

Research Article

# Investigation of Agricultural Diseases and Pests in the Republic of Kiribati and the Republic of Fiji

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## Abstract

The Republic of Kiribati (Kiribati) and the Republic of Fiji (Fiji) are two island countries in the Middle and Eastern Pacific Ocean, respectively. Coconut (*Cocos nucifera* L.), banana (*Musa* spp.), sugarcane (*Saccharum officinarum* L.), and breadfruit (*Artocarpus incisa* (Thunb.) L.) are the primary economic crops. To date, there have been few reports on the status of agricultural diseases and pests in these countries. From June 6 to June 16, 2023, our team investigated agricultural diseases and pests in Kiribati and Fiji. Thirty-six diseases, five pests and one parasitic plant from twenty-eight species of plants were identified in Kiribati. Among the deleterious organisms, coconut gray spot (*Pestalotiopsis palmarum* (Cooke) Steyaert), banana Cordana leaf spot (*Cordana musae* (Zimm) Hhonn), hala (pandanus) leaf blight (Unidentified pathogen), breadfruit anthracnose (*Colletotrichum* spp.), frangipani rust (*Coleosporium plumierae* Pat.) and noni anthracnose (*Colletotrichum* spp.) were predominant. A total of twenty-seven diseases and one parasitic plant were identified on twenty-one species of plants in Fiji. Mango bacterial black spot (*Xanthomonas campestris* pv. *mangiferaeindicae*), banana black leaf streak (*Pseudocercospora musae* (Zimm.) Deighton), pumpkin virus disease (Unidentified), and frangipani rust (*Coleosporium plumierae* Pat.) were prevalent. The results of our survey could provide the governments of Kiribati and Fiji with basic data to control the primary agricultural diseases and pests in their countries.

## Keywords

Republic of Kiribati, Republic of Fiji, Agriculture, Disease, Insect Pest, Quarantine

## 1. Introduction

The Republic of Kiribati and the Republic of Fiji are two developing island countries in the mid-eastern Pacific Ocean, with total land areas of 811 and 18,333 km<sup>2</sup>, respectively. Their climates are typical tropical marine ones.

In Kiribati and Fiji, primary crops are coconut, hala, sugarcane, banana and mango, citrus, among others. Among them, coconut and sugarcane are economically important. Although historical records or reports of agricultural diseases, pests, and

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weeds in Kiribati and Fiji [1–3] have been documented, research on them is rare in these two countries, particularly in Kiribati. In addition, international trade and tourism have become increasingly prosperous in both countries (especially Fiji). Key diseases and pests (D&P), such as the Mariana coconut beetle (*Brontispa mariana* Spaeth) [4–5], blue coconut leaf beetle (*Brontispa chalybepennis* (Zacher)) [5], coconut leaf beetle (*Brontispa longissima* Gestro) [6], and red coconut scale (*Furcaspis oceanica* Lindinger) [7], had been reported in the neighboring countries and regions, including the Federated States of Micronesia and Papua New Guinea. All of these pests have a high risk of invading Kiribati and Fiji in the future.

To date, both countries lack researches, reports or historical records related to agricultural diseases, insects and weeds. In June 2023, we studied the targets of the agricultural diseases and pests in Kiribati and Fiji during the "Coconut Production and Processing Technology Training Course in Kiribati". We conducted the study in Tarawa, Kiribati from June 6 to June 13 and on June 15 and 16 in Fiji. The results of our survey could provide basic data for the governments of both countries to obtain a thorough overview of the categories, distribution, and severity of agricultural diseases and pests in their respective countries, as well as for the subsequent prevention and control measures that should be implemented in their agricultural departments. Simultaneously, there were many diseases caused by unknown casual pathogens observed in the survey, which provides insights for future topics of research in both countries in the future.

## 2. Materials and Methods

### 2.1. Date and Location

From June 6 to June 16, 2018, our study on agricultural pests and diseases was conducted in Kiribati and Fiji. The range of our survey in Kiribati was the Tarawa Atoll (the main island), which is the site of the capital Tarawa. The study in Fiji was conducted from Nadi Nalagi Hotel to the Sri Siva Subramaniya Temple in Nandi Town in Viti Island where the capital city of Suva is located.

### 2.2. Materials

Agricultural plants, including coconut (*Cocos nucifera* L.), banana (*Musa nana* Lour), mango (*Mangifera indica*), papaya (*Carica papaya* L.), and sugarcane (*Saccharum officinarum* L.) were examined for the presence of diseases, pests, and parasitic plants.

