

Investigation of Agricultural Diseases, Pests and Weeds in the Federated States of Micronesia

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Abstract: *The Federated States of Micronesia (FSM) is an island country in the Western Pacific Ocean, in which coconut, areca palm, banana, pepper, etc are its main small-scale crops. At present, its agriculture is facing serious problems including pests and diseases. From June to July 2018, a systematic investigation of agricultural diseases, pests and weeds was conducted in four states of FSM. The results showed that forty-one diseases, eighteen pests and arthropods were observed from nineteen plants, and ten weeds were also found in the country. Among these harmful organisms, coconut stem bleeding, Mariana coconut beetle, blue coconut leaf beetle, red coconut scale, banana leaf spot, hot pepper bacterial wilt, and weed *Merremia peltata* were the most serious. The results of the survey could provide a basis for the FSM government to obtain a comprehensive understanding of the categories, distributions and damages of agricultural pests and diseases together with weeds in the country.*

Keywords: *Federated States of Micronesia; agriculture; diseases, pests and weeds; systemic investigation*

1. Introduction

The Federated States of Micronesia (FSM) is an island country in the western Pacific Ocean with a typical tropical marine climate. Its crops mainly include coconut, areca palm, banana, pepper, etc. Among them, coconut, an economically important crop, is reputed as "Tree of Life". However, its coconut industry is still in its primitive stage, facing problems such as serious diseases and insect pests, low coconut yield, and low product development. In response to the request of the former President of FSM, Peter M. Christian, for technical aid for the development of the coconut industry, a team of technical training experts in cultivation, plant protection, processing and other fields formed by Chinese Academy of Tropical Agricultural Sciences (a total of 12 experts) With the funding of the Ministry of Commerce of the People's Republic of China. From June to July 2018, the team conducted a coconut cultivation technology, pest control technology training and field practice for agricultural officials and farmers in Yap, Chuuk, Kosrae

and Pohnpei of FSM. At the same time, FSM lacks researches, reports or historical records related to agricultural diseases, insects and weeds (only the surrounding countries and regions had reports including Mariana coconut beetle [Jr, 1950], coconut red scale [Muniappan, 2003], etc.). In order to better help the government of FSM to understand its situation, the team conducted a systematic investigation in the four states (main island) led the way by officials from the agricultural department and some trainees of FSM.

The results of this survey could provide a basis for the government of the Federated States of Micronesia to fully understand the types, and to carry out follow-up prevention and control by the agricultural sector. At the same time, there were some suspected and unknown pathogenic diseases and insect pests observed during the investigation, which provided clues for further researches for FSM scholars in the future.

2. Investigation Method

2.1 Investigation time and place

From June 11, 2018 to July 05, 2018, a systematic survey was conducted on agricultural diseases, pests and weeds in four states Yap, Chuuk, Kosrae and Pohnpei of FSM.

2.2 Investigation object

Palm plants (coconut and areca palm), horticultural plants (fruit trees: banana, mango, citrus, papaya, etc.; vegetables: hot pepper, cucumber, etc.; flowers: frangipani, etc.), special cash crops (cassava, coffee, pepper, sugarcane) pests and diseases, and Agricultural weeds.

2.3 Investigation Methods

In FSM, the scale of the above-mentioned crops is small, and most of them are grown in a way of original ecology, so the random survey method was mainly adopted. During the classroom training and field practice, a key investigation was conducted on the

diseases and pests (such as coconut stem bleeding disease) raised or discovered by some trainees.

2.4 Identification methods of pests and diseases

Diseases: identification was mainly based on symptoms and characteristics [Li and Zheng, 2015] combined with literature data. Pests: were identified by morphological characteristics [Qin and Zhu, 2011] combined with reference data.

3. Results and Analysis

A systematic survey was conducted on the diseases, pests and weeds of palm plants, horticultural plants, and special economic crops in FSM. The results showed that on the 19 plants (including coconut, areca palm, banana, mango, papaya, citrus, pepper, cucumber, bitter melon, cassava), there were 41 kinds of diseases, 18 kinds of pests and arthropods on coffee, pepper, sugarcane, etc.; there were also 10 kinds of main weeds in the country (Table 1). Among them, lethal yellowing disease of coconut, yellow leaf disease of areca palm and citrus greening disease were suspected diseases. Serious diseases, insect pests and weeds included coconut stem bleeding disease, Mariana coconut beetle, blue coconut leaf beetle, coconut red scale, banana leaf spot, hot pepper virus disease, hot pepper bacterial wilt, *Merremia peltata* (L.) Merr., etc. In addition, 17 diseases caused by unknown pathogens and 11 pests of unknown taxonomic status were found on coconut, citrus, lotus mist, bread tree, dragon fruit, cowpea, pumpkin, eggplant, bitter melon, pepper and cocoa (data not shown). Table 1 summarized the types, distribution and damage of agricultural diseases, insect pests and weeds in FSM.

