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Black Pod Disease Caused by *Phytophthora palmivora* In Assigned Cocoa Center Productions in West Sumatra Indonesia.

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ABSTRACT

In 2006, the Indonesian government assigned West Sumatra as the centre of cocoa cultivation (*Theobroma cacao* L) for the western region of Indonesia. Public and the West Sumatra's local government responses were considered satisfactory, as proven by the increase in cocoa plantation area from only 25,000 ha in 2005 to more than 130,000 ha in 2013. However, the increase in the plantation was not reflected in cocoa production. Average production of cocoa in West Sumatra is 300-700 kg/ha, whereas the genetic potential could reach up to 2,000 kg/ha. From survey and discussion with farmers in six districts covering 36 smallholders of cocoa plantations in West Sumatra, it indicated that all surveyed plantations have been attacked by diseases and pests. In this study, the identification of the fungus on cocoa fruit with rot symptom was conducted by collecting samples in cocoa plantation belonging to PT. Inang Sari which covers an area of 400 ha in the District of Agam. The plantation is being attacked by diseases with different symptoms, similar to the situation of 36 smallholder plantations which have been surveyed. It was the reason why PT. Inang Sari plantation was chosen in this study as the representative of the cocoa's fruit problem in the province. The collecting of fruit with rot symptoms used purposive sampling, based on the severity of its case known from interviews conducted with technicians in charge of the area. Based on the interview, 10 areas of PT. Inang Sari having the highest level of severity and variation of symptoms were chosen. The result of this research found that 86% of fruit that have rot symptoms was caused by *Phytophthora palmivora*. It describes as the current condition of cocoa plantation in West Sumatra Indonesia.

Keywords: West Sumatra, center of cocoa development program, low production, fruit rot, *Phytophthora palmivora*.

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INTRODUCTION

In Indonesia, the decline in the production of cocoa (*Theobroma cacao* L.) is caused mainly by diseases, pests and old aged plants [22]. In the Province of West Sumatra, cultivation and sanitation systems are also the main concerns [16]. All the problems mentioned above becomes an obstacle for the government which targeted cocoa production of 1 million ton per year by the year 2013 [4]. This condition initiated a government-created rehabilitation program to develop new cocoa plantation area of 450,000 ha. To support this program, in 2006, West Sumatra was assigned as a new development area for cocoa plantations in the western region of Indonesia [10]. The impact of this initiative was the remarkable improvement in the development of new cocoa plantations in the province.

Since 10 years, the development of cocoa plantation area in West Sumatra from year to year has increased rapidly. In 2004, cocoa plantation area was only 13,197 ha, in 2005 it increased to 25,000 ha and in 2007 reached 40,000 ha [8]. In 2013, the total area of cocoa plantation in West Sumatra was 137,355 ha [21], exceeding the targeted area by 100,000 ha. There are six regions which have been developed into plantation centers and four other regions which are actively developing their cocoa plantation.

The rapid development of cocoa plantation area in West Sumatra is supported by three major factors: suitable agro-ecosystem conditions for the growth of cocoa plants, people's high desire to own cocoa farms, and continuous increase in market demand. The development of cocoa planting area can even be synergized with banana development program in the province. However, despite the condition of suitable agro-ecosystem and high public interest as shown by rapid increase in planting areas, the general conditions of cocoa farming in West Sumatra have yet to yield optimal results. This is presented by the very low productivity of cocoa, an average of only 300-700 kg/ha [8, 16, 17]. In several locations in the province, cocoa farmers reported that production only reached 200 kg / ha, while Wardoyo [23] stated that genetic potential can reach 2,000 kg/ha. According to the farmers and field surveys conducted since 2005 in West Sumatra, their cocoa fruit are attacked by fruit rot disease [8, 17]. Afriyeni *et al* [2] reported that most of fruit disease in the regions of Bukittinggi (>850 m above sea level/asl), one of the district in West Sumatra, was caused by *Phytophthora palmivora*. This study aimed to identify the fungus which attacks cocoa fruit in six assigned cocoa plantation centers in West Sumatra, from 5 up to 600 m asl.

METHODOLOGY

Location and sampling area

Studies have been conducted on 36 smallholder cacao plantations (0.5 – 3.5 ha) at six districts, which were assigned as cacao production center areas in West Sumatra. The districts are Solok, Agam, Tanah Datar, Pasaman, Payakumbuh and Lima Puluh Kota. From the survey, it was found that symptoms and distribution of cocoa fruit diseases were relatively similar in all the districts. This situation became a reason to choose only one research site, PT Inang Sari in the District of Agam, which represent the condition of the six districts surveyed. PT Inang Sari cocoa plantation occupies an area of approximately 400 ha. For sampling diseased plants, this area was divided into blocks with an area of 10 ha/block. The total number of blocks in this location were 40. The selected sample locations were 10 blocks, with the requirement that percentage and attack symptom variation was the top 10 highest/largest in quantity.

