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Phytophthora Diseases Prevalence, Its Effects and Controls in Ghana

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Abstract

The success of the UN Sustainable Development Goals in reducing hunger and poverty is limited by crop losses. Globally, plant pests and diseases account for 40% yield losses which threatens food and nutrition security, livelihoods of citizenry and erode the resources of local and national economies. *Phytophthora* diseases are among the most important diseases in sub-Saharan Africa which result in severe socio-economic consequences. Roots and tubers and cash commodity crops are important staples and foreign exchange earner crops in Ghana which are significantly challenged by the incidence and severity of *Phytophthora* diseases. To ensure food availability, safeguard the local financial ecosystem and protect the environment, innovative and sound management practices are needed and this chapter reviews the different *Phytophthora* diseases on crops; more specifically with (cocoa and taro as case studies), the consequences and available management options that can be applied to manage the disease situation in Ghana.

Keywords: economic loss, incidence, severity, Cocoa, Taro, sustainable development, Ghana

1. Introduction

1.1 Origin of *Phytophthora* diseases

Phytophthora is a genus of filamentous Oomycetes, within the Kingdom Chromista which is also referred to as Kingdom Stramenopila [1–3]. There are several species within the class Oomycetes of which over 120 species are known [4] and could either be soil or water borne. Morphologically, they bear the resemblance of fungi with both sexual and asexual spores. Most are pathogens causing disease in a large range of plant hosts. The pathogens not only cause economic damage to crops but to the natural ecosystem as well. They affect both traditional and non-traditional agricultural crops, floricultural plants such as ornamentals and forest plants and they are pervasive in soil and water globally [3]. Due to their economic and environmental impact, there is expanding interest in *Phytophthora* genetics and genomics, resulting in the recent releases of genome sequences of *P. ramorum*, *P. sojae*, *P. infestans*, *P. capsici* and *P. litchi* [5–8].

The identification of gene families encoding classes of toxins, elicitors, and effectors shared among the *Phytophthora* species is critical to understanding the disease process. The most devastating specie worldwide is the *P. infestans* which in

history caused huge damage to Irish Potatoes in 1845 as a result of Potato Late Blight outbreak thus, causing great famine in the Irish land with about 25% of its population starving and evacuating [3]. *P. infestans* are noted to affect the Solanaceous plants while the rest may either be host specific or attack varied host plants. Below are some selected species for the temperate and tropical regions of the globe; their target host plants and signs and symptoms (Table 1).

1.2 *Phytophthora* diseases prevalence: Evidence from Ghana

1.2.1 *Phytophthora* disease in cocoa production

In Ghana, the earliest form of *Phytophthora* disease was caused by the pathogen *P. megakarya*. *P. megakarya* is native and pervasive in the Western and Central parts of Africa. Known to have spread from the West from Cameroon to Ghana and Cote D'Ivoire through Nigeria and Togo and Southwards to Gabon and Equatorial Guinea [13]. *Phytophthora megakarya* is the most destructive fungal pathogen on cocoa production in Ghana [13]. The disease has been in Ghana for many years but on other alternative hosts [16]. It was originally identified in Nigeria in 1979 [17], reported in Togo in 1982 [18], and was subsequently reported in Ghana in 1985 [16]. Though the incidence of *Phytophthora* disease was originally reported in Ghana by 1985, Darkwa (1981) concluded that *P. megakarya* probably occurred before 1980 until it was officially reported in 1985 at Akomadan-Ashanti Region.

According to Tsopmbeng et al. [8] an isolate of *Phytophthora* from *Mimusops elengi* at Aburi in Ghana was distinctly different from what was hitherto referred to as cocoa or G-isolate. Turner et al. [8] further reported that the *Mimusops* isolate produced oospores in mixed culture with the cocoa isolate. Presently, the G-isolate has now been identified as *P. palmivora* and the N-isolate as *P. megakarya* [16, 19]. Until 1985, *Phytophthora palmivora* was the only known causal agent for *Phytophthora* pod rot (black pod) disease in Ghana. The appearance of *Phytophthora megakarya* in 1985 in Ghana added a new dimension to the disease complex of cocoa in the country. Similarly, studies on black pod diseases by [20] confirmed that some parts of Volta Region of Ghana consistently had the predominant type caused by *P. megakarya*. This is plausible due to the fact that the region shares boundary with Togo, a country predominantly affected by *P. megakarya* species [16].