3.1 Palm Plant Pests and Diseases

The survey results showed that there were 6 diseases on coconuts in FSM, namely Coconut stem bleeding, Coconut lethal yellowing (suspected), Coconut gray leaf spot, Coconut anthracnose, Coconut sooty mold, Coconut basal stem rot; there are 6 kinds of pests, namely Mariana coconut beetle (*Brontispa mariana* Spaeth), and Blue coconut leaf beetle (*Brontispa chalybepennis* (Zacher)), *Oryctes rhinoceros* L., *Aspidiotus destructor* Signoret, Red coconut scale (*Furcaspis oceanica* Lindinger), Coconut flat moth (*Agonoxena pyrogramma* Meyr.), Coconut mealybug (*Nipaeconius nipae* (Maskel)). There are 3 kinds of diseases on areca palm, Areca palm yellow leaf (suspected), Areca anthracnose and Areca basal stem rot. Among them, the most serious ones on coconut were stem bleeding disease, Mariana coconut beetle, blue coconut leaf beetle and red coconut scale. Coconut

stem bleeding is a fatal disease of coconut palms that occurs in all coconut growing areas of the world. The disease had occurred in China [Yu et al, 2012], India [Qin and Zhu, 2011], Brazil [Dulce et al, 2009; Carvalho et al, 2013] and other countries. The survey found that the disease burst near De Blois Point in Kosrae State. To date, dozens of coconut trees had been infected by the disease, and some of the plants had died and been cut down (Fig. 1, 2). The nearby coconut trees were also under potential threat. In addition, two suspected diseases, lethal yellowing disease of coconut and yellow leaf disease of areca palm, also need special attention. The former was distributed in a resort hotel in Kosrae State. More than 10 coconut trees had died and been cut down, and the leaves of the remaining plants (about 30 trees) also showed characteristic yellowing symptoms; the latter only occurred in a banana nursery in Pohnpei State. Lethal yellowing of coconut is a devastating disease that was first identified in the Caribbean, western Jamaica [Qin and Zhu, 2011; Li and Zheng, 2015]. Currently, the disease is distributed in the Cayman Islands, Bahamas, Cuba, Dominica, Haiti, southern Florida of the United States in Latin America, Africa and the West Indies, Indonesia, Malaysia and other places in Asia [Eziashi and Omamor, 2010; Gurr et al, 2016]. The Mariana coconut beetle and the blue coconut leaf beetle were the two most destructive pests of coconuts in FSM. The former was distributed in Yap State (Figures 3, 4), and it was also observed in Hawaii [Jr, 1950]; the latter was mainly distributed in Pohnpei State (Figures 5, 6). In the case that the two pests damaged seriously, they could lead to production decline and plant death, which severely threatened the healthy development of the coconut industry. In Kosrae and Pohnpei states, Coconut scale (Figures 7, 8) also occurred more frequently. Areca palm yellow leaf is also a devastating disease that has caused severe losses to the areca palm industry in China [Tang et al, 2022] and India [Balasimha and Rajagopal, 2004]. Plants suspected of being infected with areca palm yellow leaf disease were found in a banana nursery in Kosrae state.

3.2 Pests and diseases of horticultural plants

The results of this investigation indicated that there were 24 kinds of diseases and 6 kinds of pests on 8 kinds of fruit trees, 4 kinds of vegetables and 2 kinds of flower plants. There were two types of leaf spot diseases on bananas, Banana *Cercospora* leaf spot and Banana *Cordana* leaf spot. There are 5 kinds of diseases on mango, namely Mango anthracnose, Mango bacterial black spot, Mango sooty mold, Mango scab, Mango algae spot or Mango red rust. There were 2 diseases on papaya, Papaya *Corynespora* spot and Papaya

anthracnose; 1 pest, *Paracoccus marginatus* Williams and Granara de Willink. There were 4 kinds of diseases on citrus namely Citrus huanglongbing (Citrus greening), Citrus bacterial canker disease, Citrus sooty mold, and Citrus algae spot; 1 pest was *Aleurocanthus spiniferus* Quaintance. There was one kind of disease on guava, which was Guava sooty mold, and one kind of pest, which was Guava scale. There was one kind of disease on noni, which is Noni anthracnose. There were 5 kinds of diseases on peppers, Hot pepper viral disease, Hot pepper anthracnose, Hot pepper sooty mold, Hot pepper southern bacterial wilt, and 1 species of pest, *Bemisia tabaci* (Gennadius). There was one disease on cucumber, Cucumber *Corynespora* leaf spot. There was one disease on bitter melon, Bitter melon *Cercospora* leaf spot; one pest was Pumpkin beetles (*Aulacophora* spp.). There was one disease on taro, which was Taro blight. There were 5 kinds of diseases on the frangipani, which were Plumeria rust; one pest was *Nipaecoccus vastalor* Maskell. There was one disease on canna, Plumeria rust.

