Poll Res. 42 (2) : 262-269 (2023)

ISSN 0257–8050

DOI No.: http://doi.org/10.53550/PR.2023.v42i02.013

ABIOTIC STRESS AS A POTENTIAL CONTRIBUTING FACTOR TO ONSET AND SEVERITY OF INFECTION CAUSED BY *LASIODIPLODIA THEOBROME* AN OPPORTUNISTIC FUNGAL PATHOGEN IN COCONUT

V. GOVARDHAN RAO*[1], NBV CHALAPATHI RAO[1], CH. SREENIVAS[2], B. NEERAJA[1], A. KIREETI[1], G. KOTESWARAO[1], B.V.K. BHAGAVAN[1] AND B. SRINIVASULU[1]

[1]Dr.YSR Horticultural University, Horticultural Research Station-Ambajipeta, A.P., India
[2]Acharya NG Ranga Agricultural University, Lam, Guntur, A.P., India

(Received 13 December, 2022; Accepted 28 January, 2023)

ABSTRACT

Coconut palms irrigated with water from bore wells in close proximity with oil exploration rigs reported sudden death later to the drilling of oil wells only since January 2021 and 2017 in Billakurru village and Lanka of Thane Lanka village, respectively from erstwhile East Godavari district of Andhra Pradesh. Isolations from infected samples yielded weak pathogens which usually affect plants subjected to stress. Pathogenicity tests with the isolated cultures of organisms were not successful on actively growing tissues but could produce symptoms on detached tissues indicating their status as weak pathogens. Adhoc attempts with fungicides to manage the likely pathogenic origin were unsuccessful. Abiotic stress is a potential contributing factor to onset and severity of disease caused by *Lasiodiplodia theobrome* that causes leaf blight disease in coconut. Under stress conditions invasion of opportunistic phytopathogen leading the infection at the base of the petiole and necrosis resulted drooping and yellowing of leaves. The progression of infection to growth point leading the toppling of rotten crown and emitting foul smell. Other crop plants like banana, turmeric, sweet orange, rice, sapota, mango etc. were found healthy without any signs of stress at all in the fields in which coconut was affected. Chemical analyses of soil, water and plant samples are attributed to higher salt concentration in general and Al in particular. Higher concentration of salts (EC) and Al in soil, water and plant samples in affected fields than in healthy fields were detected with decreasing values with increasing distance from the oil wells.

KEY WORDS: Unusual Death, Coconut, Abiotic stress, Opportunistic Phytopathogens, *Lasiodiplodia theobrome*

INTRODUCTION

Coconut is one of the major horticultural crop in the Godavari delta area of Andhra Pradesh. It is known that coconut is being cultivated with various cropping systems which return good sustainable income. Though Coconut is known for its hardness against various biotic and abiotic stress, the environmental pollution done by human interference is also one of the major concerns which deteriorate the palm health. Metal contamination issues are becoming more and more common in mining industries, foundries, smelters, coal-burning power plants, and agriculture. As land application becomes one of the foremost waste utilization and disposal practices, soil is increasingly being seen as a major source of metals reaching food chain, largely through plant uptake and animal transfer. Heavy metal buildup in soils is of concern in agricultural production due to the adverse effects on crop growth due to phytotoxicity, and environmental health too. Metal toxicity has high influence on plants, and consequently, it affects the ecosystem, where the plants form an integral component. A few

metals, including copper, manganese, iron, cobalt, zinc, and chromium, are, however, essential to plant metabolism in trace quantities. It is only when metals are present in bioavailable forms and at excessive levels; they have the potential to be toxic to the plant life by interfering metabolism. Plants growing in metal polluted ecosystem express changes in metabolism, growth reduction, lower biomass production, and metal accumulation. Various physiological and biochemical processes in plants are affected by metal toxicities.

Recently in Andhra Pradesh the coconut palms aged ~ 35 years in fields irrigated with water from bore wells in close proximity with oil exploration rigs of M/s ONGC and M/s Oil India Ltd. In Billakurru village and Lanka of Thane Lanka village, respectively have been dying later to the drilling of oil wells only. In this connection the investigation was taken up by the committee constituted by the district collector East Godavari, Andhra Prdesh.