1.2.2 *Phytophthora* disease in Taro production

It is also important to highlight that not only has the prevalence of *Phytophthora* affected cocoa production after its earliest occurrence but also the production of Taro. The production of taro in Ghana, in recent times, has been affected by the taro leaf blight caused by *Phytophthora colocasiae* which has also been reported to have threatened the sustainability of taro production globally [21, 22]. In Ghana, [23] reported the presence of the disease after similar reports in Nigeria and Cameroon. The disease affects all parts of the crop including the leaves, corms, petioles and cormels, resulting in extensive damage of the foliage and reduced yield [24]. It has therefore become a limiting factor to taro production in all taro growing countries.

Taro (*Colocasia esculenta* var., *antiquorum*) is one of the most important food crops in Ghana [25]. It is a hunger crop and cultivated in almost all the ten regions of the country [26]. The corm is used for flour for bakery and in the preparation of local dishes. The corm is also high in carbohydrates [27]. The leaves can be eaten as vegetable in the country, and it is an excellent source of vitamins. A lot of village folks depend on

No.	Phytophthora species	Target host plant	Signs and symptoms	Relevant literature
1.	<i>P. alni</i>	Alder	Rot of the root and collar	[3]
2.	<i>P. cactorum</i>	Rhododendrons, Azaleas, hardwood, apple, pear, strawberry.	Causes root rot in rhododendrons, azaleas and other related species. It affects woody trees causing cancer and other economic important fruits.	[3]
3.	<i>P. cinnamomi</i>	Woody ornamental: arborvitae, azalea, Chamaecyparis; dogwood Taxus, white pine, American chestnut and Eucalyptus (jarrah).	Root rot and seedling mortality	[3]
4.	<i>P. cambivora</i>	Chestnut, apple, pear, peach, almond	Root rot to forest trees, crown dieback, flame blot at the collar region, discoloration and lesions at the growing point and wilting.	[3, 9]
5.	<i>P. citrophthora</i>	citrus, pistachio, peach and ornamental species	Root rot, it's a soil-borne disease of citrus causing gummosis and brown rot with pungent smell.	[3, 9, 10]
6.	<i>P. cryptogea</i>	Ornamental species	Causes collar rot with reduction in foliage. First reported to cause gummosis in citrus in Tunisia.	[3, 11]
7.	<i>P. kernoviae</i>	Beech, rhododendron, trees and shrub species	Restricted to the UK and Ireland environment. Causes abnormal leaf fall, necrosis and whole plant dieback.	[3, 12]
8.	<i>P. megakarya</i>	Cocoa	Virulent specie which causes pod rot resulting in black pod diseases. It reduces yield and accounts for greater losses of cocoa especially in West and Central Africa. About 60–100% losses incurred if not managed.	[3, 13, 14]
9.	<i>P. nicotianae</i>	Tobacco, onions, cotton, ornamental species, coconut and pineapple	Cause diseases	[3]
10.	<i>P. palmivora</i>	in coconuts and betel nuts, palm species, papaya, cocoa	Fruit rot, stem and root rots in other tropical fruits. Causes pod rot in cocoa in most growing countries. It causes about 20–30% yield losses	[3, 14]
11.	<i>P. infestans</i>	Potato, tomato	Infects the above ground part of the plant and occurs at any stage of the plant development. Elongated, dark lesions on tomato branches.	[15]
12.	<i>P. citricola</i>	Avocado, conifers	Causes crown and canker rots	[3]

Table 1.
Some selected species and the affected host plants.

this crop for their livelihood. Farmers obtain regular income from the production as well as food for the family [26]. Despite, the importance of taro as an important food security crop in Ghana; its production is hampered by a leaf blight disease caused by *Phytophthora colocasiae*. Marian Raciborski first described *Phytophthora colocasiae* in 1900 from Java. It was first reported in Ghana in 2012 [28]. It is the most destructive fungal disease responsible for heavy yield losses (25 to 50%) of taro [27]. In addition, this pathogen causes a serious postharvest decay of taro corms.

1.2.3 Method of isolating and identification of *Phytophthora* spp

Proper plant diseases identification is critical and it forms the basis for population genetics, epidemiological studies and development of effective control mechanisms. This review reports on how authors have isolated *phytophthora spp* in cocoa and taro respectively.

1.2.3.1 *P. Megakarya isolation*

Detailed account on experiment conducted by [29] investigating shade trees as alternative host of *P. megakarya* is given as follows. The team conducted an experiment on a 5-hectare cocoa field at erstwhile Brong Ahafo region, precisely Bechem which was planted in 1984 with two hybrids; T79/501 x Amel, and T60 x Na45 respectively. Cocoa plants in the test field were largely infected with *P. megakarya*. Forty-eight out of the fifty isolates recovered from the cocoa pods representing ninety-six percent were found to be *P. megakarya* with only two identified as *P. palmivora*.

