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FARMER KNOWLEDGE AND INCIDENCE OF TARO LEAF BLIGHT DISEASE IN MAJOR TARO-GROWING REGIONS OF GHANA

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ABSTRACT

Taro (*Colocasia esculenta* (L.) Schott) is an indispensable staple food crop for millions of citizens in Ghana and in some other developing nations. It is a popular dish in southern Ghana because of its high carbohydrate and protein content. Taro Leaf Blight, caused by the fungus *Phytophthora Colocasia*, is a devastating disease of taro in many parts of Ghana where the crop is grown. A survey was conducted using a participatory rural appraisal to evaluate farmers' perspectives on management measures for controlling Taro Leaf Blight disease in four major taro-growing regions of Ghana. To achieve this objective, a questionnaire was designed and administered to guide a structured, self-administered interviews and field observation for data collection on the level of awareness of farmers on *P. colocassia* diseases that infect the taro crop. Fifty respondents were selected using purposive sampling to assess their perception of the disease and disease management options. The four regions showed varying levels of TLB incidence, with the Eastern region having the highest incidence of 76.4 % while the Greater Accra region recorded the least (65 %). The highest disease severity was observed in Eastern (3.43) and Ashanti (3.4) regions with the least (2.43) in the Central region of Ghana. Majority (78 %) of the respondents were literate while 22.0 % had no formal education. Furthermore, the majority (56.0 %) of the respondents had more than 5 years of farming experience with 64.0 % of the farmers cultivating less than 1 acre of taro crop. Respondents obtained planting materials from different sources including their colleague farmers (62.0 %), research institutions (18 %), the Ministry of Food and Agriculture (16 %), and Non-Governmental Organizations (NGOs) (2.0 %). All the respondents admitted to the presence of TLB in their fields with the majority (42.0 %) indicating that the disease is severe in the major rainy seasons. However, most of the respondents (84.0 %) do not control the disease. Rouging (60.0 %), weed control (30.0 %), and pesticide application (4.0 %) were some of the strategies adopted by taro farmers to manage the disease.

Key words: Participatory rural appraisal, Taro Leaf Blight, Ghana, Survey, Disease, Incidence, Severity, Prevalence

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INTRODUCTION

Taro (*Colocasia esculenta* Rakib) also known as cocoyam in Ghana, is grown in nearly all parts of the humid tropics in more than 65 countries worldwide. Its tubers are important sources of carbohydrates and are used as staple foods in tropical and subtropical countries [1]. In sub-Saharan Africa, taro is an important food crop offering food security for millions of people [2]. It is ranked the 14th most consumed tuber crop in the world, with a production capacity of 12 million tonnes generated from approximately 2 million hectares of land with a corresponding average yield of 6.5 tonnes/ha [3]. Ghana ranks third highest producer of taro in sub-Saharan Africa after Nigeria and Cameroon, and fourth in the world [4]. In Ghana, it is cultivated predominantly in the Bono, Ashanti, Western and Eastern Regions which represent the forest/savannah transitional zone of Ghana [5]. The plant helps in achieving food security in Ghana due to its multipurpose nature, in which both the corms and leaves are used in different forms as food products. The leaves are rich in fiber and are the source of important nutritional compounds such as vitamins A and C. The taro leaves have health benefits and are recommended for consumption by people with gastric problems, diabetes, and the aged [6]. The plant is rich in minerals such as niacin, thiamine and riboflavin and a small amount of dietary fiber, as well as some essential elements such as calcium, phosphorus, magnesium, and potassium [7, 8]. Although low, the sugar content of corms is sufficient to affect flavour and varies according to maturity and storage conditions. Starch from taro can be used as a substitute for maize as a special binding material in the pharmaceutical industry. In Ghana, women are the major players in taro plant cultivation and trade, thereby serving as an alternative source of employment for most women in Ghana. As an important foreign trade commodity, the crop also contributes in a small way to Ghana's Gross Domestic Product [8].

Despite its numerous socio-economic benefits, yields of the taro crop continue to decline annually due to several biotic constraints including Taro Leaf Blight (TLB), a devastating disease caused by *P.colocassia* (fungus-like Oomycete) [9]. Taro beetles (*Papuana spp*.), the Bobone virus complex (ABVC), and TLB, caused by *Phytophthora Colocassia* Racib negatively impact taro yield. The collective negative impact of the insect pests and diseases has contributed, in part, to the declining production of the crop. The pathogenic disease taro leaf blight is the most serious taro disease worldwide and is responsible for potential yield losses up to 100 % of both corms and leaves [10]. Taro leaf blight epidemics can significantly reduce food availability and drive up food prices, posing a serious threat to the livelihoods of rural communities and regional food security. *P. colocassia* is disseminated by infected vegetative plant parts and by contaminated soil [11]. This pathogen impacting the taro crop has now assumed a widespread distribution with varied severity in Africa,

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East Asia, the Americas, the Caribbean, and the Pacific and all the other taro growing areas of the world [12]. According to the U.S. Department of Agriculture, taro production in 2005 was only 4 million pounds, the lowest taro yield since 1946 [13]. Several factors contributing to this low production were rainy weather, taro pocket rot (also caused by a *Phytophthora species*) and TLB [13].

