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Coconut's Bud Rot by *Phytophthora palmivora*: A Destructive Disease

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Abstract

Phytophthora palmivora (Butler) is a cosmopolitan hemibiotrophic oomycete that may infect over 200 plant species, including *cocos nucifera*, one of the world's most valuable crops which is commonly called as Coconut. Coconut is a key economic commodity in India, plays an important role in contributing to India's GDP of about 15,000 crore rupees and 72% of worlds total production is from India and productivity is also high in India. Bud rot disease caused by *Phytophthora palmivora* grounds a significant amount of crop loss each year. *Phytophthora palmivora* infects many parts of the coconut plant including the buds, causing bud rot disease. This review focuses on the overview of Coconut production in India and *Phytophthora palmivora* infection to bud of coconut plant. We highlight some current findings on the bud rot disease of coconut caused by *Phytophthora palmivora*. This review examines the identification of *Phytophthora palmivora* as a cause of bud rot disease of coconut in India, its isolation, inhibition and discuss the importance of *Phytophthora palmivora* as a major threat to coconut palm plantings globally.

Keywords: *Cocos nucifera*; Bud rot; *Phyophthora palmivora*; Isolation; Inhibition

Introduction

The coconut tree (*Cocos nucifera*) is a solitary living species of the genus *Cocos*, which belongs to the palm tree family (Arecaceae). The name "coconut" (or "cocoanut") can refer to the entire coconut palm, the seed, or the fruit, which is botanically a drupe rather than a nut. After the three indentations on the coconut shell that mimic facial features, the term is derived from the 16th century Portuguese and Spanish word coco, which means "head" or "skull." Coconut belongs to Kingdom: Plantae, Order: Arecales, Family: Arecaceae, Subfamily: Arecoideae, Genus: *Cocos*, Species: *nucifera*. It is slender, leaning, ringed; trunk of the tree rises to a height of up to 25 m (80 feet) from a swollen base and is surmounted by a graceful mature fruits, ovoid or ellipsoid in shape [1]. The coconut palm is the world's most beneficial tree. Millions of people in the tropics have coconut as part of their culture, religion, environment, social status, and cuisine. Coconut is thought to be grown in more than 93 nations around the world, covering 12.78 million hectares and producing 54 billion nuts on an annual basis. India is the second largest producer of coconut (Asian and Pacific Coconut Community (APCC) Statistical Year Book, 2014). India, Indonesia, Philippines, and Sri Lanka account for 78 percent of total world production. The coconut palm is a dominating and crucial component of homesteads and garden lands along southern India's coastal regions, and it plays an important sociocultural and economic function for a large number of small and marginal farmers [2]. Coconut tree has much economic importance as food, drink, health, shelter, medicine, fuel, aesthetics and wealth. Because of its resourceful nature it is known as "Kalpa-Vriksha", "Tree of abundance", "Tree of Heaven", "Tree of Life", Nature's super market"', "King of palm", "Tree of virtues " and by many names. It is also known as lazyman's crop [3-5].

Phytophthora is a genus of plant-damaging oomycetes (water moulds) whose members are capable of wreaking havoc on crops around the world, as well as wreaking havoc on natural ecosystems. *Phytophthora palmivora* is an oomycete that causes palm bud rot, coconut fruit rot, and areca nut kole-roga. Fungi and moulds are responsible for some of the most serious diseases in South India. The causative organism was first identified as *Phytophthora palmivora* by Butler EJ, et al. [6]. *P. palmivora* belongs to Phylum: Heterokontophyta, Class: Oomycota, Order: Peronosporales, Family: Peronosporaceae, Genus: *Phytophthora*, Species: *palmivora. Phytophthora* spp. produces more yield losses on cacao than any other disease, about 20-30% every year. BPR and canker are caused by several *Phytophthora* species, the most common of which is *P. palmivora* (Butl) Butler. Infected pods shrivel but stay in the tree canopy, providing a source of inoculum for several years, and are frequently removed and disposed of as part of infection management strategies. Each mummified pod can develop millions of sporangia in conditions of high humidity or precipitation, which are subsequently distributed by rain, insects, or harvesting equipment. Although cultural controls have been shown to be successful in regions of Ghana, they are usually used in conjunction with fungicide sprays. Fungicides active against oomycetes include chlorothalonil, mancozeb, mefenoxam, and fosetyl-Al, which have been shown to be effective against *Phytophthora*.