The team identified 34 shade trees at the test site so roots with no visible lesions of approximately 1-2 cm thick were collected from a depth ranging from 20 to 50 cm. separate samples were placed in black polythene bags and refrigerated at 4oC for up to 2 weeks before isolations were done. Samples were taken in two month intervals in the 1996/97, 1997/98 and 1998/99 cropping calendar (June, August, October, December, February and April). During the isolation process, the bulk soil and pieces of other root parts were thoroughly washed with running water. A razor blade was used to cut about 1–2 were of the roots and washed in three separate sterile distilled water. The surface sterilized immersing for 5 min in a 10% sodium hypochlorite solution and wiped dry on a paper towel. The roots were again washed for an hour in sterile distilled water on a flask shaker. In all 100 root pieces were cut from each test tree and sub divided into two groups. The isolation methods involved two techniques of “baiting with cocoa pod husks and direct plating on *P. megakarya* and *P. palmivora* agar (PPMA)” [30]. Isolates were identified on the basis of three parameters; growth rates, colony morphology and sporangium features. Out of 34 shade trees tested, *P. megakarya* was recovered from four of the roots from the shade trees after three consecutive years. *P. megakarya* was isolated most frequently in the wet season than the dry.

1.2.3.2 *P. colocasiae isolation*

A survey was conducted by [31] during the 2019 rainy (July to November, 2019) and dry seasons (November, 2019 to February, 2020) in Sunyani and Dorma-Central Municipalities to assess the incidence and severity of taro blight disease in these zones. The team collected randomly sampled from infected leaves and petioles showing sign like “the development, exudation and oozing of amber, reddish-brown or bright-orange droplets from both sides of the leaf margins, water-soaked necrotic areas, which have combined into large lesions with white powdery

appearance and blighted leaf blade. The sample was taken to the University of Energy and Natural Resources Lab in Ghana for isolation and purification of the pathogen. The isolation was carried out under a Laminar flow hood. The diseased part of the taro leaves and petiole was cut. The pieces were surface sterilized in 70% ethanol for a minute and carefully washed in three exchanges of distilled water. The pieces were blotted dry on Whatman paper for 2 minutes and plated on potato dextrose agar (PDA, Oxoid, England) at the 28°C for seven days. They were examined daily for the development of mycelial growth. The isolation process was reproduced three times. The mixed population cultures were sub-cultured by transferring hyphal tip from the mycelium edge onto a new prepared PDA medium using flamed inoculation needle to purify it.

Wet mount from the pure cultures was prepared to identify the pathogen morphologically. By using bi-nuclear microscope, the characters of the putative pathogen such as hyphae type, shape of sporangia, micro and macro conidia were also examined morphologically and the characteristics compared to a standard established identification protocols by [32, 33].

1.3 Symptoms and distribution of virulent *phytophthora* diseases in Ghana

1.3.1 *Phytophthora* disease cycle and environmental parameters for disease incidence

Direct correlation has been established between black pod disease incidence and weather condition. Thus black pod disease has been seen to be highly influenced by environmental factors and several studies [13, 34] have confirmed the role played by climate variability in the prevalence of black pod disease caused by *phytophthora* species. Akrofi et al. [35] reported that the disease develops well under frequent precipitation, high relative humidity and low temperature. Under high and regular precipitation regimes, *P. megakarya* is reported to result in a total yield loss in Cameroon where no action was taken [13, 35]. Under similar conditions; Asare-Nyako and Dakwa [34] reported losses in the range of 60 to 100% in Ghana. Asare-Nyako and Dakwa [34] emphasized that, the black pod disease in Ghana developed quickly during the day when the relative humidity stayed above 80% under shady cocoa and the frequency and amount of rainfall influenced the intensity of the disease development. Asare-Nyako and Dakwa [34] reiterated that the peak level of infection varied yearly between location and with the rainfall pattern.

In Ghana, black pod disease caused by *P. megakarya* is usually severe between August and October [16, 36]. The topmost phases of disease occurrence provide rich information in predicting disease development trends and serve as an important disease management tool. The developmental stages during *phytophthora* disease cycle in cocoa is presented in **Figure 1**.

P. colocasiae survives under high temperatures and humidity, in wet areas and plots that are densely planted [12]. Study by [25] in Aowin Suaman district in the Western Region of Ghana; a tropical rainforest with monthly temperature of 27°C and annual rainfall between 1500 and 1800 millimeters, recorded high incidence of Taro leaf blight; 99% as the described condition favored the spread of the disease.