Plant disease epidemics have influenced the course of history in some communities with devastating effect and continue to be of great economic importance, especially to those whose livelihoods depend on their crops. There are instances where plant diseases have resulted in hundreds of thousands of deaths due to the destruction of staple food crops, resulting in starvation. Studies have shown that plant diseases have a general impact on farmers as well as the environment [14]. The objective of this study was to determine the incidence and severity of TLB in major taro-growing areas in Ghana and to assess farmer-perception and management strategies to control the leaf blight disease. The information obtained from the study will inform strategic control measures of TLB in Ghana.

MATERIALS AND METHODS

Location of the Study area

The study was carried out in the Ashanti, Greater Accra, Central, and Eastern regions of Ghana (Fig. 1).

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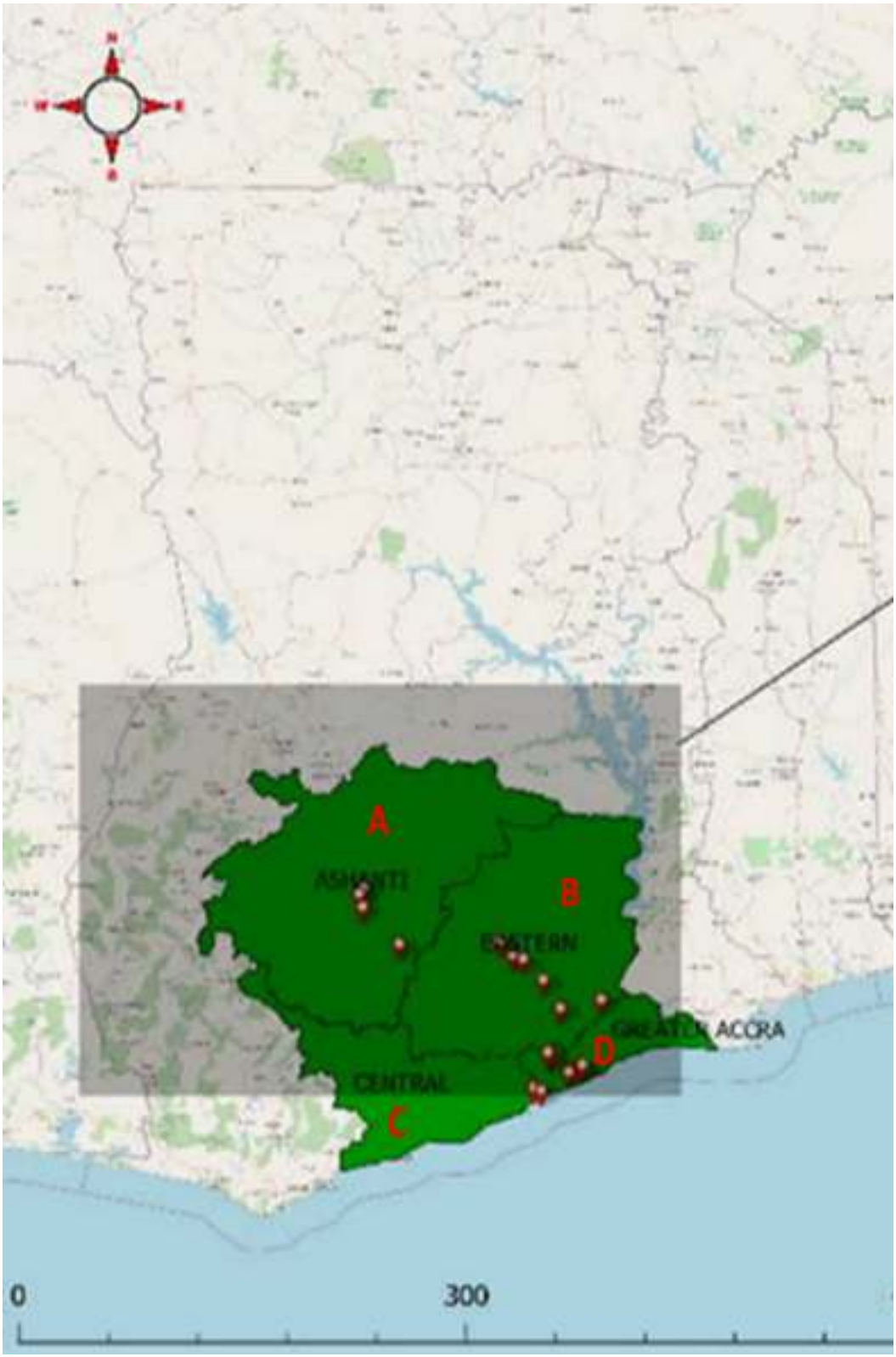

Figure 1: Map of the study area. A - Ashanti region, B - Eastern region, C - Central region, D - Greater Accra region

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Selection of farmers

Farmers were selected from each region in the study area using a purposive sampling method. A total of 50 respondents were interviewed to assess their perception of the disease, knowledge of disease occurrence, cropping system, disease severity and disease management options. The respondents comprised male and female farmers. Farmers interviewed were those who had taro farms at the time of the study and those who sold the corms. Personal observations were made of disease symptoms in farmers' fields, swamps along streams, and backyard drainage channels where taro is grown in the regions. Taro plant leaves infected with TLB were collected as leaf samples from farmers' fields for pathological analysis.