Billakurru village of Kothapeta mandal

Farmers cultivating coconut reported sudden death of palms in January 2021. The officials of the Dept of Horticulture and Scientists of HRS, Ambajipeta visited the fields and collected soil, water and leaf samples for preliminary investigations and gathered pertinent information from the farmers. The farmers reported that the problem was never encountered before and has been experienced only after oil exploratory well was dug by ONGC in 2019. They also reported that palms in the fields that have been irrigated with water from bore wells in proximity with the ONGC well were only affected. Preliminary analysis of samples showed only marginal differences in estimated parameters between healthy and affected areas. Isolations from infected samples yielded weak pathogens which usually affect plants subjected to stress. Pathogenicity tests with the isolated cultures of organisms were not successful on actively growing tissues but could produce symptoms on detached tissues indicating their status as weak pathogens.

The committee on 27.10.2021 observed that the number of dead palms rose to ~ 1000 from the initial ~30 in January 2021 with more palms beginning to show symptoms. It was observed that palms aged ~ 35 years in fields irrigated with water from bore well ~ 200 to 600 m away in west north direction from the ONGC exploratory well (with lagoons filled with the sludge removed from deep layers) are only showing symptoms while coconut palms in fields in other directions were found healthy.

Coconut grove along the road between the two affected fields that received no irrigation from the bore wells also was found healthy. Since the isolated organisms are weak pathogens that can attack stressed tissues only and the fact that the coconut palms in a grove between two affected fields were healthy indicating no spread of the pathogen to actively growing palms, involvement of a pathogen as a primary origin of the problem could not be established. Adhoc attempts with fungicides to manage the likely pathogenic origin were unsuccessful.

Other crop plants like banana, turmeric, sweet orange, rice, sapota, mango etc. were found healthy without any signs of stress at all in the fields in which coconut was affected. Hon'ble MLA and Government Whip along with farmers interacted with the committee and requested for an early solution to the problem for the benefit of farmers

Lanka of Thane Lanka village of Mummidivaram mandal

Coconut palms aged ~ 30 years in fields adjacent to the drilling site and sludge tanks of M/s Oil India Ltd have been reported dying since 2017, two to four years after drilling of oil well and storing of the sludge in tanks. The committee on 27.10.2021 observed that all the palms in the closely adjacent field are dead while in the neighbouring fields also, death of palms was sporadic and a few palms are showing signs of being closer to death. So far ~300 palms have died in these fields. The neighbouring fields have been irrigated with water from bore wells for several years but the problem surfaced only after drilling and dumping of the sludge in the tanks. Palms in the fields that have been away spatially separated by drain trenches and roads and are at a higher elevation from the drilling site were found healthy. As was observed in Billakurru, no plant species other than coconut showed any signs of stress.

The investigations conducted during 2021 - 2022 involving field and lab studies by the team of Scientists comprising Dr.V. Govardhan Rao, Scientist (Pl. Path.) HRS, Ambajipet, Dr. B. Srinivasulu, Director of Extension & University Head, Dept. of Pl. Path., Dr. YSRHU, V.R.Gudem; Dr.J.Krishna Prasad Ji, Principal Scientist [Plant Pathology], ANGARU-College of Agriculture, Rajahmundry, East Godavari district, Dr. B.V.K.Bhagavan,

Principal Scientist(Hort.) & Head; HRS, Ambajipet Dr. N.B.V. Chalapathi Rao, Principal Scientist (Ent.) HRS, Ambajipet, Dr.CH. Srinivas Principal Scientist [Soil Science] ANGARU-RARS-Maruteru, West Godavri district, and other Department Officers Sri. M. Mallikarjun, ADH, Horticulture, Amalapuram and Sri. A. Amarnath, Horticulture officer, Kothapet, Pollution control board, ground water board officials attended on THIS at Nellivaripeta (H) Billakurru (V) Kothapet (M) East Godavari district and Thane Lanka village of Mummidivaram Mandal. The continuous follow up and monthly observation collected during the last six months revealed the nature of disease. The gardens were about 25 to 30 years of age in Godavari alluvial soils and inter cropping with banana in an extent of 5 acres showing unusual death. Over a period of six months the incidence has increased the spread over 10 acres of adjacent fields. Keeping the severity of the damage the investigation was taken up. This article details the range of various abiotic parameters heavy metals, toxicity for plants, and symptoms of coconut palms to cope with metal toxicity.