1.3.2 Symptoms and distribution of *P. megakarya*

Phytophthora disease incidence and crop losses vary from one locality and farm to another [35] and fluctuate across seasons [20]. *P. megakarya* infects every

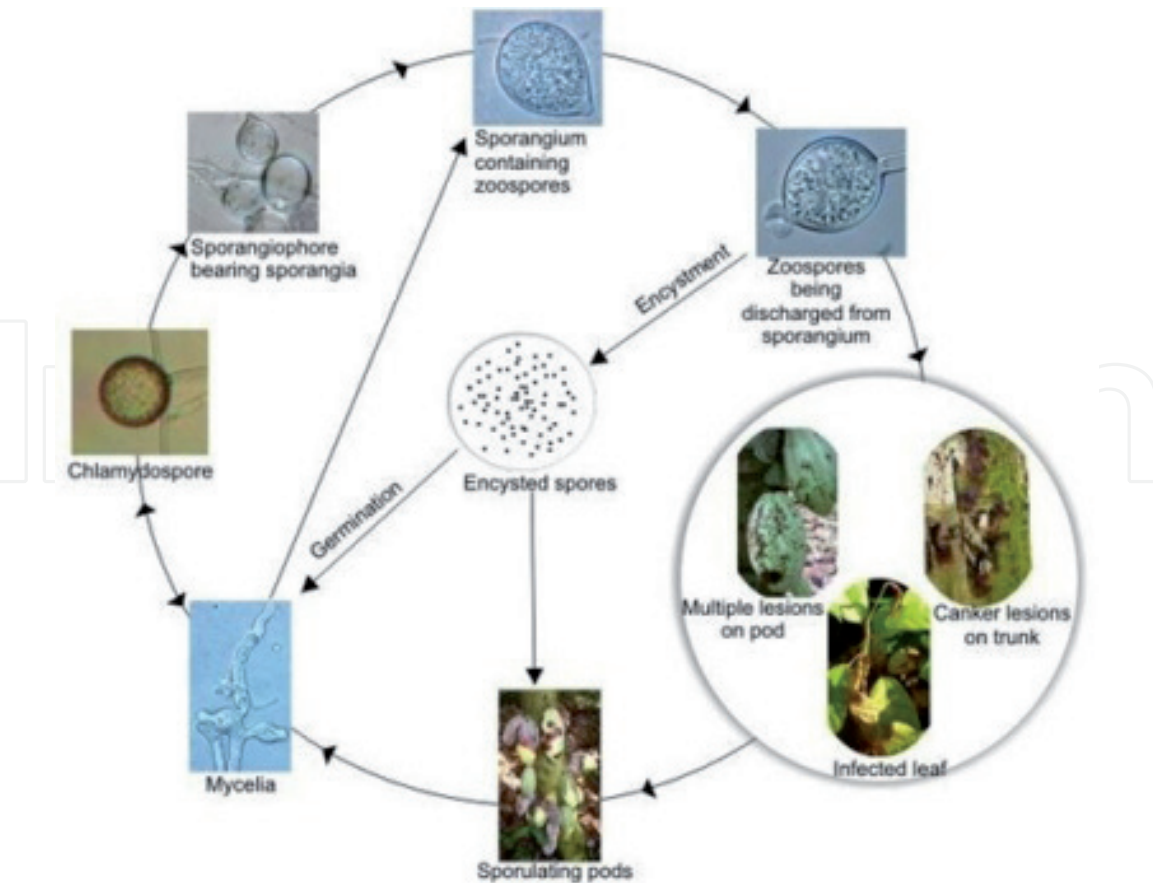


Figure 1.
Phytophthora disease cycle in cocoa. Photo credit: Akrofi et al. [13].

developmental stage and every part of the cacao plant under wet and humid conditions. Infection of seedlings leads to leaf blight and root rot in nurseries, while infections of the stem, chupons and branches lead to cankers. While every stage of pod development is susceptible to infection, immature pods are the most susceptible. Pod infection also leads to pod rot [13]. In Ghana, *P. megakarya* form stem cankers very rapidly. Unlike *P. palmivora* cankers which are usually distributed normally on the tree trunk, *P. megakarya* cankers tend to be concentrated on the lower parts of the stem close to the ground though it affects all parts of the tree [36]. Due to this, treating with chemicals become difficult and unproductive.

In Ghana, [13] found that *P. megakarya* has spread from Akomadan and Bechem where it was first reported in 1985 into 50 more administrative districts in the six cocoa growing regions of Ghana covering an approximate area of 75,298 km². They further noted that the current distribution in the country is as follows: Ashanti, 13 districts (17,676 km²); Brong Ahafo Region, 10 districts (10,422 km²); Central Region, 4 districts (5900 km²); Eastern, 7 districts (7760 km²); Western, 12 districts (25,698 km²) and Volta, 6 districts 7843 km². The corresponding percentage areas infested in the regions are 23.5%, 13.8%, 7.8%, 10.3%, 34.1% and 10.4% respectively [13]. Pictures of infected cocoa pod showing symptoms is presented in **Figure 2**.