Banana leaf spot is one of the most common diseases of banana, which is mainly distributed in every banana producing countries such as Asia, Africa and South America [Li and Zheng, 2015], and there are many types caused by different pathogens [Chen et al, 2006; Xie and Zheng, 2010; Li and Zheng, 2015]. In FSM, banana brown leaf spot was the most serious, followed by banana gray leaf spot. Citrus huanglongbing (greening) is a devastating disease that has posed a serious threat to the world's citrus industry [Bové, 2006; Gottwald, 2010; Zhou, 2018]. Citrus bacterial canker disease is also an important disease worldwide, and it is now listed as a quarantine disease in many countries [Li and Zheng, 2015; Xie and Zheng, 2010]. Citrus huanglongbing (suspected) and citrus canker occurred in Chuuk and Pohnpei States. Hot pepper virus disease is widely distributed in the world, and its occurrence often causes serious damage and loss [Li and Zheng, 2015]. Bacterial wilt is one of the most devastating diseases of Solanaceae crops [Mamphogoro et al, 2020]. The two hot peppers diseases occurred in a farm in Pohnpei State.

3.3 Pests and diseases of special economic crops

The results of this survey demonstrated that 3 kinds of diseases were found on cassava, namely Cassava Brown Leaf Spot, Cassava anthracnose, Cassava plaster; 2 pests, Carmine spider mites (*Teranychus cinnabarinus* Boisduva1), *Bemisia tabaei* (Gennadius); 1 species of arthropod, Giant African land snail (*Achatina fulica* Ferrussac). There are three diseases on coffee, namely Coffee anthracnose, Coffee brown spot, Coffee

Corticium blight. There is 1 disease on pepper, Spice pepper *Cephaleuros* leaf spot. The above diseases were not serious.

3.4 Weeds

The results showed that there were 10 main weed species in FSM, namely *Merremia peltata* (L.) Merr., Mimosa (*Mimosa pudica* Linn.), Brazilian Mimosa (*Mimosa diplotricha* C. Wright), *Mikania micrantha* Kunth, *Chromolaena odorata* L., *Wedelia chinensis* (L.) Pruski, *Wedelia biflora* (Linn.) DC., *Bidens pilosa* L. *Fimbristylis cymosa* (Lam.) R. Br., *Cyperus difformis* L. Among the weeds, *D. scutellaria* is an invasive plant in the Pacific [Garsetiasih et al, 2019], which often destructively strangles the underlying plants it covered. *M. micrantha* is one of the 100 most harmful invasive species in the world and one of the most harmful weeds in tropical and subtropical regions of the world [Wan et al, 2010]. Fragrant Eupatorium herb (*C. odorata*) is also one of the most serious invasive alien species. It is a vicious and poisonous weed recognized worldwide [Wan, 2010]. In FSM, the most serious weed is *M. peltata*, which had already caused devastating damage to the natural vegetation of FSM (including coconut, cassava, bread tree, etc.) (Fig. 9).



Fig -1 : Leave symptoms caused by Coconut stem bleeding disease



Fig -2 : The dead plants infected by stem bleeding were cut down



Fig -3 : Adults of Mariana coconut beetle



Fig -4 : Symptom of Mariana coconut beetle attacked on coconut tree

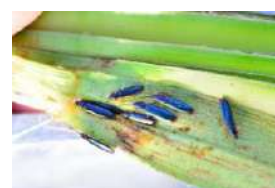


Fig -5 : Adult Dark Blue Coconut Beetle



Fig -6 : Symptom of blue coconut leaf beetle attacked on young trees



Fig -7 : Leaf symptom of coconut red scale attacked on coconut tree damages coconut leaves



Fig -8 : Leaf and petiole symptoms of coconut red scale attacked on coconut tree



Fig -9 : Coconut and other crops were affected by *Merremia peltata* (L.)



Fig -10 : Natural vegetation were destroyed by *Merremia peltata* (L.)

