



ISSN (E): 2277-7695

ISSN (P): 2349-8242

NAAS Rating: 5.23

TPI 2023; 12(12): 1853-1856

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www.thepharmajournal.com

Received: 13-10-2023

Accepted: 27-11-2023

B Neeraja

Ph.D. Scholar, Department of Plant Pathology, Agriculture College, Bapatla, Andhra Pradesh, India

V Prasanna Kumari

Professor and Head, Department of Plant Pathology, Agriculture College, Bapatla, Andhra Pradesh, India

K Gopal

Associate Dean, Professor, Department of Plant Pathology, College of Horticulture, Anantharajupeta, Andhra Pradesh, India

G Vijaykumar

Assistant Professor, Department of Entomology, college of Agriculture, Bapatla, Andhra Pradesh, India

Occurrence of the cocoa *Phytophthora* pod rot disease in Andhra Pradesh

B Neeraja, V Prasanna Kumari, K Gopal and G Vijaykumar

Abstract

Pod rot disease in cocoa (*Theobroma cacao* L), caused by *Phytophthora palmivora*, has been identified as one of the main production constraints in all cocoa growing areas across the world. *Phytophthora palmivora* (Butler) is a hemibiotrophic oomycete capable of infect over 200 plant species. To assess the mapping and prevalence of black pod rot disease in major cocoa growing areas viz., East Godavari, West Godavari and Srikakulam districts of Andhra Pradesh (2020-2021 & 2021-2022). An intensive roving survey was conducted among the mandals surveyed, Nagullanka mandal had the highest mean cocoa pod rot incidence (84.19%) and cocoa pod rot severity (51.66%), followed by Ainavelli mandal in East Godavari district with 77.72% pod rot incidence and 37.93% pod rot severity and Chagallu mandal in West Godavari district with 73.82% pod rot incidence and 33.92% pod rot severity. Dwaraka Tirumala mandal in west Godavari district had the lowest percentage of pod rot incidence (11.65%) and severity (4.81%), followed by Kaviti mandal in Srikakulam district, which had 13.98% pod rot incidence and 8.50% pod rot severity.

Keywords: Cocoa, Pod rot, Disease incidence and Disease severity

Introduction

Pod rot disease in cocoa (*Theobroma cacao* L), caused by *Phytophthora palmivora*, has been identified as one of the main production constraints in all cocoa growing areas across the world. *Phytophthora palmivora* (Butler) is a hemibiotrophic oomycete capable of infect over 200 plant species, including one of the most economically important crops, *Theobroma cacao* L. (cocoa). It infects different parts of the cocoa plant, including the main stems, jarquets, cushions, and pods, resulting in black pod rot and stem canker disease. The disease spreads by infected plant debris, soil, and water.

Though cocoa being raised as intercrop with coconut and oil palm especially in Andhra Pradesh, its area has increased considerably from 24,156 ha (2016-2017) to 36,455 ha (2019-2020) due to increased industrial importance of cocoa (dccc.gov.in). The increasing popularity of chocolate and the drink cocoa is self-evident, as evidenced by the many "chocolate lovers" who look forward to special occasions and national holidays when chocolate is traditionally given as a gift to loved ones and friends. The demand for chocolate is increasing, and the question now is whether the world supply of a product derived solely from a tropical, rainforest-dwelling tree will be sufficient to meet the demand. Several important fungal diseases and pests have gained prominence in the last two decades and pose a serious threat to the supply of chocolate.

Cacao black pod rot is caused by a pathogen in the genus *Phytophthora*, which means as "plant destroyer." This is the genus that caused the Irish potato famine of 1845-1852. These pathogens were originally classified as fungi, but they have since been reclassified as Stramenopila. There are over 80 *Phytophthora* species that cause plant diseases, with several, including *P. palmivora*, *P. megakarya*, *P. citrophora*, and *P. capsici*, being responsible for cacao black pod rot. *Phytophthora* spp. is responsible for 20 to 30% of the total cacao crop loss each year, with some plantations losing up to 90% of their pods due to the disease (Acebo-Guerrero, 2012) [1].

Materials and Methods

A roving survey was conducted during monsoon 2020-2021 and 2021-2022 to assess the disease incidence of pod rot disease in major cocoa growing mandals of East Godavari, West Godavari and Srikakulam districts of Andhra Pradesh. In every mandal, two villages and in each village, two to five gardens were surveyed at random.