1.3.3 Symptoms and spread of *Phytophthora colocasiae*

Taro (*Colocasia esculenta* (L.) Schott) suffers attacks from several pathogens, among which *Phytophthora colocasiae*, Racib, associated with the Taro leaf blight being the most destructive. The disease is associated with 90% and 50% loss in leaf



Figure 2.
Symptoms of *P. megakarya* in cocoa in Ghana. Photo credit: Akrofi et al. [13]. (a) multiple lesions on cocoa pod; (b) coalescing lesions; (c) abundant sporangia indicated by the arrow; (d) diverse infection phases on the cocoa; (e) distal infection; (f) proximal infection; (g) lateral infection; (h) canker lesions prior to scraping and (i) canker lesions once scraped displaying scarlet colouration.

and corm yield of taro, respectively [22]. *Phytophthora colocasiae* is disseminated by infected vegetative plant parts and possibly contaminated soil [21]. Conventionally, variations in *Phytophthora* species have been detected on host differential, biochemical test, morphological and molecular level characterizations [37]. According to studies, the foliar pathogen has spread across Africa, East Asia, the Americas, the Caribbean, and the Pacific, as well as all other taro-growing regions of the world, with varying degrees of severity [28, 38].

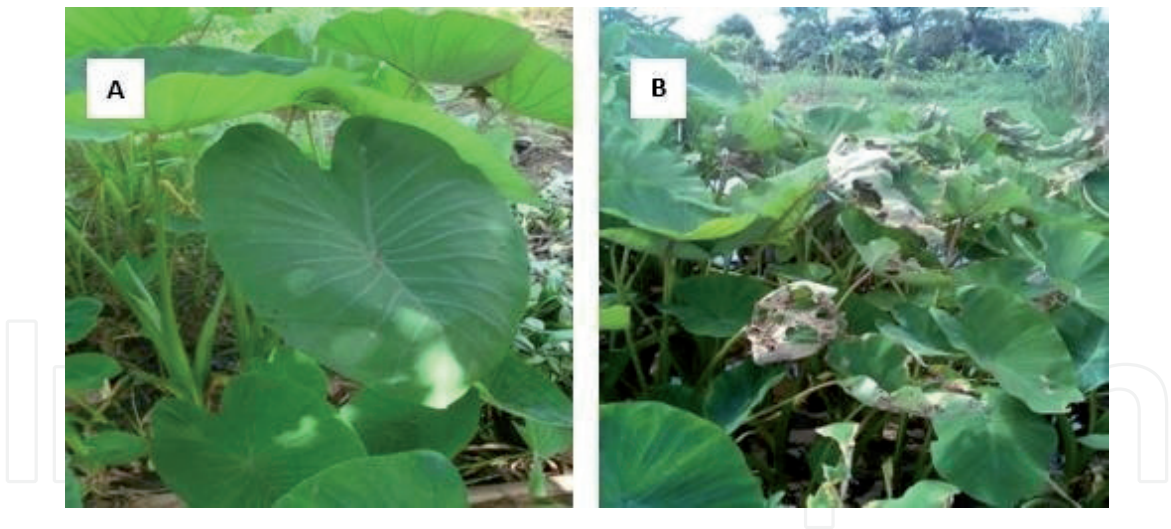


Figure 3.
A. Asymptomatic leaf; B. Symptomatic leaf. Photo credit: Abdulai et al. [31].