### 2.3. Methods to Determine the Presence of Deleterious Organisms

Investigation and collection of insect pests was by beating

and sweep nets. Survey of diseases (leaf, fruit, flower and stem) was conducted by visual observation, detailed symptoms and severity were described and recorded. All insect pests and diseases were photograph and kept for further identification.

### 2.4. Methods to Determine the Presence of Deleterious Organisms

The diseases were primarily identified based on the characteristics of their symptoms. The pests were distinguished based on their morphological characteristics and the symptoms they caused on their host plants [5]. Simultaneously, real physical object or photos of both the diseases and pests were identified based on professional literature and historical records in both countries [5].

Severity of disease and pest was according to the standard of literature [8]: +, common; ++, middle; +++, serious.

## 3. Results

### 3.1. Agricultural D & P in Kiribati

The primary crops in Kiribati include coconut, banana, hala (pandan) (*Pandanus tectorus*), sugarcane, pumpkin (*Cucurbita moschata* (Duch. ex Lam.) Duchesne ex Poiret), and papaya among others. Among them, coconut is economically important, and coconut copra is the primary source of income for farmers on the outer islands. Hala (pandan) and banana are the most common fruits, while sugarcane and pumpkin are not abundant in Kiribati.

A total of twenty-eight types of plants, including coconut, banana, breadfruit (*Artocarpus incisa* (Thunb.) L., papaya, guava (*Psidium guajava* L.), pumpkin, hala (pandan), sugarcane, castor bean (*Ricinus communis* L.), noni (*Morinda citrifolia* L.), frangipani, sago palm (*Cycas revoluta* Thunb), periwinkle (*Catharanthus roseus* (L.) G. Don), *Plumeria obtusa* L., Ti plant (*Cordyline fruticosa* (L.) A. Cheval), chaya (*Cnidoscolus aconitifolius* I. M. Johnst.), coffee senna (*Senna occidentalis* (Linnaeus) Link), Chinese ixora (*Ixora chinensis* Lam.), song of India (*Dracaena reflexa*), copper leaf (*Acalypha wilkesiana* Müll. Arg.), tiaré flower (*Gardenia taitensis*), noni (*Morinda citrifolia* L.), edible canna (*Canna indica* L.), wild coffee (*Polyscias guilfoylei* (Cogn. et March.) Bailey), Indian almond (*Terminalia catalpa* L.), Chinese fan palm (*Livistona chinensis* (Jacq.) R. Br. ex Mart.), sea randa (*Guettarda speciosa* L.), and *Premna subcapitata* Rehd were surveyed in our study. A total of thirty-eight diseases, five pests, and one parasitic plant (Table 1) were observed. Among these harmful diseases, the prevalent ones were coconut gray spot (*Pestalotiopsis palmarum* (Cooke) Steyaert), banana Cordana leaf spot (*Cordana musae* (Zimm) Hhonn), noni anthracnose (*Colletotrichum* spp.), hala (pandan) leaf spot (Unidentified pathogen), and breadfruit leaf blight (*Colletot-*

*trichum* spp.) among others. Love-vine (*Cassytha filiformis* L.), a species of parasitic plant, was found on the sea randa plants. The primary categories, distribution, and severity of the agricultural diseases and pests in Kiribati are shown in Table 1.

Three diseases, including coconut stem bleeding (CSB, *Thielaviopsis paradoxa* (de Seynes) Vohnel) (Figure 1), coconut gray spot, and coconut lethal yellowing (suspected, phytoplasma), were found on coconut, the most economically important crop in Kiribati. Two species of pests, coconut

rhinoceros beetle (*Oryctes rhinoceros* L.) and an unknown whitefly, were also observed on coconut. A suspected disease, coconut lethal yellowing (CLY) that has typical symptoms of leaf yellowing and the death of individual plants, which leaves bare trunks, was also found in the southern area on the Kiribati mainland. Further research is expected to determine whether CLY is the causal agent of the symptoms of yellowing leaves and the death of trees in Kiribati.

The primary D&P on the other nine major economic crops that include both fruit trees and vegetables, particularly.