MATERIALS AND METHODS

Farmers cultivating coconut palms aged ~ 35 years in fields irrigated with water from bore wells in close proximity with oil exploration rigs of M/s ONGC and M/s Oil India Ltd. have been dying later to the drilling of oil wells only at Nellivaripeta hamlet, Billakurru village, and Lanka of Thane Lanka village, respectively under the jurisdiction of Dr.YSR Horticultural University-Horticultural research station, Ambajipeta, East Godavari District, Andhra Pradesh reported sudden death of palms in January 2021. The officials of the Dept of Horticulture and Scientists of HRS, Ambajipeta visited the fields and collected soil, water and leaf samples for preliminary investigations and gathered pertinent information from the farmers. Preliminary analysis of samples was done at Central Research Institute for Dry Land Agriculture [CRIDA],Hyderabad.

INVESTIGATION ON BIOTIC FACTORS

Laboratory investigation for biotic studies: The collected disease specimens were carried out the laboratory investigation for bacterial and fungal organisms.

Isolation of the disease specimens: Infected leaf sheath, roots, inflorescence and growth point were collected from the symptoms expressed palms in the field. These samples were surface sterilized with mercuric chloride and dissected as small section to place on PDA and NA medium. Observed for growth of fungal and bacterial colonies.

Detached leaf technique: under aseptic conditions 8 mm dia mycelial plugs obtained from PDA medium was inoculated by plugged on petiole base of coconut fronds created with a 9-mm wound with a cork borer. Control plants mock-inoculated with PDA plugs. The inoculated area covered with moisture cotton swabs to maintain enough moisture and kept in BOD incubator for 7 days and observed the symptoms (Al-Naemi *et al*., 2014)

Potted plant experiments for Pathogenicity studies: The pathogenicity studies conducted in the laboratory to confirm the pathogen by mycelia plugging to the rachis of the fronds on the 9 months old coconut palms, 7 days old mycelia disc taken from the test pathogen and plugged in the cork borer made holes on the rachis and cover with moist cotton swabs. The plants covered with polythene bags to maintain humidity in the screen house. The inoculated palms were observed up to 30 days for symptom expression.

***In vitro* efficacy of fungicides**

Selected fungicides (each @ 100, 250, 500 ppm) tested *in vitro* against test pathogen (*Lasiodiplodia theobromae* using poisoned food technique and Potato dextrose agar (PDA) as a basic culture media. Based on the active ingredient, the necessary quantity of test fungicides were determined and thoroughly mixed with autoclaved and cooled (40^{o}C) PDA medium to obtain desired concentrations in conical flasks separately. This PDA medium was then poured aseptically in Petri plates (90 mm dia.) with the sample fungicides separately (20 ml / plate) and allowed to solidify at room temperature. Three plates / treatment / replication were maintained for each of the sample fungicide and its target concentrations.

After solidification of the PDA medium, all the plates were aseptically inoculated by placing a 5 mm culture disk of test pathogen in the center obtained from the 7 days old pure culture of test pathogen and incubated in an inverted position at 28±2 ^{o}C. Petri plates filled with plain PDA (without any fungicide) and inoculated with pure culture disc of

test pathogen were maintained as untreated control.

By applying the following equation per cent inhibition of the test pathogen with the test fungicides over untreated control was calculated.

$$\text{Per cent inhibition} = \frac{C - T}{C} \times 100$$

Where,

C = growth of the test fungus in untreated control plate

T = growth of the test fungus in treated plate

Experimental Details: Combi- fungicides

Design: : C.R.D. (Completely Randomized Design)
Replications : Three
Treatments : Nine

Combi/Contact- fungicide treatments

Tr. No.	Treatments	Tr. No.	Treatments
T_1	Copper oxy chloride 50 WP	T_6	Tebuconazole 39% sc@ 30
T_2	Metalaxyl 8 % + Mancozeb 64 % WP	T_7	Hexaconazole 5 EC
T_3	Hexaconazole 5% SC + Validamycin 25% SC	T_8	Control (Untreated)
T_4	Azoxystrobin 11% + Tebuconazole 18.3% SC		
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG		

Pot culture study: The coconut variety Dr.YSRHU-Gowthami Ganga seedlings at the age of 9 months were selected for planting in the poly bags and filled with potting mixture. The planted seedlings allowed recovering for one month. The seedlings were used to inoculate with test pathogen using mycelia plugs. Inoculated portion was covered with moist cotton swab. The total plant was covered with polythene bag to maintain humidity inside the bag. The inoculated plants were observed for 30 days for symptom expression.