Data collection

Field survey

The primary data were collected by means of structured, self-administered interviews and field observation guided by a questionnaire. The questionnaire comprised of open and closed-ended questions, which were written in the English language but was administered in both English and Twi (local language). The research data were collected during the major taro cropping season. Data on the socio-economic characteristics of respondents included their age, educational background and levels, land size, and farming experience.

Assessment of Taro leaf blight (TLB) incidence and severity on the farmers' field

A survey was conducted in selected communities in the four major taro-growing regions of Ghana including Ashanti region (Fawade, Old Tafo, Tafo Estate, Gyenyasi), Central region (Kasoa), Eastern region (Atimpoku, Akim Tafo, Koforidua, Anyinam, Osino, Sekyere, Somanya) and Greater Accra region (Adenta, Haatso, Weija, Medie, Ashale Botwe, Kwafokrom). The incidence and severity of TLB disease were documented. The distances between the selected farms in the communities were between 0.5-1 km. In each region, taro farms (0.10 - 0.80 ha in size) were selected randomly and 50 taro plants were randomly selected in a diagonal direction across the farm and examined for TLB incidence and severity. The distributions of selected farms within the regions are presented in Table 1. Personal observations on the severity of symptoms of TLB disease in the farmers' fields were scored using a subjective score scale of 0 to 5. Infected taro plant leaf samples were collected from farmers' fields for pathological analysis.

Disease incidence and severity were computed using the formula developed by the CSIR- Crops Research Institute (CRI), Kumasi, Ghana as follows:

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$$\text{Disease incidence (DI)} = \frac{Number\ of\ infected\ plants}{Total\ number\ of\ plants}\ X\ 100\%$$

$$\text{Disease severity (S)} = \frac{Area\ of\ leaves\ affected\ X\ The\ rating\ value}{Total\ area\ of\ leaves}$$

The disease severity is rated using 0-5 scoring scale [24].

Data Analysis

Data on taro farmers' socio-demographic characteristics, farm history and agronomic practices and knowledge and perceptions on TLB disease and its management practices were analyzed using Statistical Product and Service Solutions (SPSS, V 25.0, IBM). The results were also quantified in percentages and presented in tables and pie charts using Microsoft excel software. Data on disease incidence and severity were also analyzed by SPSS and graphs and tables were generated.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

Majority of the respondents (60.0 %) were male and 40.0 % female. Most respondents were above 50 years old. The majority (40.0 %) of the respondents had junior high school education, 30.0% had completed primary school, 8.0 % had senior high school education, while 22.0 % accounted for no formal education. None of the farmers had tertiary education. The results show that the majority (56.0 %) of farmers had more than 5 years of farming experience, and 22.0 % of the farmers had grown taro for less than 1 year, while the remaining 22 % had between 1- and 5 years of experience in growing taro (Fig. 2).

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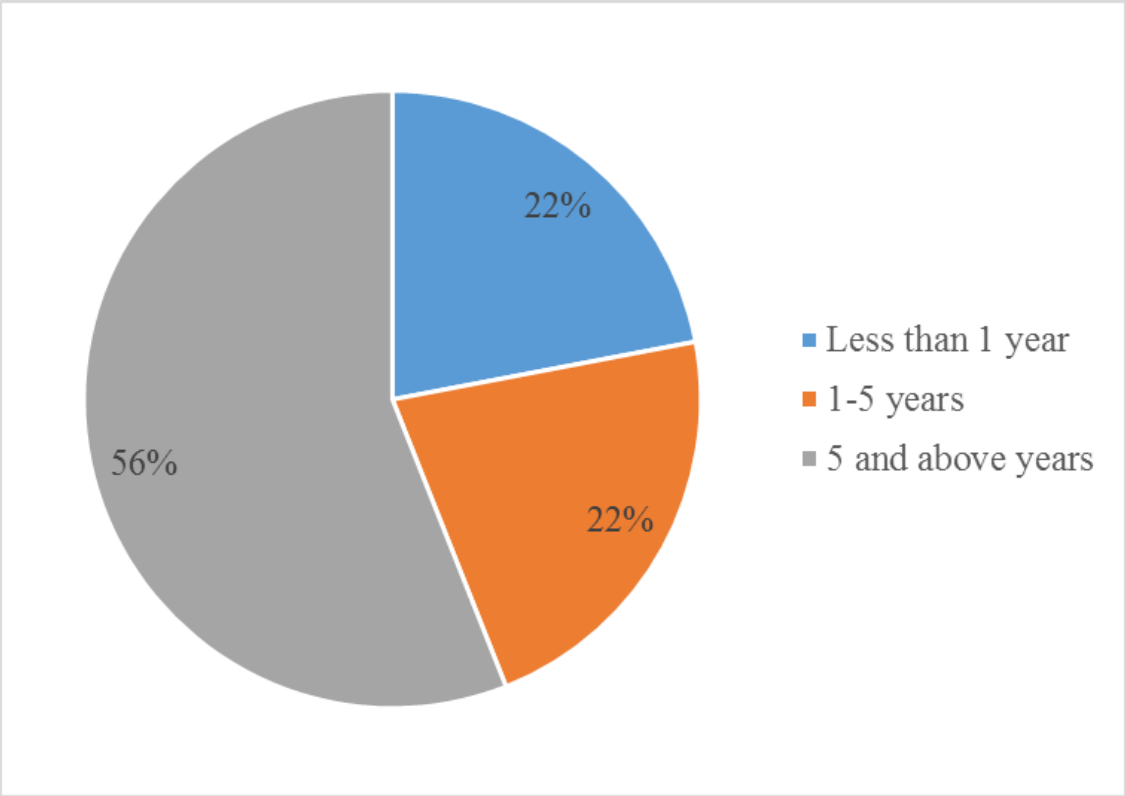