**Table 1.** Categories and Distributions of Agricultural Diseases, Pests and Weeds in the Republic of Kiribati.

Harmful Microorganisms	Scientific name	Distribution
Coconut stem bleeding	<i>Thielaviopsis paradoxa</i> (de Seynes) Vohnel	Occasional++
Coconut lethal yellowing*	Phytoplasma	Occasional++
Coconut gray leaf spot	<i>Pestalotiopsis palmarum</i> (Cooke) Steyaert	Common+
Coconut rhinoceros beetle	<i>Oryctes rhinoceros</i> L.	Occasional+
Coconut Scale	Unidentified	Occasional+
Banana Cordana leaf spot	<i>Cordana musae</i> (Zimm) Hhon	Common++
Banana stem rot	Unidentified	Common+
Mealybug	Unidentified	Common+
Breadfruit anthracnose	<i>Colletotrichum</i> spp.	Common+
Papaya Corynespora spot	<i>Corynespora cassiicola</i> (Berk. et Curt) Wei	Occasional+
Guava sooty mold	Unidentified fungi and scale	Occasional+
Guava Scale	Unidentified	Occasional+
Pumpkin downy mildew	<i>Pseudoperonospora cubensis</i>	Occasional+
Pumpkin virus disease	Unidentified	Occasional+
<i>Pandanus tectorius</i> leaf blight	Unidentified	Occasional+
Sugarcane brown spot	<i>Cercospora longipes</i> Butler	Occasional+
Sugarcane stem rot	Unidentified	Occasional+
Castor bean leaf spot	Unidentified	Occasional+
Noni anthracnose	<i>Colletotrichum</i> spp.	Common+
Noni fruit rot	Unidentified	Occasional+
Plumeria rust	<i>Coleosporium plumierae</i> Pat.	Prevalent+
Plumeria brown spot	Unidentified	Occasional+
Sago cycas leaf blight	Unidentified	Occasional+
Chinese ixora brown spot	Unidentified	Occasional+
Copper leaf spot	Unidentified	Occasional+
tiar éflower leaf spot	Unidentified	Occasional+
<i>Gardenia tahitensis</i> crown gall	Unidentified	Occasional+
<i>Morinda officinalis</i> leaf diback	Unidentified	Occasional+
<i>Morinda officinalis</i> leaf blight	Unidentified	Occasional+

Harmful Microorganisms	Scientific name	Distribution
<i>Canna indica</i> leaf blight	Unidentified	Occasional+
Chinese fan palm Scale	Unidentified	Occasional+
sea randa leaf blight	Unidentified	Common+
<i>Premna subcapitata</i> leaf galls	Unidentified	Occasional+
love-vine	Unidentified	Common+

\*indicates suspected disease, a few plants died; +indicates common harmful organism which need no control measures; ++indicates more harmful organism which need attention and control measures; +++indicates serious harmful organism which need urgent control measures.

The same as below banana, breadfruit, papaya, guava, pumpkin, hala (pandan), sugarcane, castor bean, and noni were banana Cordana leaf spot (Figure 2), breadfruit leaf blight (Figure 3), hala (pandan) leaf spot, and pumpkin leaf spot (Unidentified pathogen), sugarcane brown spot (*Cercospora longipes* Butler), and noni anthracnose (Table 1). The noni anthracnose and frangipani rust were relatively common in Kiribati.

The other nineteen plants, including flowers and tall trees

among others, were primarily found to be infected by leaf spot types of diseases. These diseases, except for the sago palm leaf blight (Unidentified pathogen), *Morinda citrifolia* leaf wilt (Unidentified pathogen), and *Guettarda speciosa* leaf blight (Unidentified pathogen), were not severe.

In addition, *G. taitensis* galls (Unidentified insect or pathogen) and a parasitic plant love-vine (*Cassytha filiformis* L.) were also observed, and the latter was primarily found on *G. speciosa* trees in the southern part of the main island of Kiribati.