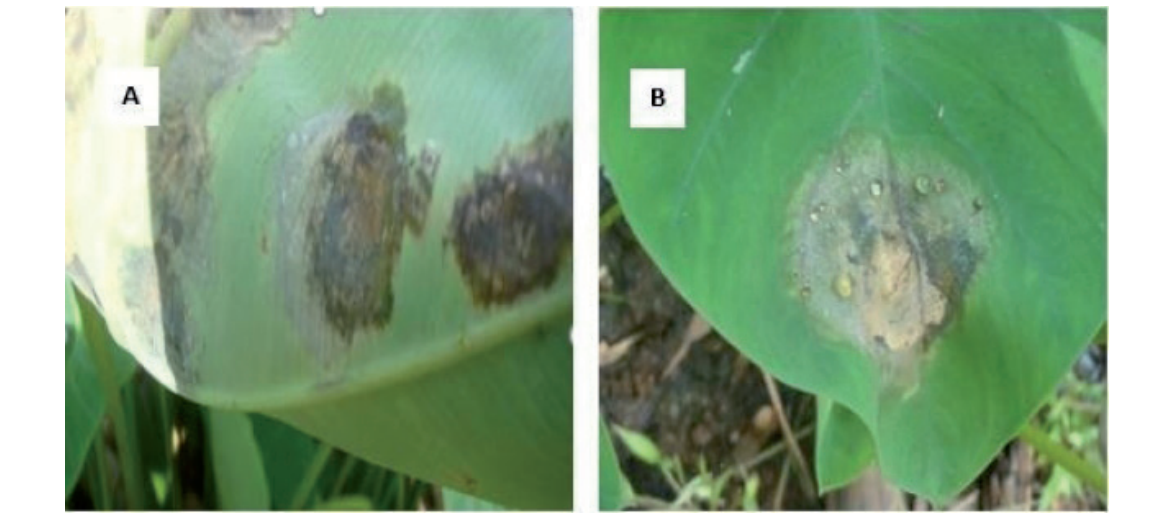


Figure 4.
A. Water-soaked appearance on plant; B. Light exudate from both sides of the water-soaked leaf margins. Photo credit: Abdulai et al. [31].

In terms of its dissemination, [31] indicated that windy rains and splashing water from irrigation or running water are two ways that the sporangia on the infected plant surface are quickly disseminated. The pathogen can grow in the soil as an encysted zoospore with thick cover layers or as chlamydospores in the absence of the host for several months as a survival mechanism under dry stress conditions [28, 39]. Blight of the leaf blade is the most visible symptom of the disease; other symptoms include postharvest rot of the corm and rotting of the petiole in susceptible varieties [40]. Early plant leaf infection is most common in areas where there is sufficient accumulation of guttation droplets, dew, or rainfall. The pathogen sporangia usually appear on infected leaves as small, brown, water-soaked necrotic areas that quickly coalesce into large lesions from which yellow exudates emerge, followed by defoliation and plant death within a few weeks after infection [25, 28].

The fluctuating day/night cycle influences the development of specific symptoms. Cool night temperatures encourage lesion expansion with 3–5 mm wide water-soaked margins that dry out during the day and return to water-soaked status at night, resulting in zonation around the necrotic lesion that is easily visible when viewed from the bottom of the infected leaf [41]. Some symptomatic and asymptomatic plant parts are shown in **Figures 3–5**.

