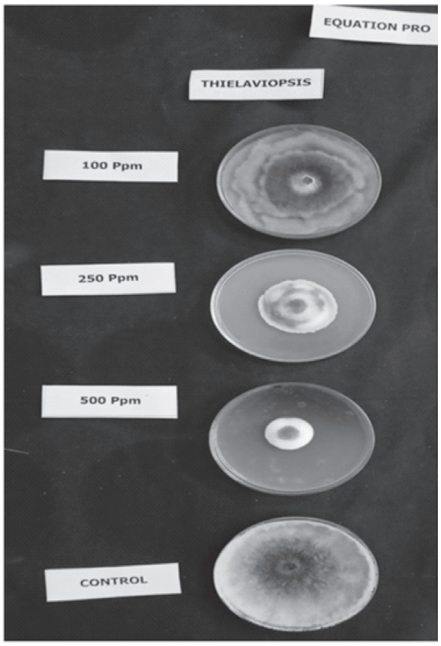

Plate 8. Famaxadone 16.6% + Cymaxanil 22.1% SC (Equation Pro)

Table 3. Evaluations of identified systemic fungicides against stem bleeding disease under field conditions

Tr. No.	Disease Index (DI)										
	Pre treat mental data	3MAT (Jan-21)	6MAT (April-21)	9 MAT (July-21)	12 MAT (Oct-21)	15 MAT (Jan-22)	18 MAT (April-22)	21 MAT (July-22)	24 MAT (Oct-22)	27 MAT (Jan-23)	Reduction Overinitial
T_1	22.96 (28.62)	22.51 (28.29)	24.21 (29.44)	23.61 (24.57)	21.45 (23.25)	19.39 (26.08)	18.93 (25.75)	18.30 (25.28)	17.84 (24.95)	17.68 (24.83)	23.01
T_2	22.06 (27.99)	23.01 (28.64)	23.45 (28.95)	22.19 (23.02)	22.01 (23.02)	20.37 (26.78)	20.06 (26.56)	20.06 (26.56)	19.68 (26.29)	19.52 (26.18)	11.53
T_3	25.03 (30.02)	25.13 (30.04)	25.63 (30.40)	23.27 (23.80)	21.46 (23.80)	20.82 (27.08)	20.17 (26.61)	19.44 (26.04)	19.05 (25.76)	18.84 (25.61)	24.75
T_4	23.56 (29.03)	24.56 (29.68)	25.21 (30.13)	22.67 (23.90)	19.45 (21.85)	18.28 (25.24)	18.28 (25.24)	16.97 (24.27)	16.48 (23.90)	16.22 (23.68)	31.17
T_5	26.08 (30.71)	26.08 (30.69)	27.94 (31.90)	25.56 (25.97)	23.32 (24.57)	24.18 (29.42)	23.48 (28.94)	22.92 (28.57)	22.92 (28.57)	22.66 (28.39)	13.13
T_6	24.52 (29.68)	23.56 (29.02)	25.01 (29.99)	22.67 (23.02)	19.45 (20.89)	16.58 (23.94)	16.11 (23.61)	15.57 (23.19)	15.10 (22.83)	14.22 (22.12)	42.00
T_7	26.10 (30.72)	26.9 (31.23)	27.31 (31.82)	24.32 (24.55)	21.65 (24.55)	18.97 (25.80)	17.94 (25.03)	17.45 (24.66)	16.90 (24.24)	16.69 (24.08)	36.05
T_8-Control	26.22 (30.79)	27.14 (31.38)	28.32 (32.15)	31.25 (28.78)	32.56 (29.55)	32.68 (34.46)	33.75 (35.48)	34.22 (35.77)	34.22 (34.88)	34.22 (35.97)	0.00
SEm±	NS	0.61	0.46	1.47	1.45	0.69	0.74	0.77	0.73	0.72	
CD (P≤0.05)	NS	1.79	1.35	4.23	4.16	2.01	2.15	2.23	2.12	2.09	

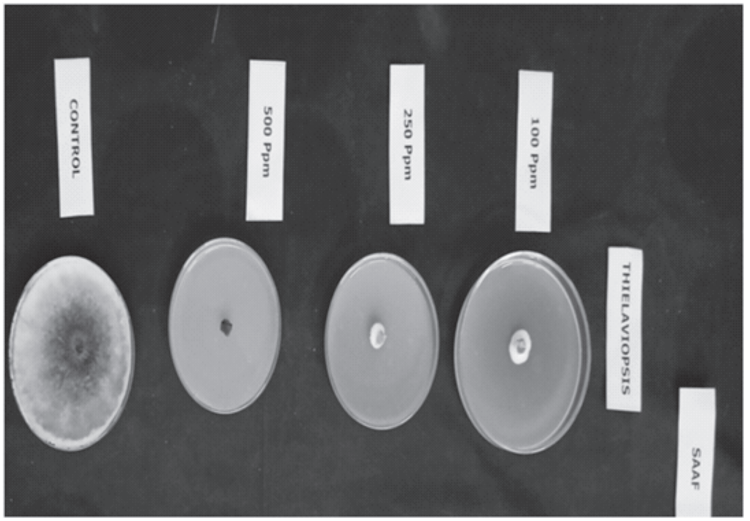

Plate 9. Carbendazim 12% + Mancozeb 63% WP[saaf]