Coconut Production in India

The agriculture sector in India is very significant to the Indian economy. The Government of India issued "State of Indian Agriculture 2015-16" in 2016, highlighting the importance of India's agriculture sector. The contribution of agriculture and related sectors to production, employment, and exports is steadily expanding. At the same time, agriculture's contribution to GDP is steadily diminishing as the service and manufacturing sectors contribute significant growth. Agriculture and allied sectors contributed 14% to GDP in 2013-14, according to a report by the Government of India. According to Sathya R, et al. [7], India is the world's second largest producer of coconut, accounting for 24.24% of global production, first in productivity, and third in cultivated area (16%). According to the Government of India, the total coconut area under cultivation in India was 2088.47 thousand hectares, with 22167.45 million nuts produced and a productivity of nut per ha.10614 in 2015-2016 (Coconut Board). Kerala ranked first among Indian states in terms of cultivated land, with 770.62 ha and a 36.9% share of the total Indian population. Karnataka ranked second with 526.38 ha and a 25.2 percent part of the total Indian population in 2015-16. Coconut producers face difficulties in India, notably in the state of Karnataka.

S.no	States/Union Territories	AREA ("000 Hectares)	Production (Million Nuts)	Productivity (Nuts/Ha)
1	Andhra Pradesh	115.21	1,377.53	11,957
2	Assam	20.6	153.27	7,440
3	Bihar	14.9	141.09	9,469
4	Chhattisgarh	1.48	8.77	5,926
5	Gujarat	24.44	336.65	13,775
6	Karnataka	513.85	6,773.05	13,181
7	Kerala	770.79	7,448.65	9,664
8	Maharashtra	20.9	198.85	9,514
9	Nagaland	0.47	2.67	5,681
10	Odisha	50.91	341.68	6,711
11	Others	52.76	142.38	2,699
12	Tamil Nadu	461.06	6,570.63	14,251
13	Telengana	0.5	2.09	4,180
14	Tripura	4.61	32.23	6,991
15	West Bengal	29.63	374.56	12,641
Total		2,082.11	23,904.10	11,481

Table 1: Area, Production and Productivity of Coconut in India Raghavi MD, et al. [8].
Source: Horticulture Division, Dept. of Agriculture & Cooperation, Ministry of Agriculture & Farmers Welfare, Government of India.

According to Raghavi MD, et al. [8] with a total cultivated area of 1975 acres, coconut is one of India's most important plantation crops. India ranks third in the world with 81 thousand hectares and a production of 21,665 million nuts. India leads the globe in coconut production, with 13 billion nuts produced year, surpassing Indonesia and the Philippines, the other two major coconut-growing countries. During the fiscal year 2021, volume of coconut produced in India accounted for over 14 million metric tons (Table 1).

Bud rot Disease of Coconut

Several factors limit coconut production, with illnesses playing a significant influence. Coconut crop diseases, which are a primary biotic stress, wreak havoc and cause significant yield reductions. Several important illnesses have been documented from our country as a result of microbial infections, causing serious harm to the plant body, including Basal stem rot (Thanjore wilt), Bud rot, Leaf blight, Leaf rot disease, Root wilt, and Stem haemorrhage [9]. Bud rot disease caused by *Phytophthora palmivora* has been shown to be particularly severe in coconut palms. Bud rot disease affected palms of all ages, although immature palms were found to be more susceptible, especially during the monsoon season, when temperatures are low and humidity is high.