The balance of natural ecology and biodiversity were also under a serious threat (Figure 10).

4. Conclusions and Recommendations

4.1 Conclusion

In FSM, the crops (such as coconut, chili, coffee, and pepper) are small-scale and are mostly grown in a way of original ecology. They were grown on both sides of the road, hotels, and small farms. In the survey, 59 kinds of pests and diseases were observed and identified on 19 plants including coconut, areca palm, banana, mango, papaya, pepper, cucumber, bitter gourd, cassava, coffee, and pepper. The findings revealed that 10 major weed species also existed in FSM. In addition to various common leaf spot (for example anthracnose), scale insects and other pests and diseases, there were some important and even fatal or destructive pests and weeds, such as lethal/destructive diseases and insect pests coconut stem bleeding disease, Mariana coconut beetle, blue coconut leaf beetle, hot pepper virus disease, hot pepper bacterial wilt, and important invasive weeds, *M. peltata*, *M. micrantha* and *C. odorata*. On the whole, the incidence of coconut stem bleeding, Mariana coconut beetle, blue coconut leaf beetle, and weed *M. peltata* were more serious, and effective control is in urgent need. In addition, the three suspected diseases of coconut fatal yellowing disease, areca palm yellowing disease, and citrus greening disease, as well as pests and diseases such as coconut scale, citrus canker, pepper virus disease, pepper bacterial wilt, and

whitefly, occurred in local areas, but should be given attentions.

4.2 Recommendations

So far, different scholars have systematically studied, summarized or warned about tropical and subtropical plants (including palm plants, fruit trees, vegetables, flowers) and invasive organisms [Ploetz et al, 1994; Elliott et al, 2004; Balasimha and Rajagopal, 2004; Chen et al, 2006; Xie and Zheng, 2010; Wan et al, 2010; Qin and Zhu, 2011; Li and Zheng, 2015; Tang et al, 2016]. The results of this survey filled in the gaps in FSM's agricultural diseases, insect pests and weeds, helping the government to fully understand the types, distribution and harm of agricultural diseases, insects and weeds in the country, and providing a basic basis for its prevention and control. The existence of some suspected and unknown pathogenic diseases and pests with unspecified classification status provided clues for scholars to carry out further researches on pathogen and pest identification in the future. Finally, in view of the weak situation of agricultural science and technology for the Federated States of Micronesia, the following suggestions are suggested in order to better promote and ensure the healthy development of agriculture in FSM:

- (1) Vigorously develop the economy and increase government's revenue.
- (2) Actively cooperate with international organizations (such as Food and Agriculture Organization of the United Nations) and friendly countries to seek financial and intellectual aid.
- (3) Emphasize education and cultivate local professionals; strengthen the training of agricultural technicians and farmers, and improve the ability to identify, prevent and control diseases, insect pests and weeds.

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Table 1: Categories and Distributions of Agricultural Diseases, Pests and Weeds in the Federated States of Micronesia

Common name	(Pathogen) Scientific name	Distribution/Severity	Common name	(Pathogen) Scientific name	Distribution/Severity
Coconut stem bleeding disease	<i>Ceratocystis paradoxa</i> (Dade) Mor.	Kosrae/+++	Citrus huanglongbing	<i>Lierobacter asiaticum</i>	Pohnpei (suspected)/+++
Coconut lethal yellowing	phytoplasma	Chuuk (suspected)/+++	Citrus canker	<i>Xanthomonas campestris</i> pv. <i>citri</i> Dye	Chuuk和Pohnpei/+
Coconut gray leaf spot	<i>Pestalotiopsis palmarum</i> (Cooke)Steyaert	All States/+	Citrus sooty mould	Unidentified fungi	Chuuk/+
Coconut anthracnose	<i>Colletotrichum</i> spp.	All States/+	Citrus algae spot	<i>Cephaleuros virescens</i> Kunze	Pohnpei/+
Coconut sooty mould	Unidentified fungi	All States/+	-	<i>Aleurocanthus spiniferus</i> Quaintance	Pohnpei/+
Coconut basal stem rot	<i>Ganoderma lucidum</i> (Leyss. Ex Fr.) Karst	Yap/+	Guava sooty mold	Unidentified fungi	Kosrae /+
Mariana coconut beetle	<i>Brontispa mariana</i> Spaeth	Yap/+++	Guava scale	Unidentified	Kosrae /+
Blue coconut leaf beetle	<i>Brontispa chalybepennis</i> (Zacher)	Pohnpei/+++	Noni anthracnose	<i>Colletotrichum</i> spp.	Yap/+
-	<i>Oryctes rhinoceros</i> L.	Gum of America, quarantine pest/+++	Hot pepper viral disease	Unidentified virus	Kosrae /++
-	<i>Aspidiotus destructor</i> Signoret	Yap, Kosrae and Pohnpei/+	Hot pepper anthracnose	<i>Colletotrichum</i> spp.	All States/+
Red coconut scale	<i>Furcaspis oceanica</i> Lindinger	Pohnpei, Gum of America/++	Hot pepper southern bacterial wilt	<i>Pseudomonas solanacearum</i> (Smith)Smith	Kosrae/++
Coconut flat moth	<i>Agonoxena pyrogramma</i> Meyr.	Pohnpei/+	Hot pepper sooty mold	Unidentified fungi	Kosrae/+
Banana leaf spot	<i>Pseudocercospora musae</i> (Zimm.)Deighton	All States/++	Cucumber Corynespora leaf spot	<i>Corynespora cassicola</i> (Berk & Curt)Wei	Yap/+
	<i>Cordana musae</i> (Zimm) Hhon	All States/+	Bitter gourd Cercospora leaf spot	<i>Cercospora citrullina</i> (Fuckel)Rehm	Yap/+