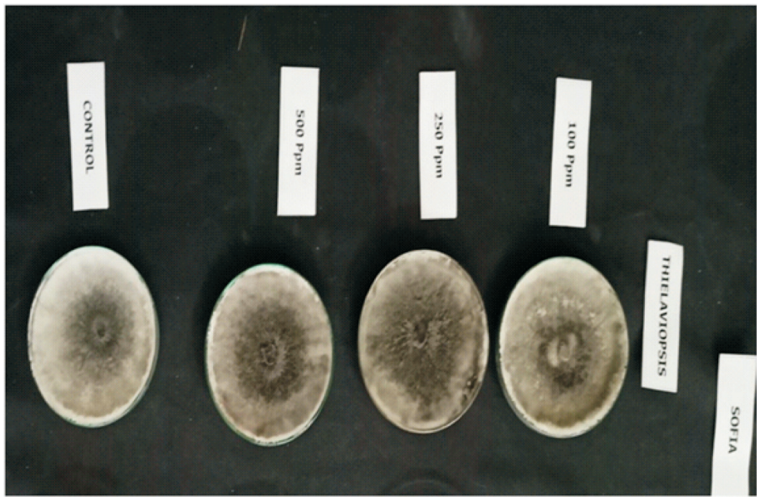

Plate 10. Hexaconazole 4% + Carbendazim 16% SC (Sofia)

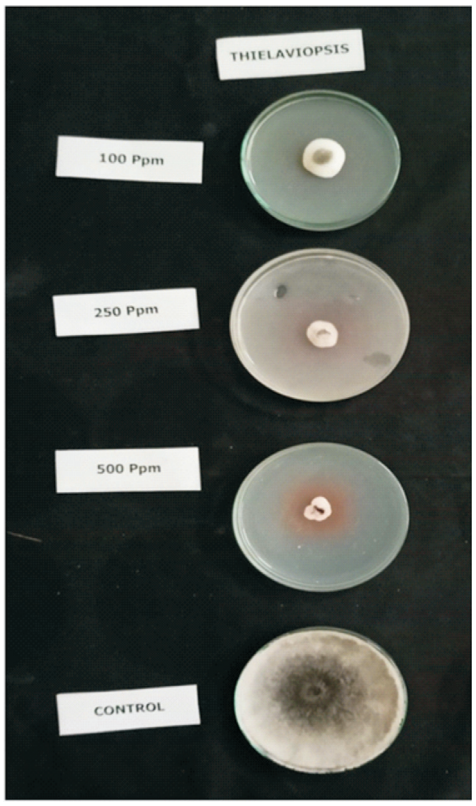

Plate 11. Mancozeb 75% WP

terly schedule for a period of two years to observe its affect on the disease. The data (Table 3) of the experiment indicated that after 27 months of quarterly treatment with T6: Root feeding of Hexaconazole 5% + Validamycin-2.5 % SC @4 ml in 100 ml water + soil drenching @2ml litre^{-1} in 15 litre palm^{-1} was found superior with 42.00 per cent reduction over initial followed by the positive check T7: Root feeding with Hexaconazole @4 ml in 100 ml of water Palm^{-1}) with 36.05 % reduction over initial. The next best treatments in the order of merit are T4: Root feeding of Hexaconazole + Validamycin 4 ml in 100 ml of water/palm recorded 31.17 % reduction over initial followed by treatment T3: Root feeding of Azoxystrobin 11% + Tebuconazole-18.3% SC @ 4 ml in 100 ml water + Soil drenching @ 2ml/litre in 15 litre palm^{-1} resulted 24.75 % reduction over initial. The treatment T1: Root feeding of Azoxystrobin 11% + Tebuconazole-18.3% SC @ 4 ml in 100 ml water was recorded substantial influence with 23.01% followed by T5:Soil drenching Hexaconazole 5% + Validamycin-2.5% SC (@2ml/l) 15 litre palm^{-1}. The treatment T2: Soil drenching of Azoxystrobin 11% + Tebuconazole-18.3% SC @ 2 ml litre^{-1} in 15 litre palm^{-1} recorded 11.53% reduction over initial and stand last in descending order of merit.

The present findings are in conformity with the results of Somasekhara (2009) who reported that the fungal growth and survival of *C. fimbriata* on PDA medium was completely inhibited by Carbendazim, Benomyl, Mancozeb, Ridomil, Ziram and Propiconazole. Kuldeep *et al*., (2011) reported in vitro efficacy of fungicides against wilt pathogen of pomegranate and found the complete inhibition of mycelial growth of *C. fimbriata* in carbendazim (0.1 %), Propiconazole (0.2 %), Hexaconazole (0.1 %), Mancozeb (0.2 %) and Captan (0.2 %). Ramanujam *et al*., (2005) reported the fungicides Carbendazim, Propiconazole and Hexaconazole (each @ 500 ppm) as highest inhibitory to *Ceratocystis paradoxa*. The fungicides viz Carbendazim, Propiconazole (each @ 500 ppm and 1000 ppm), Hexaconazole (@ 1000 ppm), Thiram and Captan (each @ 1000 ppm and 2000 ppm) were reported to cause complete inhibition of the pathogen.

Conclusion

Root feeding of combi and systemic fungicides Hexaconazole 5% + Validamycin-2.5 % SC @4 ml in 100 ml water + soil drenching (@2ml/l) 15 litre/palm (at quarterly interval) is affective and advisable to manage the disease at field level.

Acknowledgement

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Conflict of Interest : None

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