The disease signs were initially described by Briton-Jones HR, et al. [10]. The withering of the spindle, defined by light color, is the first obvious indication. The spear leaf, sometimes known as a spindle, becomes brown and folds over. Basal tissues of leaf rot quickly and can be easily detached from the crown. The spindle withers and droops, and the inner leaves fall away one by one, leaving the crown with only completely grown leaves. The decomposing tissue emits a horrible odour Nambiar KKN, et al. [9]. With the demise of the spindle, the palms succumb to the disease [10-12]. Later on, the infection spreads to the older leaves, resulting in sunken leaf spots that cover the full leaf blade and extend up and down. When the leaves are unfolded, the typical uneven spots are seen on the blade. Spot edges are irregular and water saturated. The entire crown of severely afflicted trees may rot, and the trees may wilt in a few months. The heart leaf wilts, becoming chlorotic, and eventually falls over. The disease can spread to older, nearby leaves and spathes, resulting in a dead centre surrounded by living leaves. On leaf bases, stipules, and pinnae, light brown to yellow oily sunken lesions can be noticed. The tissues beneath the bud deteriorate internally, discoloring pink to purple with a dark brown border. Brown to black necrotic regions with a yellow border rise to the surface of infected nuts. They have a speckled appearance on the inside.

Young nuts are prone to illness, fail to grow, and eventually fall off the tree. Infected nuts ripen normally as they get older [13,14]. The entire crown eventually collapses, and the palm dies. "Bud rot illnesses" were first discovered in Jamaica, Puerto Rico, Africa, Peninsular Malaysia, and the Philippines in the 1920s Menon K, et al. [11]. It was later documented in India, Sri Lanka, Central America, the West Indies, Fiji, and Vanuatu, among other places. To prevent the spread of bud rot disease, several procedures were implemented, including chemical spraying, maintaining the garden clean, and applying a talc powder formulation to rotting spots, among others Srinivasulu B, et al. [15] (Figure 1).

Figure 1: Coconut Bud rot.

Causal Agent: *Phytophthora palmivora*

Phytophthora palmivora Butler EJ, et al. [16] is a cosmopolitan pathogen with a wide host range, including some very important economic crops such as cacao, papaya, black pepper, rubber, coconut, and citrus. The center of origin is believed to be southeastern Asia [17]. In 1907, Butler originally described a new species, *Pythium palmivorum*, from palms and coconut. In 1918 it was reclassified as *Phytophthora palmivora* [18]. *P. palmivora* was placed in morphological group II by Stamps DJ, et al. [19] and in clade 4 Balci Y, et al. [20]; Cooke DEL, et al. [21] on the basis of ITS sequences of genomic rDNA.

Phytophthora palmivora is a ubiquitous pathogen that causes a variety of illnesses in a variety of plants. The infection was thought to have originated in Southeast Asia, but it is now found all over the world. Farmers of tropical fruit and vegetable crops suffer huge losses. Hundreds of plant species, including horticultural, ornamental, and agricultural crops, are infected by *P. palmivora*. It's also a frequent soil dweller. Cocoa (black pod, canker, cherelle wilt), papaya (fruit rot), durian (fruit rot, canker), pineapple (heart rot), citrus (canker), black pepper (foot rot), and coconut are all important agricultural hosts (bud rot). *P. palmivora* thrives in humid, moist environments, causing severe losses in a variety

of commercially important tropical fruit crops [15]. Chemical and cultural approaches can be used to control *Phytophthora palmivora*. As part of an integrated management strategy, resistant cultivars, sanitation (including complete harvesting and removal of infected planting material and weeds), improved nursery cleanliness, pruning to improve air flow and reduce humidity, and increasing organic matter in the soil can all be used. Metalaxyl, phosphonates, or copper hydroxide is used to paint cankers, while phosphonates are employed as a soil drench, trunk injection, or foliar spray to control *P. palmivora* (Figure 2).

Figure 2: Spores of *Phytophthora palmivora* (Source: Alchetron).