Common name	(Pathogen) Scientific name	Distribution/Severity	Common name	(Pathogen) Scientific name	Distribution/Severity
Mango anthracnose	<i>Colletotrichum</i> spp.	All States/+	Pumpkin beetles	<i>Aulacophora</i> sp.	Yap/++
Mango bacterial black spot	<i>Xanthomonas campestris</i> pv. <i>mangiferae</i> indicae	Pohnpei/+	Taro blight	<i>Phytophthora colocasiae</i> Racib.	Kosrae/+
Mango sooty mould	Unidentified fungi	Pohnpei/+	Plumeria rust	<i>Coleosporium plumeriae</i> Pat.	All States/+
Mango scab	<i>Elsinoë mangiferae</i> Bitancourt et Jenkins	Pohnpei/++	-	<i>Bemisia tabaci</i> (Gennadius)	Yap/++
Mango algae spot	<i>Cephaleuros virsens</i> Kunze	Pohnpei/+	-	<i>Nipaecoccus vastalor</i> Maskell	Chuuk/+
Papaya Corynespora spot	<i>Corynespora cassiicola</i> (Berk. et Curt)Wei	Yap/+	Plumeria rust	<i>Puccinia cannae</i> (Wint.)P. Henn	Kosrae /+
Papaya anthracnose	<i>Colletotrichum</i> spp.	Pohnpei/+	Cassava Brown Leaf Spot	<i>Passalora henningsii</i> Allesch	Kosrae /+
-	<i>Paracoccus marginatus</i> Williams and Granara de Willink	Pohnpei/+	Cassava anthracnose	<i>Colletotrichum</i>	All States/+
Cassava plaster	unknown	Yap and Kosrae /+	-	<i>Merremia peltata</i> (L.)Merr.	All States/+++
-	<i>Teranychus cinnabarinus</i> (Boisduva1)	Kosrae /+	-	<i>Mikania micrantha</i> Kunth	All States/+++
-	<i>Bemisia tabaei</i> (Gennadius)	Kosrae/+	Mimosa	<i>Mimosa pudica</i> Linn.	All States/+
Giant African land snail	<i>Achatina fulica</i> Ferussac	Kosrae/+	-	<i>Chromolaena odorata</i> L.	Yap
Coffee brown spot	<i>Cercospora coffeicola</i> Berket Cooke	Pohnpei/+	Brazilian Mimosa	<i>Mimosa diplotricha</i> C. Wright ex Sauvalle	All States/+
Coffee anthracnose	<i>Colletotrichum</i> spp.	All States/+	-	<i>Wedelia chinensis</i>	All States/+
Coffee Corticium blight	<i>Corticium koleroge</i>	Pohnpei/+	-	<i>Wedelia biflora</i> (Linn.) DC.	All States/+
Spice pepper Cephaleuros leaf spot	<i>Cephaleuros virescens</i> Kunget	Pohnpei/+	-	<i>Bidens pilosa</i> Linnaeus	Kosrae/+
Graysugarcane scale	<i>Dysmicoccus boninsis</i> (Kuwana)	Pohnpei/+	-	<i>Fimbristylis cymosa</i> R. Br	Yap/+
-	<i>Oxya japonica</i> Thunberg	Pohnpei/+	-	<i>Cyperus difformis</i> L	All States/+

Notes: indicates invasive pest; +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.