**Table 2.** Categories and Distributions of Agricultural Diseases, Pests and Weeds in the Republic of Fiji.

Harmful Microorganisms	Scientific name	Distribution
Coconut basal stem rot	<i>Ganoderma</i> spp.	Occasional+
Coconut sooty mould	Unidentified fungi	Occasional+
Coconut rhinoceros beetle	<i>Oryctes rhinoceros</i> L.	Occasional+
Banana black leaf streak	<i>Pseudocercospora musae</i> (Zimm.) Deighton	Prevalent++
Pumpkin virus disease	unknown	Occasional+
Mango bacterial black spot	<i>Xanthomonas campestris</i> pv. <i>mangiferaeindicae</i>	Common+
Mango anthracnose	<i>Colletotrichum</i> spp.	Common+
Citrus canker	<i>Xanthomonas campestris</i> pv. <i>citri</i> Dye	Occasional+
Breadfruit black spot	Unidentified	Occasional+
Breadfruit algal spot	Unidentified	Occasional+
Papaya <i>Corynespora</i> spot	<i>Corynespora cassiicola</i> (Berk. et Curt) Wei	Occasional+
<i>Colocasia esculenta</i> leaf spot	Unidentified	Occasional+
Noni anthracnose	<i>Colletotrichum</i> spp.	Common+
Noni fruti rot	Unidentified	Occasional+
Noni leaf galls	Unidentified	Occasional+
Plumeria rust	<i>Coleosporium plumeriae</i> Pat.	Common+
mast tree leaf spot	Unidentified	Occasional+
<i>Codiaeum variegatum</i> leaf spot	Unidentified	Occasional+
<i>Codiaeum variegatum</i> read spot	Unidentified	Occasional+
<i>Polyalthia longifolia</i> leaf spot	Unidentified	Occasional+



Harmful Microorganisms	Scientific name	Distribution
Peepul leaf spot	Unidentified	Common+
Dodder	<i>Cuscuta chinensis</i> Lam.	Occasional+

### 3.2. Agricultural D&P in Fiji

The primary crops in Fiji are coconut, banana, mango, citrus (*Citrus* spp.), and taro (*Colocasia esculenta* (L.) Schott) among others. Among these crops, sugarcane is widely planted in the country because it is easily sold to the foreign market owing to its high content of sugar. Thus, it is one of the primary sources of income for Fijian farmers.

A study was conducted on twenty plants, including coconut, banana, pumpkin, mango, citrus, breadfruit, papaya, taro, noni, frangipani, periwinkle, Ti Plant, golden Pothos (*Epipremnum aureum* (Linden et Andre) Bunting), sago palm, *P. guilfoylei*, lady palm (*Rhapis humilis* (Thunb.) Bl.), corn plant (*Dracaena fragrans* (L.) Ker Gawl), croton (*Codiaeum variegatum* (L.) A. Juss.), mast tree (*Polyalthia longifolia* (Sonn.) Thwaites), Bodhi (*Ficus religiosa* L.), and areca palm (*Areca catechu* L.). A total of twenty-four diseases, one pest, and one parasitic plant species were observed on these plants (Table 2). Among these agricultural D&P, the common ones included the coconut rhinoceros beetle (Figure 4), banana black leaf streak (*Pseudocercospora musae* (Zimm.) Deighton) (Figure 5), noni anthracnose, pumpkin virus disease (Unidentified virus), mango bacterial black spot (Figure 6), and citrus canker (*Xanthomonas citri* pv. *citri*) (*Pseudocercospora musae* (Zimm.) Deighton) among others. The categories, distribution, and severity of major agricultural diseases and pests in Fiji are summarized in Table 2.



Figure 1. Symptoms of coconut stem bleeding.



Figure 2. Symptoms of banana Cordana leaf spot.



Figure 3. Symptoms of breadfruit anthracnose.



Figure 4. Leaf symptoms caused by coconut rhinoceros beetle.



Figure 5. Symptoms of black leaf streak.



**Figure 6.** Symptoms of bacterial black spot.

The survey showed that two types of diseases, coconut basal stem rot (*Ganoderma* spp.) and coconut sooty mold (Unidentified fungi), were commonly found on coconut trees. One species of pest, the coconut rhinoceros beetle, was also found on coconut trees. The primary diseases on the other eight most common economic plants (fruit trees and vegetables: bananas, pumpkins, mangoes, citrus, papaya, taro, and noni) were banana brown leaf streak, *pumpkin virus disease*, mango bacterial black spot, mango anthracnose, citrus canker, and noni anthracnose. Among these diseases, banana brown leaf streak, mango bacterial black spot, mango anthracnose, citrus canker, and noni anthracnose were prevalent. In addition, noni fruit rot, an occasional disease, may lead to a yield losses on noni.

The primary harmful pathogens on the other twelve plants, including flowers and tall trees among others, were leaf spot types of diseases. All of these diseases except for plumeria rust, aureus leaf wilt (Unidentified fungi), and Bodhi leaf spot (which was also reported in China [9]) (*Diaporthe tulliensis*; anamorph: *Phomopsis heveicola*), were not serious. In addition though the parasitic plant dodder (*Cuscuta* sp.) was observed, it poses a slightly harm to its host plant.