Isolation and identification

Fungi isolation used moist chamber method [2]. Symptomatic rotten rind of cocoa fruit was sliced in 0.5 x 0.5 cm sizes, the areas taken were those between the healthy and infected parts. The sliced piece was dipped into HgCl₂, then rinsed with sterile distilled water for 30 seconds, twice in a row. It was then wind-dried, placed in a petri dish that already contained filter paper moistened with sterile distilled water, and then incubated at 25°C for 3-5 days.

The growing fungi was transferred to Potato Dextrose Agar (PDA), Phytophthora Selective Medium (PSM) and Vegetable Juice Agar/ V8 (VJA 8) medium [5]. It was then purified by the method of single spore technique. The result from this purification was then grown in PDA, PSM and V8. Its macroscopic and microscopic development was observed such: its colony shape, color of the colony, the hyphae, conidia and

spores. The key in identifying the fungi was based on Malloch [13], Barnet and Hunter [7], Fusarium [9] and Drenth and Sendall [11].

RESULT AND DISCUSSION

Survey for investigation of fruit with disease symptoms were conducted on 36 cocoa plantations in the districts of Tanah Datar, Payakumbuh, Lima Puluh Kota, Padang Pariaman, Pasaman and Sijunjung, which are under the administration provincial system of the Province of West Sumatra (Picture 1). All of the districts are assigned as cocoa production center regions in West Sumatra. Lack of good agricultural practices implemented in the regions were found in 32 out of 36 plantations of the six districts surveyed. During the survey, there was no plantation free from fruit diseased with the percentage was relatively similar up to 45% at each of the plantation surveyed. The plantation of PT Inang Sari was then chosen for this project because it represents the situation of cocoa’s plantation in all of these six districts, with none of the blocks free from disease attack. The symptoms on severed fruit, both symptoms of pests and diseases were present in each block, ranging between 20 to 45%. The disease attack can be easily recognized visually. PT. Inang Sari cocoa plantations was opened in the 1980s and have been gradually developing. Today, the plantation covers a vast ± 400 ha. Since 2006, there has been an increase in plant disease attacks in this plantation. Control is mainly conducted using chemical pesticides, however it has been proven that the attacks are beyond control.



Picture 1: Map of the districts of assigned cocoa center production areas in West Sumatra, Indonesia.

Due to the high rate of the attacks in the plantation, fruit with disease symptoms collected were limited to 25 per block with the total of fruit collected were 250. Each fruit collected was focused on a single specific symptom. But it was likely that fruit which were severely infected could have more than one fungus (Picture 2, right side). In the laboratory, rotten fruit with the same symptomatic appearance were classified in the same group. The result of this symptoms grouping were: 1. Symptoms of fruit specifically attacked by *P. palmivora*. 2. Black rotten fruit covered by white mycelium. 3. Fruit rot symptoms 2 with soft fruit base and piled black spots on its rind (different from the type attacked by *P. palmivora*).

Fungi identification from the infected fruit was as follows:

Aspergillus

The fungi was collected at the base of the fruit which was damaged. It had soft and black-colored tissue, which spread covering the surface of the fruit rind which was also covered by cotton-like hyphae. The fungi was grown in PDA medium. At the beginning of macroscopic observation, the edge of the colony was irregular and had dense white mycelium. But after the third day, the mycelium turned into blackish color. Microscopically, the hyphae fungal character is insulated and hyalined, while conidiophores are straight, smooth, elongated with conidial head enlarged forming globus and filled with conidia. Conidia consists of a

single cell, black or brownish black. According to Barnet and Hunter [7], the characters found in the fungi collected belongs to *Aspergillus niger*.

Fusarium

This fungi was isolated from rotting fruit with most parts colored blackish brown. Other parts of the fruit was also covered with white cotton-like mycelium. This fungi grew well in PDA and provided the following characteristics: round colony, uneven, pointy and pink mycelium. From microscopic observation, microconidia and macroconidia were found, both crescent shaped. Macroconidia had three partitions and microconidia had one partition. Microconidia *phialid* and macroconidia *hyaline*, colonies grew fast (2-4 days). From these characteristics, especially of the types of conidia, according to Booth [9] this fungus is *Fusarium sp.*

Gloeosporium

Fungi was collected from the fruit with circular black spots which slightly sink into the surface of the fruit rind and partly covered by a collection of white mycelium. The fungi was isolated and grown in PDA medium. Macroscopically, the fungi grew in the media taking the shape of circular waves, pink color and had colonies with uneven edges. Under the microscope, the conidia was shaped similar to bacillus, hyaline, partitioned two-three, scattered around the hyphae, single and were at the end of **conidiophore**. The **conidiophore** was short, non-partitioned and colorless. From the characters mentioned above, according to Malloch [13], the fungi is *Gloeosporium*.