Figure 2: Respondents' years of experience in taro production

The percentage of women involved in taro farming was low compared to men. This observation was evident in areas such as Kasoa and Anyinam where food crops are normally sold in the open market. This is likely to be due to women involvement in buying and selling of farm produce rather than primary farming, as well as the labour-intensive nature of taro farming that are not well-suited for women. It was also observed that the majority of men involved in taro farming were married, supporting the observation that married individuals tend to dominate cocoyam production in rural areas—likely due to greater access to family labor and the need for subsistence farming to support their households [15]. Most respondents were above 50 years old, suggesting that the younger generation are perhaps not interested in taro farming.

The current study has revealed that most of the respondents in the study area had some form of formal education, even though none of them had tertiary education. The importance of education in farmer training, as well as in understanding and applying extension recommendations, has been emphasized as a critical factor for success [16]. The findings of this research imply that most of the respondents are literate and thus adopted the information on TLB including disease management in the taro farming practices.

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It was observed that a greater number of respondents had cultivated taro long enough and may have noticed the significant effects of TLB disease as affecting their livelihoods. These relatively long years of farming experience are likely to have exposed the taro farmers in terms of experience in taro production, marketing activities, and other related information. Long farming experience can influence a farmer's willingness to learn and adopt new agricultural practices more readily [17]. This may be because several innovations may have been made available to them either by design or accident, especially through friends, neighbors, and extension workers. It was also observed that small-size taro farms generally dominate the taro production sector in Ghanaian agriculture, an indication of neglect and underutilization of the taro crop. While taro is significant, it is less produced than other staple crops in Ghana.

Planting materials are a very important component of crop production. According to the respondents, taro planting materials are obtained from different sources including colleague farmers, the Ministry of Food and Agriculture (MoFA), non-governmental organizations (NGOs) and research institutions. The respondents however, indicated that obtaining planting materials from research institutions and other organizations is costly, and prefer to obtain their planting materials from colleague farmers at a lower or no cost (Table 2).

Farm characteristics and agronomic practices of respondents

As shown in Table 2, 64.0% of taro farmers grow taro on less than 1 acre (0.40 ha) of land, , while 20.0% use between 1-3.0 acres (0.40-1.21 ha) of land with the remaining 16.0% growing taro on more than 3 acres (1.21 ha) of land. This shows that small-size taro farms generally dominate the taro production sector in Ghana. Taro remains largely a smallholder crop in Ghana due to limited market development, vulnerability to diseases like taro leaf blight, and insufficient agricultural extension services. Its labor-intensive nature, fragmented land ownership, and cultural role as a subsistence crop also restrict commercial scaling. Additionally, taro has received less policy attention and research funding compared to other staple crops. To expand taro production commercially, improvements in disease-resistant varieties, market infrastructure, farmer training, and supportive policies are essential. Without these, taro is likely to stay a primarily small-scale, subsistence crop. The majority (62%) of the farmers collect their planting materials from colleague farmers (Table 2). Eighteen percent (18%) and 16% of taro farmers obtain their planting materials from research institutions and the MoFA, respectively. The least percentage of farmers (2.0 %) obtain their planting materials from NGOs.

The findings of this research showed that none of the taro farmers routinely apply fertilizer on their farms to grow taro crops, especially those producing taro for subsistence. According to them, fertilizers diminish the quality and storability of taro.

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Contrary to their assertion, that fertilizer diminishes taro quality and storability, the taro crop has been found to respond well to fertilizers, manures, and composts [18]. The application of 15:15:15 NPK fertilizer increases tuber yield in cocoyam [18]. Furthermore, John *et al*. [19], showed that poultry manure contains vital nutrient elements that promote high photosynthetic activities in taro to stimulate root and vegetative growth. Different researchers, including Gasim [20] and Dauda *et al.* [21] reported similar results.

Disease incidence and severity on the farmers' field

The four regions in this study had varying levels of the taro leaf blight (TLB) disease incidence (DI). Eastern region had the highest disease incidence (76.4 %) followed by Ashanti (75.0 %) and Central (70 %) regions, respectively (Table 3). Greater Accra region recorded the least DI of 65 %, showing a significant difference with Ashanti region (Fig. 3). Furthermore, there were varying levels of TLB disease incidence within farmers' field across the four regions. Anyinam had the highest DI with 95 %, followed by Sekyere with 90 %, while Atimpoku had the least DI of 50 % without any significant difference with the DI of 55 % at Kwafokrom (Fig. 4).