Management of unusual death at field condition: Ad hoc treatments were given to the damage prone areas where unusual death observed. Treatments given as soil drenching, root feeding, foliar spray and crown drenching with contact and systemic fungicides.

INVESTIGATION ON ABIOTIC FACTORS

Preliminary processing of collected samples carried out at HRS, Ambajipeta and send for analysis at accredited laboratory namely Andhra Pradesh State Pollution Control Board - Vishakhapatnam, Central Research Institute for Dry land Agriculture [CRIDA]-Hyderabad and VIMTA Laboratory-Hyderabad. Soil, water, from affected and healthy fields besides soil and sludge samples from Oil well sites at Billakurru and Lanka of Thane Lanka villages were collected and analyzed

Table 1. Ad hoc field treatments with chemical fungicides

Tr.No.	Treatment details
T1	Soil drenching of COC @ 3g/l were given
T2	Soil Drenching of Azoxystrobin 11% + Tebuconazole 18.3% SC (CUSTODIA)(@30 ml in 15 L of water/palm
T3	Soil Drenching of Tebuconazole 50%+ Trifloxystrobin 25% w/w WG (NATIVO) (75 WG)@ 30 g in 15 l of water
T4	Soil Drenching of Hexaconazole 5% SC + Validamycin 25% SC (VALIDEX)@ 30 ml in 15 L of water/palm
T5	Soil Drenching of Tebuconazole 39% sc@ 30 ml in 15 l of water
T6	Soil drenching of Metalaxyl + Mancozeb @ 2.5 g/l
T7	Foliar spray+Crown pouring Azoxystrobin 11% + Tebuconazole 18.3% SC(CUSTODIA)@ 30 ml in 15 L of water
T8	Foliar spray+Crown pouring of Tebuconazole 39% sc@ 10 ml in 5 l of water
T9	Foliar spray+Crown pouring of Hexaconazole 5% SC + Validamycin 25% SC VALIDEX)@ 10 ml in 5 L of water/palm
T10	Foliar spray+Crown pouring of Tebuconazole 50%+ Trifloxystrobin 25% w/w WG (75 WG) (NATIVO)@ 10 g in 5 L of water/palm
T11	Foliar spray+Crown drenching of Metalaxyl + Mancozeb @ 2.5 g/l
T12	Foliar spray+Crown drenching of COC @3 g/l + Plantomycin @ 1 gm/10 l
T13	Foliar spray+Crown drenching of Hexaconazole@1ml/l,
T14	control

Design- RBD, Replications-4, Interval -20 days and three times

Sample collection at Billakurru village

Samples type	Infected (I)	Infected healthy (H)	Control ©
Soil	10	5	5
Leaf	10	5	5
Root	10	5	5
Inflorescence	5	3	2
Water	4	0	2
Sub Total	**35**	**18**	**17**
Total samples to beanalyzed		35+18+17+6 =76	

Sample collection at Thane Lanka

Samples type	Infected (I)	Infected healthy (H)	Control ©
Soil	5	3	2
Leaf	5	3	2
Root	5	3	2
Inflorescence	2	1	1
Water	3	0	2
Sub Total	20	10	9
Total samples to beanalyzed		20+10+9=39	

Experimental design and analysis

The experiment was carried out in vitro and pot culture studies in completely randomized design. Observations on the number of palms affected were recorded. Pre treatment data were recorded in all treatments before commencement of spraying. Sprayings were done at 20 days interval and recorded the data. The incidence of disease was estimated using the following equation (Mayee and Datar, 1986).

$$\text{Incidence (\%)} = \frac{\text{Number of palms infested}}{\text{Total number of palm}} \times 100$$

RESULTS

The present study was conducted on unusual death of coconut during 2021-22 on various aspects, such as survey, symptomotology, isolation, pathogenicity and identification (pathogenic, cultural, morphological and molecular) of *Lasiodiplodia theobromae* isolates. The observations of all aspects were analyzed and interpreted in the following subheadings. Pathogenicity study and *in vitro* studies on bio-efficacy of fungicides, were conducted in the Department of Plant Pathology, Dr.YSRHU-HRS, Ambajipeta. Management of unusual death with ad hoc treatments was conducted at farmers field where the unusual death was noticed. The results of laboratory, screen house, field experiments and management of unusual death of coconut are presented in following pages under different subheadings.