Corresponding Author:

B Neeraja

Ph.D. Scholar, Department of Plant Pathology, Agriculture College, Bapatla, Andhra Pradesh, India

In each field, disease incidence and severity was recorded. The disease incidence in the fields will be assessed with the following formula (Jayalakshmi *et al.*, 2017)^[4].

Percent disease incidence = (No. of plants infected/Total number of plants examined) x 100

The pod rot affected pods were collected during survey were brought to laboratory in brown paper cover and were used for pathogen isolation. The disease severity is calculated based on the pod rate scale obtained from the CPCRI, Vittal (0-8 scale) Disease severity was calculated as per the following formula given by Wheeler (1969)^[7].

$$\text{Disease severity (\%)} = \frac{\text{Sum of individual disease ratings}}{\text{Number of pods disease scored} \times \text{Maximum disease scale}} \times 100$$

Data was collected during the survey was documented as per the proforma mentioned in results

Results and Discussion

Cocoa Pod Rot Disease Occurrence in Andhra Pradesh

Incidence and severity of cocoa pod rot disease were studied in five gardens in a village, two villages in a mandal and two mandals in East Godavari, West Godavari and Srikakulam districts of Andhra Pradesh during the monsoon seasons of 2020-2021 and 2021-2022. In the surveyed gardens, percent disease incidence and percent disease severity on pods was calculated (Table 1).

Pod rot disease incidence was observed in all the surveyed gardens in all districts and varied in its incidence and severity. Pod rot disease incidence of 60.16% was observed in East Godavari district when compared to the west Godavari (39.26%) and Srikakulam districts. In East Godavari district, the incidence of pod rot ranged from 21.23% to 85.25%. In West Godavari district, the disease incidence ranged between 10.98% to 84.52% with the lowest mean incidence of 10.98% among the villages surveyed in all the three districts. In Srikakulam, the disease incidence ranged between 12.21% to

22.35%. (Table 2).

East Godavari district have a very high level of disease incidence (60.16%) and severity (28.56%) compared to West Godavari district, which have a disease incidence (39.26%) and severity (17.03%) and Srikakulam district, which had a disease incidence (17.21%) and severity (5.48%). This could be related to the fact that the majority of gardens use flood irrigation, and alluvial soils have better water retention than sandy soils, where disease development is more prevalent due to the favorable conditions. (Table 1). Increased soil moisture in high-rainfall locations can increase the chance of black pod rot. (Vanegtern *et al.*, 2015)^[6]. Several gardens in the East Godavari district fail to carry out timely pruning, which results in a more closed crop canopy where appropriate sunlight and air cannot penetrate leads to high humidity. Pathogen isolate (EGPPI) from Avidi village, Kothapeta mandal of East Godavari district (82.35% cocoa pod rot incidence and 32.54% disease severity) was selected for morphological, pathological and molecular characterization. Peter and Chandramohan, (2011)^[5] conducted random survey of cocoa gardens in four southern cocoa growing states of India and reported that Phytophthora diseases such as pod rot, black pod, stem canker and seedling blight as major problems in cocoa that are leading to heavy economic loss to the growers. They reported that stem canker caused by *Phytophthora palmivora* caused 45.14 percent disease incidence in Andhra Pradesh.

Cocoa pod rot disease incidence and severity varied differentially within and among the districts surveyed. Of the six mandals surveyed, Nagullanka mandal of East Godavari district was found with the highest mean disease incidence (84.19%) and (51.66%). The lowest mean disease incidence (11.65%) and severity (4.81%) was recorded in Dwaraka Tirumala mandal of West Godavari district. It was noticed that disease incidence and severity is more in East Godavari district, where the gardens are mostly with flood irrigation compared to West Godavari and Srikakulam districts, where majority of the gardens are with drip irrigation system

Table 1: Prevalence of cocoa pod rot disease in major cocoa growing areas of Andhra Pradesh during monsoon season during 2021-2022