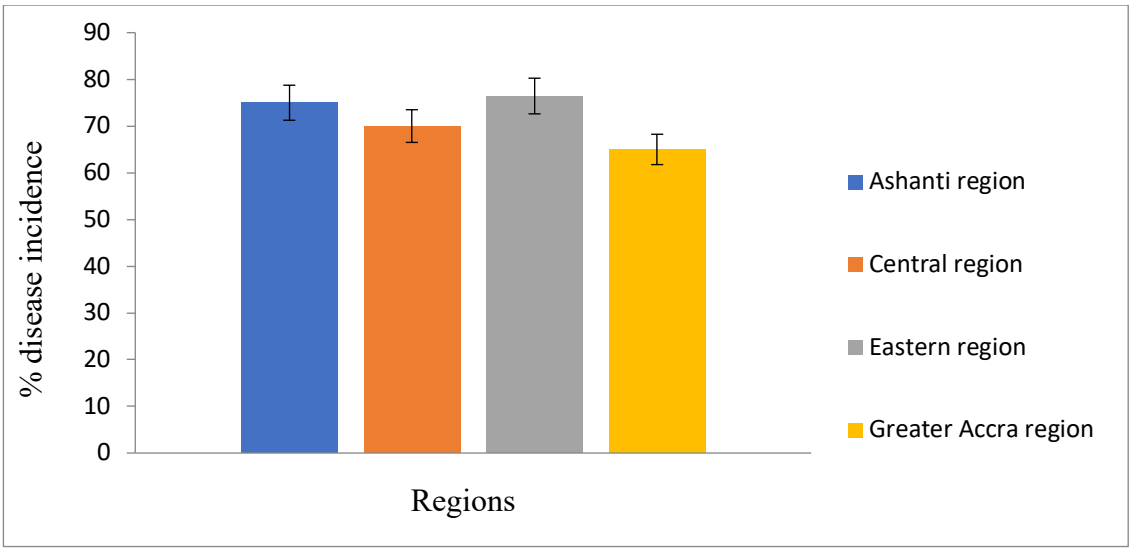

Figure 3: Taro leaf blight disease incidence in the four regions studied

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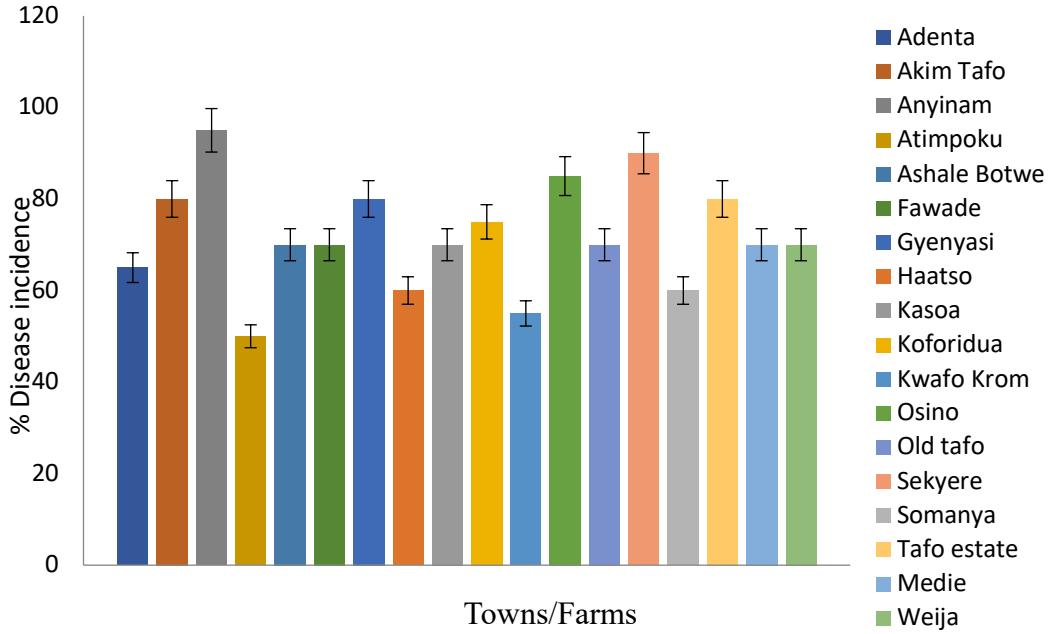

Figure 4: Disease incidence observed among taro farms within the various towns in four regions

Disease symptoms typical of TLB disease were observed on affected taro plants (Figure 5 A-H). Disease severity percentages for all the four regions were above 2.0, indicating the devastating nature of the TLB disease (Fig. 6). Eastern and Ashanti regions recorded the highest disease severity of 3.43 and 3.4, respectively (Fig. 6), whilst the least DI severity was recorded in the Central region with 2.43 (Fig. 6). Within the farms surveyed, TLB disease was most severe in Anyinam (Eastern region), which recorded the highest disease severity score of 4.25, followed by Sekyere (Ashanti region) and Koforidua (Eastern region) with 3.92 and 3.87, respectively. Atimpoku had the least severity of 2.0 (Fig. 7).