BIOTIC STUDY

Symptoms observed: The constant observation during last six months revealed the symptoms include necrosis at the base of the petiole, blackening at the base of the petiole resulting the drooping and yellowing of leaves. At the same point rotting of spathe and dropping of nuts were also noticed. In severe condition, when the infection reaches the growth point the crowns would fall down (Toppling) and the rotten growth point emitting foul smell. But spindle is still looking green up to the toppling stage.

Diseased plant samples were collected on the basis of symptoms observed during field visit by the usual pathogen (*Lasiodiplodia theobromae*) in coconut. These infected root, inflorescence and leaf samples were washed thoroughly in tap water and dried between folds of the filter papers. The samples were then kept in labeled paper bags properly and preserved at room temperature in laboratory The collected disease specimens were carried out the laboratory investigation for bacterial and fungal organisms. These organisms were sent to the Agarkar Research Institute, Pune for identification and the list of organisms identified are 1. *Ceratocystis* sp. 2. *Lasidiplodia* sp. 3. *Fusarium* sp. 4. *Monochaetia* sp AND one bacteria, i.e 5. *Providencia vermicola* .In addition to that the inflorescence samples were collected and sent to the Scientist (Pl.Pathology) CPCRI, Kasaorgod for Phytoplasma investigation. However, its presence has not ascertained by the Scientist.

Pathogenicity syudy: Pathogenicity of the test pathogen was studied with detached leaf method (Plate 6) under laboratory conditions and screen house using susceptible coconut variety DrYSRHU-Gowthami ganga. The pathogenicity studies confirmed the pathogen inoculated with *Lasiodiplodia theobromae* isolate has shown the symptoms and reisolated the same. However the pure culture of the same pathogen used for pot culture palms were not expressed the symptoms. It shows the status of the pathogen as a weak pathogen where it is not able to infect the active tissues.

Disease management strategies

***In vitro* evaluation of systemic fungicides**

Mycelial growth

Results revealed that all the tested eight systemic fungicides exhibited significant effect on radial mycelial growth of *Lasiodiplodia theobromae* where the radial growth was decreased with increase in concentrations (100, 250 and 500 ppm) of test fungicides.

Results revealed that among the fungicides tested Tebuconazole 39% SC, Hexaconazole 5% SC, Azoxystrobin 11% + Tebuconazole 18.3% SC and Hexaconazole 5% SC + Validamycin 25% SC and Tebuconazole 50% + Trifloxystrobin 25% WG were significantly inhibited the mycelia growth ranged from 0 mm to 5 mm under *in vitro* conditions. However, the fungicides Copper oxy chloride 50 WP and Metalaxyl 8 % + Mancozeb 64 % WP were not found effective under in vitro conditions where no growth inhibition observed (Table 1, Plate 7).

Management of unusual death at field conditions with ad hoc treatments

In agreement with the preliminary management practices conducted ad hoc under *in vitro*, it was further proceeded to investigate and manage the unusual death of coconut at field level during 2021-22. Though the integration of selective and best treatments from in vitro studies, none of the treatments has shown 100 per cent control of unusual death of coconut. Among the treatments Foliar spray + Crown pouring of Tebuconazole 39% sc@ 10 ml in 5 l of water, Foliar spray+Crown pouring of Hexaconazole 5% SC + Validamycin 25% SC (VALIDEX) @ 10 ml in 5 l of water/palm and Foliar spray+Crown drenching of Hexaconazole@1ml/l were showed only 25% of mortality. Where as some of the fungicides which are effective as crown drenching are less affective as soil application method by 75%. However they were delayed the expression of the symptoms.

ABIOTIC FACTORS STUDY

Since no known cause of death of the palms could be observed, the committee is of the opinion to collect and analyse soil and sludge samples from the drilling site of M/s Oil India Ltd and soil, water and coconut plant tissues for ascertaining the cause of death of palms. The committee felt the need for analysis of samples for certain parameters by collecting the samples during summer period taking into consideration the temporal variability in ground water quality and also for the purpose of confirmation. Accordingly, samples were collected and got analysed by a Ministry of Environment and Forests, Government of India accredited laboratory for a few parameters which showed significant variation in samples between affected and healthy fields. The following are the salient results and inferences of analyzed samples from affected and healthy fields.