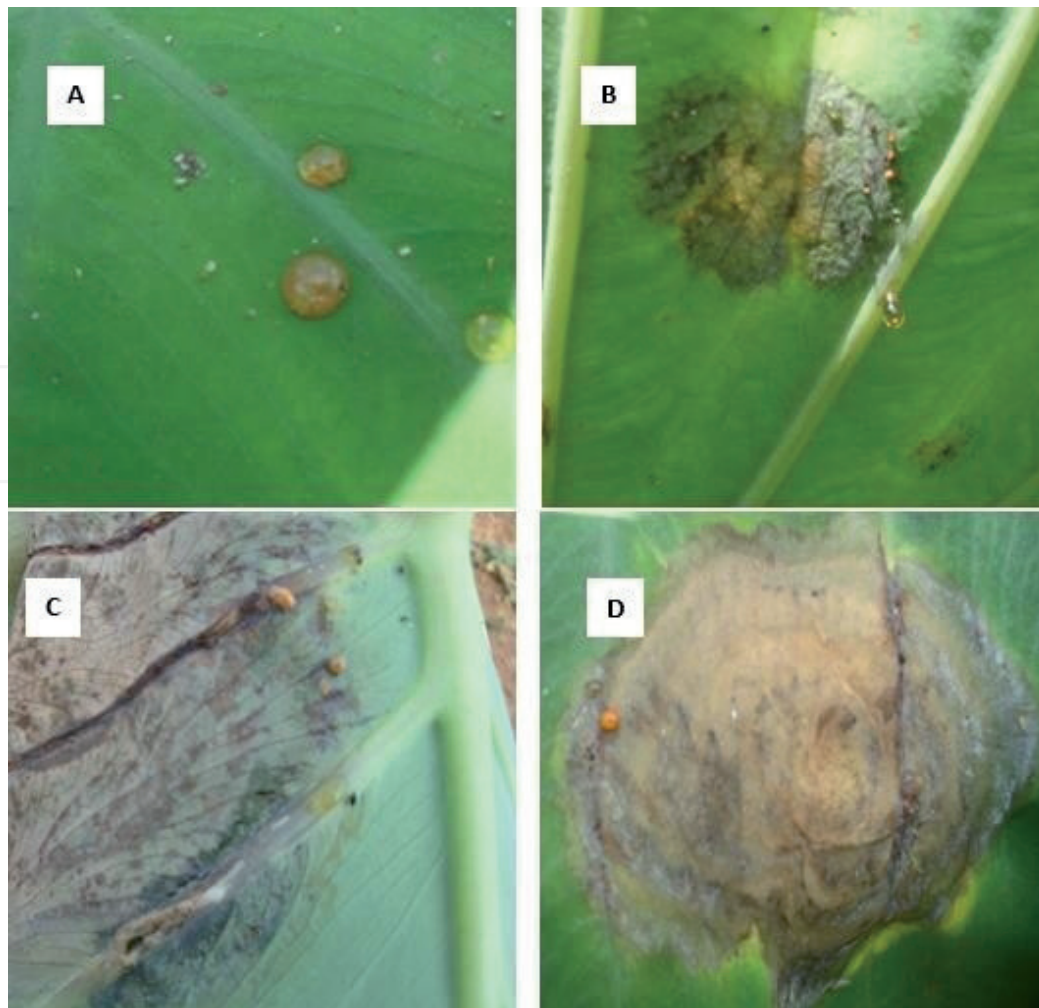


Figure 5.
 A–D. Fresh and dried Amber; bright-Orange or reddish-Brown exudate on Taro leaves. Photo credit: Abdulai et al. [31].

2. Social and economic impact of infectious *Phytophthora* diseases in Ghana

2.1 Impact of *Phytophthora megakarya*

Though cocoa is native of South America, the bulk of the beans production comes from Africa with Ghana being the second largest world's producer after Cote D'Ivoire [42, 43]. With Ghana's position in the International cocoa production and export markets [42], cocoa contribution to the nation's economic growth is limited by high yield losses resulting from *Phytophthora* disease infections [13]. *Phytophthora palmivora* which accounted for pod losses of less than 30% was the only known causal agent of black pod disease of cocoa in Ghana prior to 1985. *P. megakarya* causes yield losses as high as 60–100% in Ghana according to a report by [44]. *P. megakarya* has become the main yield-limiting factor for cocoa production in affected areas [36], rapidly surpassing the importance of *P. palmivora*. The emergence of *P. megakarya* has had dramatic social and economic consequences in cocoa producing countries in West and Central Africa including Ghana, clearly demonstrating the scale of damage that it may cause in case it spreads into other cocoa producing territories.

Particularly in Ghana, it was reported that some cocoa farms were neglected or abandoned and, some cocoa farmers switched over to cultivate vegetables and other crops because of *P. megakarya* infections on their cocoa farms [35, 36].

A report by COCOBOD in 2014 is also indicative that Ghana lost over 25% (212,500 MT) of its annual output of 850,000 MT of cocoa beans to black pod disease, representing a revenue loss of about GH¢7.5 million in 2012. *P. megakarya* still remains an invasive species in Ghana and was reported to be spreading in the Ghanaian cocoa belt towards the border with Cote d'Ivoire [29]. A study by [16] noted that several national programmes, including the National Cocoa Pests and Diseases Control Programme (CODAPEC), were instituted by the Ghanaian government in which *P. megakarya* infected farms were sprayed with fungicides at the expense of the government. The money spent on these programs could have been better spent on improving the lives of farmers. In addition, [36] noted that in view of the severity of *P. megakarya* mediated black pod during the disease-conducive period (July–October), some famers in Ghana attached some belief to its incidence due to the devastating nature; thinking that it was a strange disease caused by evil forces or the effects of the Volta Lake [35] which has influenced farmers to adopt wrong attitudes towards its control.

2.2 Impact of *Phytophthora colocasiae*

Globally, it is generally believed that diseases decrease agricultural productivity by more than 10%, which is comparable to half a billion tonnes of total food produced each year [40]. The impact of fungal diseases on crop production has been well explained by [31] who reported that, when fungal diseases are properly controlled on five (5) major crops alone, more than 600 million people could be fed each year in the world. Taro plant is not an exception, as it is known to be infected by more than ten serious pests and diseases caused by a number of insect pests and pathogens across the globe [45]. Among all the disease-causing agents in taro plants, *P. colocasiae*, which causes leaf blight of taro is known to be the most important. This pathogen has been reported widely for causing leaf yield loss of 95% and 50% in postharvest rot of corm yield and quality [39, 46].

It is believed that *P. colocasiae* is disseminated by means of vegetative propagation materials [28] and the case may not be different in Ghana. There are no accredited supply centers for planting materials in the country, and farmers rely on families, neighbors and open market for their supplies of planting materials, which may be coming from already infested fields. The constraints of taro blight disease to productivity of taro have been acknowledged in the West-African Sub Region [28, 38, 47]. The disease poses serious threats to global food security as well as economic hardship to the people in these taro producing regions of the world. In Ghana, apart from the three northern regions, taro production is mainly carried out in the southern part of the country. A few research works have been reported so far on Taro [47–50]. Even then, the focus had been on the profitability of the taro enterprise. More studies such as ours reporting on the incidence and severity of *P. colocasiae* are needed to provide valuable data to inform interventions towards the management of taro blight in the country.