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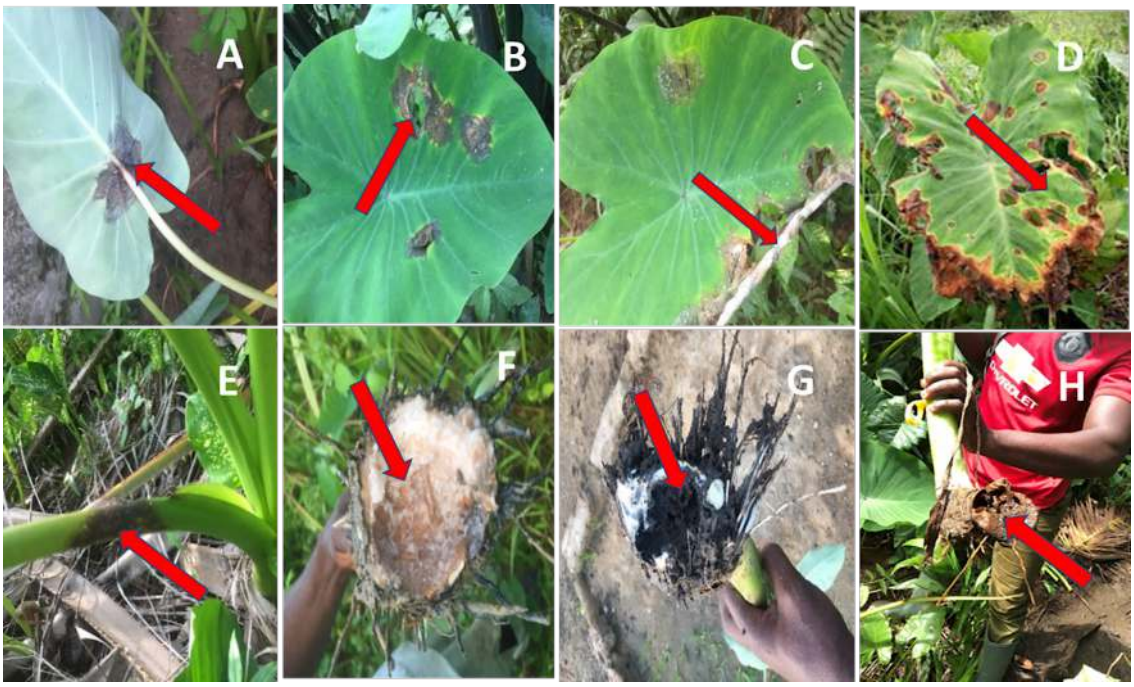

Figure 5: Symptoms of taro leaf blight disease on farmers' field (Symptoms arrowed). A and B: lesion on the leaves of taro plant; C and D: leaves turned dark brown and creating holes; E: petiole turn dark brown; F, G and H: rotting of corms