Perusal of the data of analysis from the accredited laboratories engaged by M/s ONGC and M/s Oil India Ltd revealed no significant differences between samples from affected and control fields.

Since the samples are heterogeneous in location of collection, the likelihood of variability in results received from the accredited laboratory engaged by the PD (APMIP) & DDH, East Godavari district indicated significant differences between samples from affected and healthy fields for majority of the parameters tested. Hence, the results from the latter accredited laboratory were considered relevant and reliable for interpretation.

Of all the parameters, EC in soil (57-2670 µS/cm in affected plots, 74-78 µS/cm in control area in

Table 1. Fungicide treatments

Tr. No.	Treatments	Mycelial Growth [mm]
T_1	Copper oxy chloride 50 WP	90[68.41]
T_2	Metalaxyl 8 % + Mancozeb 64 % WP	90[66.75]
T_3	Hexaconazole 5% SC + Validamycin 25% SC	5[13.83]
T_4	Azoxystrobin 11% + Tebuconazole 18.3% SC	5[13.17]
T_5	Tebuconazole 50% + Trifloxystrobin 25% WG	5[13.76]
T_6	Tebuconazole 39% SC	0[0.0]
T_7	Hexaconazole 5% SC	0[0.0]
T_8	Control	90[71.73]
	CD@1%	3.11
	SEm	1.06

Thane Lanka) and water samples (750-11-5 µS/cm in affected plots, 674-755 µS/cm in control area in Billakurru, 3380-30940 µS/cm in affected plots, 1490-2960 µS/cm in control area in Thane lanka) (Table 3).

Aluminum (Al) in water (<0.01 – 1.95 mg/l in affected plots, 0.15-0.28 mg/l in control area in Billakurru, 2.54 – 108.9 mg/l in affected plots, 0.06 – 0.78 mg/l in control area in Thane lanka) and plant (9.66 – 33.14 ppm in affected plots, 10.39- 11.25 ppm in control area in Billakurru, 11.47- 14.92 ppm in affected plots, 8.45-12.91 ppm in control area in Thane lanka) were found to be in higher concentration in samples from affected fields than the healthy fields (Table 4).

Results of the plant sample analysis revealed a substantially higher Al content in plant samples from affected palms than in samples from healthy palms (Table 5).

DISCUSSION

Biotic Factors Study: Isolations from infected

Table 2. Ad hoc treatments given to manage the unusual death in coconut

Tr. No.	Treatment details	% Mortality at 45 DAT
T1	Soil drenching of COC @ 3g/L were given	100
T2	Soil Drenching of Azoxystrobin 11% + Tebuconazole 18.3% SC (CUSTODIA)(@30 ml in 15 L of water/palm at 60 days interval	100
T3	Soil Drenching of Tebuconazole 50%+ Trifloxystrobin 25% w/w WG (NATIVO) (75 WG) @ 30 gm in 15 L of water	100
T4	Soil Drenching of Hexaconazole 5% SC + Validamycin 25% SC (VALIDEX)@ 30 ml in 15 L of water/palm	75
T5	Soil Drenching of Tebuconazole 39% sc@ 30 ml in 15 L of water	75
T6	Soil drenching of Metalaxyl + Mancozeb @ 2.5 g /l	100
T7	Foliar spray+Crown pouring Azoxystrobin 11% + Tebuconazole 18.3% SC(CUSTODIA) @ 10 ml in 5 L of water	75
T8	Foliar spray+Crown pouring of Tebuconazole 39% sc@ 10 ml in 5 L of water	25
T9	Foliar spray+Crown pouring of Hexaconazole 5% SC + Validamycin 25% SC VALIDEX) @ 10 ml in 5 L of water/palm	25
T10	Foliar spray+Crown pouring of Tebuconazole 50%+ Trifloxystrobin 25% w/w WG (75 WG) (NATIVO)@ 10 g in 5 L of water/palm	75
T11	Foliar spray+Crown drenching of Metalaxyl + Mancozeb @ 2.5 g /L,	100
T12	Foliar spray+Crown drenching of COC @3 g/l +Plantomycin @1g/10 L	100
T13	Foliar spray+Crown drenching of Hexaconazole@1ml/L,	25
T14	control	100