District	Mandal	Village	GPS Coordinates	Pod rot Disease incidence (%)	Pod rot Disease severity (%)	Cropping pattern	Irrigation	Soil type
East Godavari	Kothapeta	Avidi	16.6744,°N 81.9040°E	82.35	32.54	Coconut + cocoa	Flood irrigation	Alluvial
		Modekurru	16.6533,°N 81.9286°E	21.23	17.25	Coconut + cocoa	Flood irrigation	Alluvial
		Palivela	16.6859,°N 81.8747°E	78.23	22.24	Coconut + cocoa	Flood irrigation	Alluvial
		Mandal Mean		66.60	24.01			
	Ainavelli	Tottaramudi	16.6871°N 81.0926°E	85.22	40.28	coconut+ cocoa + arecanut	Flood irrigation	Alluvial
		k.jaganadhapuram	16.63822°N 82.0397°E	69.72	35.28	coconut+ cocoa + arecanut	Flood irrigation	Alluvial
		Ainavelli lanka	16.6766°N 81.9906°E	78.21	38.22	Coconut + cocoa	Flood irrigation	Alluvial
		Mandal Mean		77.72	37.93			
	Ambajipeta	Pulletikurru	16.6382°N 81.9436°E	42.80	22.54	Coconut + cocoa	Flood irrigation	Alluvial
		Vyagrareswaram	16.6392°N 81.9343°E	38.29	13.54	Coconut + cocoa	Flood irrigation	Alluvial
		Mandal Mean		40.55	18.04			
	Mummidivaram	Lanka of thane Lanka	16.6700°N 82.0877°E	45.30	17.72	Coconut + cocoa	Flood irrigation	Alluvial
Pallivaripalem		16.6871°N	29.12	16.56	coconut+ cocoa	Flood	Alluvial	

			81.0926°E			+ arecanut	irrigation		
		Mummidivaram	16.6391°N 82.0999°E	35.50	14.19	Coconut + cocoa	Flood irrigation	Alluvial	
		Mandal Mean		36.64	16.16				
	Allavaram	Kodurupadu	16.5370°N 82.0079°E	68.54	32.21	Coconut + cocoa	Flood irrigation	Alluvial	
		Immidivarapadu	16.5409°N 82.0056°E	42.00	14.85	Coconut + cocoa	Flood irrigation	Alluvial	
		Mandal Mean		55.27	23.53				
	Nagullanka	Gannavaram	16.5412°N 82.0063°E	83.12	44.72	Coconut + cocoa	Flood irrigation	Alluvial	
		Gudimellanka	16.4252°N 81.8065°E	85.25	58.59	Coconut + cocoa	Flood irrigation	Alluvial	
		Mandal Mean		84.19	51.66				
		District Mean		60.16	28.56				
	West Godavari	Chagallu	Kalavalapalli	16.6871°N 81.0982°E	84.52	28.32	Oilpalm + Coconut + cocoa	Drip irrigation	Sandy soil
			Chagallu	16.9856°N 81.6675°E	63.12	39.52	Coconut + cocoa	Drip irrigation	Sandy soil
Mandal Mean			73.82	33.92					
Denduluru		Naguladevinapalem	16.8324°N 81.1856°E	34.25	13.71	Coconut + cocoa	Drip irrigation	Alluvial	
		Challachintalapudi	16.8565°N 81.2122°E	48.25	20.68	Coconut + cocoa	Drip irrigation	Sandy loam soil	
		Mandal Mean		41.25	17.20				
Pedavegi		koppulavarigudem	16.8272°N 81.1433 °E	54.28	16.83	Coconut + cocoa	Drip irrigation	Sandy loam soil	
		Pedavegi	16.8033°N 81.5053°E	73.45	32.21	Coconut + cocoa	Drip irrigation	Sandy loam soil	
		Mandal Mean		63.87	24.52				
Devarapalli		Yernagudem	16.6871°N 81.0926°E	25.12	14.81	Oilpalm + Coconut + cocoa	Drip irrigation	Alluvial	
		Chinnayagudem	17.0467°N 81.4836°E	14.40	8.34	Coconut + cocoa	Drip irrigation	Alluvial	
		Marallamudi	16.9240°N 81.3712°E	23.42	14.90	Coconut + cocoa	Drip irrigation	Sandy loam soil	
		Mandal Mean		20.98	12.68				
Nallagerla		Kothagudem	16.9128°N 81.3919°E	22.32	7.58	Coconut + cocoa	Drip irrigation	Sandy soil	
		Bheemadolu	16.9809°N 81.2379°E	25.65	10.50	Coconut + cocoa	Drip irrigation	Sandy soil	
		Mandal Mean		23.99	9.04				
Dwaraka Tirumala		Vempadu	16.8890 °N 81.2110°E	10.98	4.24	Oilpalm + cocoa	Drip irrigation	Sandy loam soil	
		Thimmapuram	16.9117°N 81.2489°E	12.32	5.37	Coconut + cocoa	Drip irrigation	Sandy loam soil	
		Mandal Mean		11.65	4.81				
		District Mean		39.26	17.03				
Srikakualm		Kaviti	Pragadaputtuga	19.0196°N 84.6952°E	15.65	11.73	Coconut + cocoa	Drip irrigation	Sandy soil
			Jagathi	18.5835°N 83.8995°E	12.21	5.26	Coconut + cocoa	Drip irrigation	Sandy soil
			Mandal mean		13.98	8.50			
		Ranasthalam	Ranasthalam	18.2021°N 83.6901°E	18.50	12.32	Oilpalm + cocoa	Drip irrigation	Red Sandy soil
		Pydibheemavaram	18.1408°N 83.6197°E	22.35	9.86	Oilpalm + cocoa	Drip irrigation	Red Sandy soil	
	Mandal mean		20.43	11.09					
	District Mean		17.21	9.80					