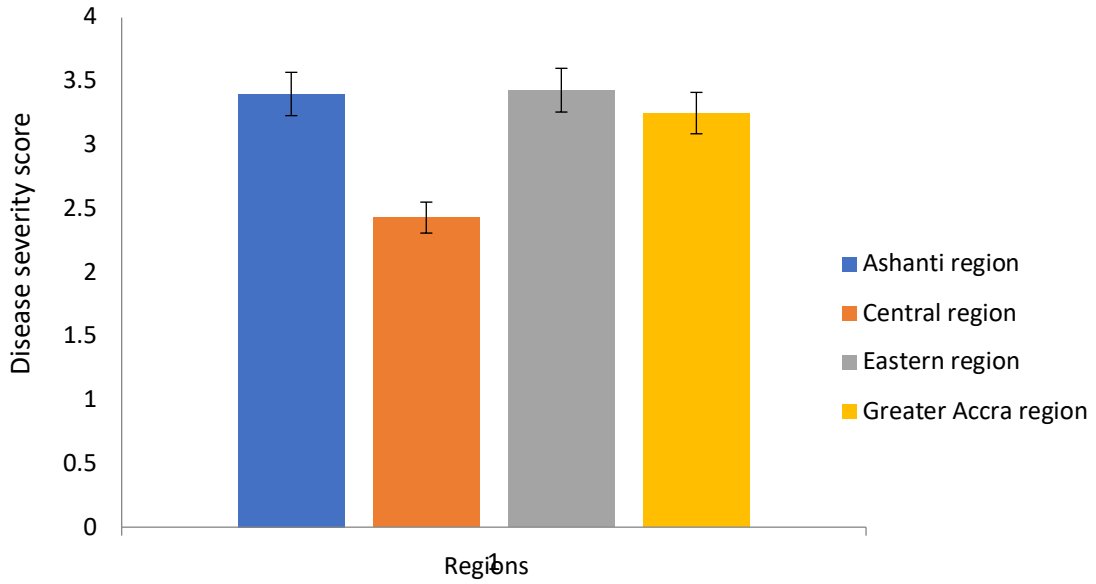

Figure 6: Taro leaf blight severity recorded in the four regions

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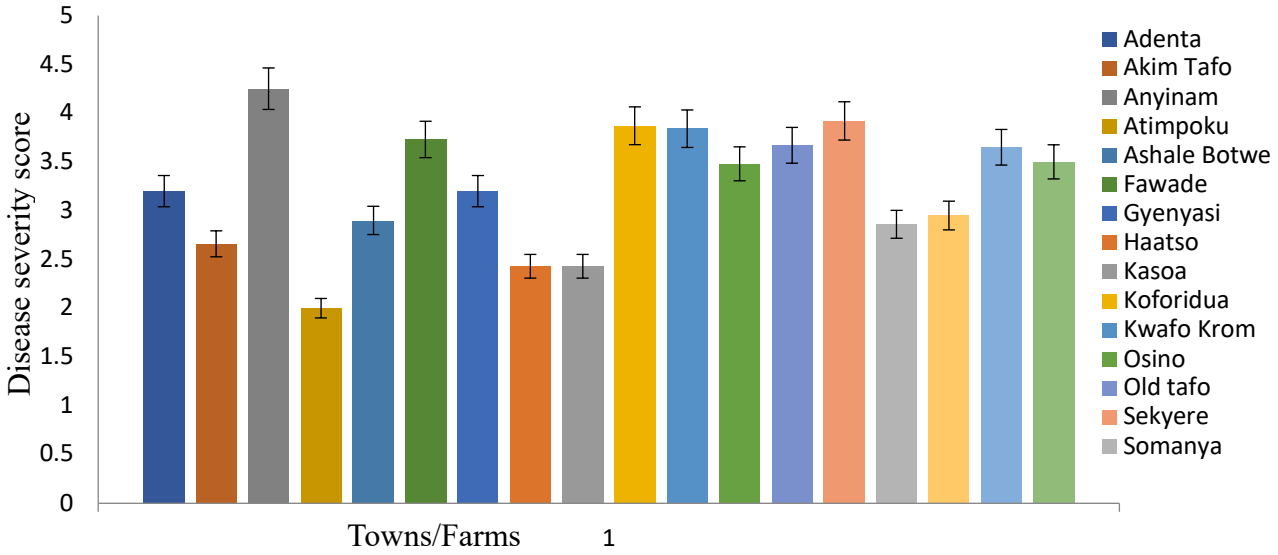

Figure 7: Taro leaf blight severity in taro farms within the various towns in the four regions

Taro leaf blight (caused by the Oomycete *Phytophthora colocasiae*) is a disease of major economic importance in many taro-growing regions of the world. In Africa, Cameroon, Nigeria, and Ghana continue to experience the most devastating effect of the disease on the livelihoods of small-holder farmers and rural settlers who are dependent on the crop [22, 23]. The current study revealed that all taro-growing areas of the four regions in Ghana had disease incidence above 50 %, suggesting a higher level of TLB disease incidence. However, the disease incidence within taro farms in the Greater Accra region was relatively low compared to the other regions (Fig. 3). The low disease incidence in the Greater Accra region could be due to the prevailing weather conditions including erratic rainfall patterns experienced in the region. Likewise, the high disease incidence observed in the Eastern and Ashanti regions could be attributed to the high rainfall patterns observed in the regions. Weather conditions have been reported to influence TLB disease incidence [24]. According to Venier *et al.* [25], atmospheric moisture is generally the single most important environmental factor influencing the incidence and severity of fungal diseases on plants. The relatively high disease incidence observed in the wet season in the current study is consistent with the findings of Aggarwal and Mehrotra [26] who found high relative humidity and frequent rainfall as important factors that favour the development of phytophthora leaf blight. Singh *et al.* [22] also reported that favourable temperatures and regular periods of leaf wetness, particularly in the

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humid tropics, promote TLB epidemics by favouring pathogen dispersal, infection, and subsequent disease development.

Disease severity values for all the four regions were high, highlighting the devastating nature of TLB disease. However, the severity was significantly high in the Eastern and Ashanti regions, which experience high amount of annual rainfall and humidity. The severity of a disease depends on the level of interaction between the host, the pathogen, and the environment [27]. According to Singh *et al.* [22], rainfall, humidity, and temperature are the key factors that influence taro leaf blight disease cycle and epidemiology. These factors are known to favour pathogen dispersal, infection, and disease development. The disease spreads faster when there is intermittent rainfall and high humidity, but the rate of spread decreases when temperatures are high. It is, therefore, not surprising to see high disease incidence and severity in the Ashanti and Eastern regions compared to the Greater Accra and Central regions of Ghana. It was observed that most of the taro farms visited were in a monoculture, which may have influenced disease incidence and severity. In a study, Asraku [28] observed more pronounced TLB symptoms in monocropping than in mixed cropping systems.

Disease awareness and management

Table 3 shows that all 50 farmers interviewed admitted to the presence of TLB disease in their fields.

The majority (42.0 %) of the farmers indicated that the disease is severe in the major rainy seasons. However, 34.0 % of the farmers revealed that the disease spreads faster in all the seasons (major rainy, minor rainy and dry season). Twenty-two (22.0 %) and 2.0 % of the farmers indicated that TLB spread in minor raining season and in the dry season, respectively (Table 3). They confirmed that the disease affects both young and old plants.

A list of symptoms of the TLB disease was presented to each farmer to ascertain whether they had observed any on their farms. Most of the respondents (64.0 %) gave multiple responses; the most common symptom observed was the water-soaked lower leaf surface or dry grey appearance. Twenty percent (20.0 %) of the farmers observed rapid spot enlargement on leaves making the crop purplish brown to brown in colour, 12.0 % responded that their taro crop demonstrates early spots on the leave, and 4.0 % said the crop turns bright orange or reddish brown with the disease. Fourteen percent (14.0 %) indicated that TLB disease makes the leaves of the plant die off, whilst 8 % admitted that the disease physically challenges the crop by reducing the number of leaves on the plants.

Most of the respondents (84.0 %) indicated that they do not control the disease on their fields, while 16.0% of the respondents control the disease. Respondents

suggested a possible 'burning down' of their crops due to pesticide application as the main reason for not controlling the disease.