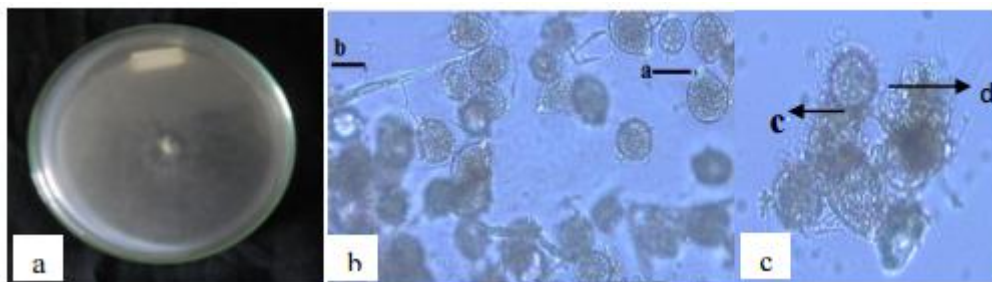
Phytophthora

Of all the samples identified from the three groups of rotten fruit above, 86% of them are infected with pathogenic fungi *P. palmivora*. To be certain, diseased fruit tissue was grown in specific medium: PV8 [5]. Its macroscopic characteristic was white colonies and colonies with uneven edges. From microscopic observation, there was presence of hyphae hyaline, branches and non-partition. A specific characteristic that identifies this fungus as *P. palmivora* is the pear shaped sporangium with pointed tip (Picture 3 b-c) [11, 5].



Picture 2: Severe damaged cacao fruit caused by *Phytophthora palmivora* (left side) and other fungus (right side).

One of the three most destructive pathogens which limit cocoa production worldwide is *P. palmivora* [15, 6]. *P. palmivora* symptoms are very specific, easily recognized because it is characterized by a clear boundary between the color of the fruit infected and the color of the healthy fruit tissues (outer), as it was found in this study (Picture 2, left side). Fruit attacked by *P. palmivora* is brown or dark brown and commonly known worldwide as black pod disease. Severely damaged fruit becomes soft and covered by mycelium (Picture 2, left and right). In this condition, usually another fungus could be discovered as it was also shown on Pic.2 (right side).



Picture 3.a. Colony of *P. palmivora* on PV8, and b-c, pear shaped (tip shaped) sporangium as the specific character of *P. palmivora* (black line/arrow of a and c).

This fungi is known as the most virulent and pathogenic fungi most commonly found attacking the cocoa plant in the world, not only the fruit, but also other parts of this plant [20, 1, 15, 16, 14, 19]. The malignance of *P. palmivora* attacks can cause crop failure up to 100% [23, 20, 6, 12, 3]. In other cocoa producing countries in the world such as Ghana and Ivory Coast, cocoa pod disease are caused by both of *P. megakarya* and *P. palmivora* [1, 6, 12, 3] with yield loss range from 60 to 100% [5]. However, during this study, cocoa pod disease in West Sumatra was only caused by *P. palmivora* on the basis of sporangium type identification (Picture 3, b-c). These attacks can be triggered by heavy rains in West Sumatra (300 mm/month) or insufficient planting materials. However, during field studies in 2008-2012 [16, 2] and discussion with the growers in the six districts surveyed during this study, it can be stated that the most important cause was negligence of the disease's initial signs and lack of cultivation management. In these visited areas, most of the trees, branch growth/pruning have not been evenly done while leaves, twigs and pods can be found on soil around the cocoa plants.

In this study, three other fungi were isolated from the diseased fruits these were *Gloesporium* and *Fusarium*, but neither of them are major pathogens. So far there has also been no reports of *Aspergillus* as a pathogen on cocoa. It was suspected that *A. niger* is a secondary fungus in cocoa plants. Following the result of this study, PT. Inang Sari under the supervision by the researchers from Andalas University, responded in taking actions to control the disease by using natural bio-pesticide of essential oils of *Elettariopsis slahmong*. The essential oil has been successfully tested against insect vector of *Ralstonia sonacearum* on banana [18]. It was found that this bio-pesticide reduced the disease percentage caused by *P. palmivora* up to 50% in the plantation.

CONCLUSION

Phytophthora palmivora is the most virulent, largest distribution and highest percentage of the fungus pathogen at the assigned cocoa production center in West Sumatra. It was mainly due to the lack of farm maintenance.

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