3. Management of *phytophthora* diseases in Ghana

3.1 Management of *Phytophthora megakarya*

Huge losses resulting from *P. megakarya* and associated management cost pose serious threats on the socio-economic development of cocoa growing countries in terms of their financial resources such as Ghana. Timely, more integrated and sustainable practices which involve the use of resistant varieties, chemical application,

quarantining germplasm received outside the country, cultural and biological control are imperative [13, 35]. To effectively prevent disease caused by *P. megakarya*, these integrated control strategies must be employed on time. Planting material movement from one location to another within Ghana account for the quick spread of the pod rot pathogens. The amalgamation of cultural and chemical methods in Ghana has proven to be effective against *P. megakarya*. Cultural practices present a cost effective way of managing plant diseases as it provides the right ecosystem for effective performance of fungicides. Cultural practices alone, including judicious shade management, pruning, removal of basal chupons, mistletoes and frequent harvesting, can be sufficient to control *P. palmivora* [34, 36]. Cultural practices are not only essential for increasing yield, but also provide the right environment for the efficient performance of recommended fungicides [36]. Frequent harvesting, for instance, saves partly infected mature pods and reduces sources of sporangial inoculum while shade management; opening up the canopy and reducing basal chupons, enhances air circulation in the cocoa farm, thereby reducing disease incidence [51]. Iwaro et al. [51] noted that at least six applications are required in one black pod sea.

The recommendation of 3-weekly fungicide spraying in Ghana (son (May–October). This rather high frequency of spraying, coupled with the ever-increasing cost of inputs (labour and fungicides) and the lack of knowledge in techniques for effective spraying, make the adoption of chemical control very low. Four-weekly spraying of either metalaxyl and copper-1-oxide (Ridomil 72 plus) or cuprous oxide (Nordox 75) combined with cultural practices had been found effective against *Phytophthora megakarya* in researcher-managed trials [52]. This spraying regime reduces the number of sprays per season to five.

3.2 Management of *Phytophthora colocasiae*

To be able to control or manage taro blight disease, which usually limits the productivity of this crop, it is important that the pathogen is isolated from the diseased tissues and characterized. On that basis, the pathogen was successfully isolated and identified morphologically as *P. colocasiae* based on the important characters of the pathogen using standard Mycological identification keys according to [32, 33]. The sporangia are ovoid to ellipsoid with a well-defined narrow semi-papillate structure and are usually formed at the end of unbranched or casually branched sporangiophores at the edge of necrotic lesions. The sporangium is normally segregated from sporangiophores by the rain, leaving a small pedicel that is attached to their base [53], signifying the important role rain plays in the pathogen dispersal.

The incidence and severity of the disease are closely linked to the ability of the pathogen to be dispersed from one place to the other and hence the reason for the varied incidence and severity of the disease across the various fields in the communities'/farmers' fields. Management practices of taro leaf blight include hygienic practices, use of disease-free planting materials, wide spacing between plants when planting, clearing, removal and burning of infected debris (leaves) during the initial stage of disease development, separating the diseased plant from the healthy ones, planting near forest plantations which can serve as a barrier to disease transmission to the taro plants [54, 55].

Singh et al. [40] in his study was able to avoid serious taro blight disease in his field by planting during the dry season. Appropriate timing of planting is therefore recommended. Biological control methods such as the use of microorganisms, eg. *Pseudomonas fluorescens*, *Trichoderma viride* have also been applied [56]. Chemical control involving the use of systemic and protectant fungicides such as phosphorus acid (Foschek); copper (e.g. copper oxychloride); Mancozeb

(e.g. Dithane M45) and metalaxyl (e.g. Ridomil Gold MZ) has successfully been used to control taro blight disease [46, 55]. Lastly, the use of the most effective and promising management strategy is the utilization of resistant taro cultivars [40] some of which were recently released by Scientists at CSIR-Crops Research Institute, Kumasi, Ghana.

4. Conclusion and recommendation

Despite the widespread distribution of *Phytophthora* diseases and resulting crop harm across the globe, there is a scarcity of knowledge about the diseases' incidence and intensity in Ghana. However, to efficiently establish a long-term management program for its control for farmers in Ghana to increase productivity, there is a need for more research to determine factors likely to limit the productivity of crops affected by *Phytophthora* disease. The continuous development of improved and high yielding varieties that are resistant or tolerant to *Phytophthora* diseases should be intensified for all crops.

Conflict of interest

None.

Author details

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