The disease control strategies employed in the management of TLB disease by the respondents are recorded in Table 3. The results revealed that 60.0 % of farmers use rouging, 30.0 % employ other methods such as mechanical weed control such as hoeing, 6.0 % use weedicides, while 4.0 % use pesticides to control the TLB disease. Although wide spacing and selection of sites surrounded by forest as a barrier to disease spread have been used for TLB disease control, these were not used by any of the respondents.

Additionally, it was observed during the survey that most of the farmers practiced monoculture with *C. esculenta* and some also practiced mixed cropping, cultivating *C. esculenta* as the main crop intercropped with sugar cane or maize in the dry season.

Plant diseases if not properly managed can lead to severe consequences including famine, reduced income and food insecurity. One such disease is TLB, which affects production wherever it occurs, resulting in significant yield losses. The findings of this study suggest that the respondents were aware of the devastating nature of TLB disease in their fields but had no idea about the cause of the disease. Therefore, they attributed the incidence of the TBL disease in their fields to pesticide drift from nearby vegetable growers. They further disputed the fact that corm rot is as a result a fungal infection. Instead, they attributed it to overgrowth when corms are not harvested on time and are left in the water for a long period.

It was evident from this study that most of the respondents do not control TLB disease in their fields perhaps due to lack of knowledge on the cause of the disease. It may also imply the fact that they have never had any extension education in the management of TLB disease. According to Nhemachena [29], exposure to extension services influences the capacity of farmers to adapt to disease effects. The disease control strategies employed in the management of TLB disease by the respondents were rouging, pesticide application, mechanical hoeing, and weed control using herbicides. Although wide spacing and selection of sites surrounded by forest as a barrier to disease spread have been used for TLB disease control [30], these were not used by any of the respondents.

According to the respondents, the disease reduces the yield of affected taro plants, resulting in significant yield and income losses. Respondents attributed the yield reduction to defoliation and tuber rot. This observation is consistent with the findings of Otieno *et al.* [24] who reported that the TLB disease affects all parts of the crop including the leaves, corms, and petioles, resulting in extensive damage to the

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foliage to reduce crop yield. The defoliation limits photosynthesis resulting in decreases in yield.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The results of the current study revealed varying levels of taro leaf blight (TLB) disease incidence among the four regions of Ghana. The Eastern region had the highest incidence of TLB disease incidence, and the Greater Accra region recorded the lowest TBL disease incidence. Additionally, the Eastern and Ashanti regions of Ghana had the highest disease severity rate, and the Central region recorded the least severity of the TBL disease. These variations are apparently due to different weather patterns with the duration of rainfall, temperature and humidity playing a major role. Most of the respondents, with over 5 years of farming experience were literate, but none of them had tertiary education and this could be a factor in the acquisition of knowledge on TLB and options to manage it. Most of the respondents who collect their planting materials from colleague farmers had less than 1 acre of taro crop under cultivation. All the respondents admitted to the presence of TLB disease in their fields, with the majority associating disease severity with the major rainy seasons. Despite the devastating nature of the disease, and its negative impact on the likelihood of small-holder farmers, it is usually not controlled or managed in most farms. Thus, the development of effective control measures for TLB to boost taro production is warranted.

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Data Availability

The data that support the findings of this study are available from the corresponding author upon request.

Declarations

The authors declare no conflict of interest.

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Table 1: Farms selected for disease incidence and severity assessment in the four regions

Region	City/Towns	Number of farms surveyed
Ashanti	Fawade	5
	Gyenyasi	5
	Old Tafo	2
	Tafo estate	3
Eastern	Anyinam	6
	Akim tafo	3
	Sekyere	4
	Osino	3
	Koforidua	2
	Atimpoku	1
	Somanya	1
Greater Accra	Adenta	1
	Ashale Botwe	2
	Haatso	2
	Weija	3
	Medie	3
	Kwafo krom	1
Central	Kasoa	3
Total		50

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Table 2: Percentage distribution of taro farmers based on size of farm, age, source of planting material and fertilizer application in Ashanti, Greater Accra, Central and Eastern regions

Variable	% taro farmers' response
A. Size (acre)	
Less than 1	64.0
1-2	20.0
Above 3	16.0
B. Planting materials	
Market	2.0
Farmers	62.0
Research institutions	18.0
MoFA	16.0
NGO	2.0
C. Fertilizer application	
Yes	0.0
No	100.0

Table 3: Percentage distribution of taro farmers based on TLB disease presence, season of TLB disease, effect of TLB disease, control, and method of control in Ashanti, Greater Accra, Central and Eastern regions

Variable	% taro farmers' responses
A. Presence	
Yes	100.0%
No	0.0%
B. Season	
Major raining	42.0%
Minor raining	22.0%
Dry season	2.0%
All the above	34.0%

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C. Effect	
Drying of leaves	14.0%
Rotting of corms	78.0%
Reduced number of leaves	8.0%
D. Control	
Yes	16.0%
No	84.0%
E. Method of control	
Weedicides application	6.0%
Removal of infected plant	60.0%
Pesticide application	4.0%
Other	30.0%
F. Symptoms	
Early spots often occur on the leaves and accumulates	12.0%
The spots enlarge rapidly becoming purplish brown to brown in colour	20.0%
The lower leaf surface is water-soaked or dry grey appearance present	64.0%
The plant become bright orange or reddish brown	4.0%

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