## 4. Discussion

A total of forty-four diseases, pests, and parasitic plants were observed on twenty-eight plants in Kiribati and twenty-six harmful organisms on twenty plants in Fiji. In both countries, leaf spot types of diseases (including types of anthracnose) and mealybugs were common and less harmful, while coconut stem bleeding (CBS), coconut rhinoceros beetle, banana black leaf streak, *pumpkin virus disease*, citrus canker, mango bacterial black spot, and dodder were severe. Some of the harmful organisms observed in both countureis were lethal or highly devastating and merit attention and management measures are necessary in case they emerge as severe pathogens or pests. CSB, which was first observed in Sri Lanka, is a fatal disease on coconut trees. It has been reported from Brazil [10, 11], China [12], and Micronesia [5]. Banana leaf spot, including banana black leaf streak and banana Cordana leaf spot, is one of the most prevalent banana diseases. It has become a primary aggressive disease in all the regions in which bananas are grown, including Asia, South

America, and Africa [13].

To date, tropical and subtropical plant diseases and pests [5, 13–18] and invasive organisms [19] found all over the world had been systematically summarized by different researchers. The key harmful pests that must be closely monitored in Kiribati and Fiji include coconut lethal yellowing [13, 20, 21], Mariana coconut beetle (*Brontispa mariana* Spaeth) and blue coconut leaf beetle (*Brontispa chalybepennis* (Zacher)), citrus huanglongbing, areca palm yellow leaf, and red palm weevil, which have emerged as serious threats in neighboring countries or regions. Coconut lethal yellowing (CLY) is a devastating disease [13], which occurs in South America, Africa, and Asia (Indonesia, Malaysia, and other places) [20, 21]. Bogia coconut syndrome is also a devastating disease similar to CLY, which has been reported in Papua New Guinea [22]. Banana Fusarium wilt disease (also known as Panama disease) is becoming the most devastating disease of banana plantations all over the world [23]. Citrus huanglongbing is a lethal disease that seriously threatens the citrus industry worldwide [24, 25], and both it and citrus canker are listed as quarantine diseases in many countries [13, 18]. Areca palm yellow disease has also caused serious losses to the betel nut (*Areca catechu* L.) industry in India [14] and in Hainan Province in China [26]. The two coconut beetles described above are two of the most harmful pests on coconut, and they have both been documented in Hawaii (USA) [4] and Micronesia [5]. In addition, pests, such as the red palm weevil [27], also merit vigilance to ensure that they are kept out of Kiribati and Fiji.

## 5. Conclusions and Recommendations

In Kiribati and Fiji, except for coconut (Kiribati) and sugarcane (Fiji), other crops, such as banana and mango, are grown on a small scale on the sides of roads, small farms or around hotels and courtyards. Though tens of diseases, pests, and parasitic plants were observed in both countries, most of which were less harmful diseases and mealybugs. However, agricultural technologies are weak in Kiribati and Fiji. Our survey can enrich or fill in the basic knowledge or gaps in agricultural diseases and pests for both countries. This should help the governments to comprehensively master the categories, distribution, and severity of harmful pests in their respective countries and can also provide insight for future topics of research in both countries in the future.

It should be delineated that international trade and tourism in Kiribati and Fiji (especially the latter) have become increasingly frequent. To ensure the healthy development of the agricultural industry, the customs and agricultural departments of both countries should be vigilant, establish a list of quarantine or invasive diseases and pests (including Mariana coconut beetle, blue coconut leaf beetle, red palm weevil, coconut lethal yellowing), and develop rapid detection technologies (including banana Fusarium wilt, citrus huanglongbing, coconut lethal yellowing) to prevent the potential invasion of these harmful organisms from imported agricultural

products, tourists, and other manners. In addition, key researches on the harmful organisms are required by national affiliations (for example Universidad del Pacífico). An international cooperation with scientists from other countries or organizations (for example Food and Agriculture Organization of the United Nations) would be of great help for Kiribati and Fiji.

## Abbreviations

D&P: Diseases and Pests

CBS: Coconut Stem Bleeding

CLY: Coconut Lethal Yellowing

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## Conflicts of Interest

The authors declare no conflicts of interest.

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