Overall all the surveyed villages, flood irrigation fields have more pod rot incidence compared to the drip irrigation fields.

Some times it may vary depends on density of the cropping systems.

Table 2: Cocoa pod rot incidence and intensity in different districts of A.P.

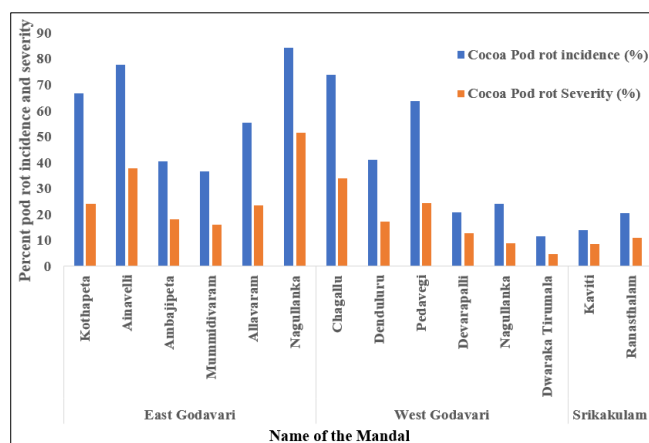
District	Cocoa Pod rot incidence (%)		Cocoa Pod rot Severity (%)	
	Range	Mean	Range	Mean
East Godavari	21.23 – 85.25	60.16	13.54 – 58.59	28.56
West Godavari	12.32 – 84.52	39.26	4.24 – 33.92	17.03
Srikakulam	12.21 – 22.35	17.21	5.26 – 12.32	9.80

Further, it may also be observed from the data that the gardens with flood irrigation had higher disease incidence compared with the gardens with drip irrigation systems. Majority of the cocoa gardens in East Godavari have the flood type of irrigation, the mean district pod rot incidence (60.16%) and severity (28.56%) compared to the west godavari district, where majority of the cocoa gardens have the drip type of irrigation, where the mean pod rot incidence (39.26%) and severity (17.03%) and same in srikakaulam district where, the mean pod rot incidence (17.21%) and severity (9.80%). The duration of free water, in soil or on foliage or fruit is the most important environmental factor in the development of disease caused by *Phytophthora* because it is during this time that propagules proliferate and infect (Erwin and Ribeiro 1996) [3].

Table 3: Cocoa pod rot disease incidence and disease severity in different mandals of A.P.

District	Mandal	Cocoa Pod rot incidence (%)	Cocoa Pod rot Severity (%)
East Godavari	Kothapeta	66.60	24.01
	Ainavelli	77.72	37.93
	Ambajipeta	40.55	18.04
	Mummidivaram	36.64	16.16
	Allavaram	55.27	23.53
West Godavari	Nagullanka	84.19	51.66
	Chagallu	73.82	33.92
	Denduluru	41.25	17.20
	Pedavegi	63.87	24.52
	Devarapalli	20.98	12.68
	Nagullanka	23.99	9.04
Srikakulam	Dwaraka Tirumala	11.65	4.81
	Kaviti	13.98	8.50
	Ranasthalam	20.43	11.09

Among the mandals surveyed, Nagullanka mandal had the highest mean cocoa pod rot incidence (84.19%) and cocoa pod rot severity (51.66%), followed by Ainavelli mandal in East Godavari district with 77.72% pod rot incidence and 37.93% pod rot severity and Chagallu mandal in West Godavari district with 73.82% pod rot incidence and 33.92% pod rot severity. Dwaraka Tirumala mandal in west Godavari district had the lowest percentage of pod rot incidence (11.65%) and severity (4.81%), followed by Kaviti mandal in Srikakulam district, which had 13.98% pod rot incidence and 8.50% pod rot severity. (Table 3 and Figure 1).

**Fig 1:** Cocoa pod rot disease incidence and disease severity in different mandals of A.P

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