Table 3. Soil Analysis Report

Parameter	Unit	Soil Analysis Report							
		Billakurru				Lanka of Thanelanka			
		Infected		Control		Infected		Control	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
EC (1:5 aqueous extract)	µ S/cm	57-2670	583.2	74-78	76	114-9670	3309	65-175	120

Table 4. Water Analysis Report

Parameter	Unit	Water Analysis Report							
		Billakurru				Lanka of Thanelanka			
		Infected		Control		Infected		Control	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Aluminium	mg/l	0.01-4.95	1.315	0.15-0.286	0.218	25.48-108.9	61.733	0.065-0.781	0.423

Table 5. Leaf Samples

Test Parameters	Leaf Samples					
	Billakurru Village			Tane lanka		
	Farmer 1	Farmer 2	Farmer 3	Healthy field	Affected field	Healthy field
Distance from oil well	200 m	800 m	1000 m	2000 m	200 m	2000 m
Al (mg/kg)	294.46	130.77	40.82	9.64	75.62	9.64

samples yielded weak pathogens which usually affect plants subjected to stress. Pathogenicity tests with the isolated cultures of organisms were not successful on actively growing tissues but could produce symptoms on detached tissues indicating their status as weak pathogens. Coconut grove along the road between the two affected fields that received no irrigation from the bore wells also was found healthy. Since the isolated organisms are weak pathogens that can attack stressed tissues only and the fact that the coconut palms in a grove between two affected fields were healthy indicating no spread of the pathogen to actively growing palms, involvement of a pathogen as a primary origin of the problem could not be established.

Adhoc attempts with fungicides to manage the likely pathogenic origin were unsuccessful. Other crop plants like banana, turmeric, sweet orange, rice, sapota, mango etc. were found healthy without any signs of stress at all in the fields in which coconut was affected. Based on the above observations the committee felt it imperative to collect and analyse more water, soil and coconut plant samples from both healthy and infected fields as also the soil and sludge samples from lagoons at ONGC well to conclusively establish the cause of the death of palms.

Abiotic Factors Study: Plants differ in their tolerance to physico-chemical characters of soil and water. Depending upon their propensity for uptake of elements, differences in accumulation of elements in tissues of plant species occur. Very high electrical conductivity in soil and water samples indicated high presence of salts in affected fields than in healthy fields. Substantially higher Al content in plant samples from affected palms than in healthy palms indicated a higher Al uptake by coconut palms in affected fields than in healthy fields.

Coconut is known to withstand to substantial salinity. Aluminum is not an essential element. Although listed under beneficial elements, it is reported to be toxic at higher concentration to some plants particularly which are known to be susceptible to Aluminum at a concentration of above 200 µM Al (Cristancho *et al.,* 2011) as it causes membrane disruption through peroxidation of lipids.

Since the palms that were irrigated from water from the bore wells in the proximity of Oil exploration wells only have been affected at both the locations, the cause of the problem could be attributed to the higher electrical conductivity (Table 1) and Al content in water (Table 2) which might have risen in concentration post drilling of the oil exploration wells which is supported by the reasons such as. A] The palms in the affected fields were healthy prior to drilling of the oil exploration wells at both the locations. B]Decreasing Al content in plant tissues of palms with increasing distance from the oil wells bolsters, and C] Symptom expression and nature and progression of damage have been found similar in both the locations

CONCLUSION

Based on the observations and chemical analyses of soil, water and plant samples, death of the palms in the affected fields is attributed to higher salt concentration in general and Al in particular may be reason for the stress which consequently weakens the host and chance to opportunistic plant pathogens to cause the infection and death of the coconut.

REFERENCES

Al-Naemi, F. A., Nishad, R. and Ahmed, T. A. 2014. First report of *Thielaviopsis punctulata* causing black scorch disease on date palm in Qatar. *Plant Dis*. 98: 1437.

Cristancho, Jose, Hanafi, Mohamed, Omar, Syed, Rafii, M., Martínez, Fernando, Castilla and Carlos, 2011. Alleviation of aluminum in acidic soils and its effect on growth of hybrid and clonal oil palm seedlings. *Journal of Plant Nutrition - J PLANT NUTR. 34*. 387-401. 10.1080/01904167.2011.536880.

Mayee, C. D. and Datar, V. V. 1986. *Phytopathometry*. Tech. Bull.-1 Marathwada Agric. Univ. Parbhani. pp. 66.