Isolation, Identification and Inhibition of *P. palmivora* using Biosynthesized Nanoparticles

Rashmi AR, et al. [22]; Sharadraj KM, et al. [23] and many other researchers reported the isolation of *Phytophthora palmivora* which caused bud rot and root rot in coconut. In 2008, Srinivasulu B, et al. [15] and coworkers made a complete report on *Phytophthora palmivora* isolation from bud rot caused tissue of coconut and well written about the disease management Srinivasulu B, et al. [15]. Including Bud rot of coconut, *P. palmivora* is one of the reasons for many deadly diseases of other plants. In the same way, Chun-Hsien H, et al. [24] identified *P. palmivora* from root rot symptoms of Citrus maxima in Thailand. Serious root rot disease of citrus and papaya caused by *P. palmivora* has been recorded in India Graham JH, et al. [25] and America Zitko SE, et al. [26]. Mounde LG, et al. also isolated and characterized *Phytophthora* species which caused Citrus Gummosis in Kenya. Suskiri, et al. reported *Phytophthora* form Durian Orchard in Chumphon Province, Thailand. Root rot and stem rot are the major disease of durian orchard, which is caused by *Phytophthora* species. Root rot of Pomelo caused by this pathogen was observed in Thailand [27]. There are many other major diseases are associated with *Phytophthora* species which causing major loss to agricultural and ornamental crops. Hence, the fungus should be inhibited to avoid loss for economy.

As previous reports suggests, biosynthesized nanoparticles were already proved that they are remarkable antifungal agents against many pathogenic fungus like *Candida albicans* and *Aspergillus niger* [28] and *Rhizoctonia solani, Fusarium oxysporum, Sclerotinia sclerotiorum* and *Sclerotium rolfsii* [29]. Nida TK, et al. [30] reported antifungal activity against *Candida glabrata*, *Candida albicans* and *Candida tropicalis* using fungal mediated nanoparticles in disc diffusion method [30]. However, there is a report available on antifungal activity of nanoparticles against pathogenic fungus causing red root rot disease in tea plants [31]. Recently, Avinash B, et al. [32] published an extensive report on isolation, identification and inhibition of *Phytophthora palmivora* using biosynthesized nanoparticles. They were able to isolate the fungus that causes bud rot disease from infected coconut plant samples in Karnataka. The isolated fungus was identified primarily through microscopy, and the same sample was sent for molecular analysis. 18s rRNA sequencing verified the existence of *Phytophthora palmivora*. Biosynthesized Silver and Copper nanoparticles efficiently reduced the growth of isolated fungus [33,34]. Nanoparticles had excellent inhibitory effects against *Phytophthora palmivora* in a dose-dependent manner. When compared to the common fungicide Fluconazole, silver nanoparticles synthesied from Silkworm faeces showed higher inhibitory action against *Phytophthora palmivora*. They also claimed that, their study was the first trial of biosynthesized nanoparticles as antifungal agents against this bud rot causing pathogenic organism *Phytophthora palmivora* and inhibition study against *Phytophthora palmivora* stands in front with the previous reports on inhibition of *P. palmivora*. As a result, those silver nanoparticles may be effective in preventing the pathogenic fungus that causes coconut bud rot.

Conclusion

We have shown in this review that *P. palmivora*-caused bud rot of coconut palms is a severe threat to coconut output in India. The severity of the bud rot epidemics serves as a sharp reminder of *Phytophthora* infections' devastating potential in various crops. *Phytophthora* species, particularly *P. palmivora*, are a serious barrier to crop production due to their capacity to thrive in the environment; it is a generalist pathogen with a wide host range. The survival and perpetuation of sources of inoculum are aided by the diversity and quantity of susceptible host plant species. *P. palmivora* is a sleeping giant that has awoken and satisfies all of the criteria for becoming a destructive infection, posing a severe threat to not only coconut palm output but many other food crops as well.

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