Mapping bacterial leaf blight disease of rice (*Xanthomonas oryzae pv oryzae*) in North Sumatra

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**Abstract.** Bacterial leaf blight is the most important rice disease in Indonesia and other rice producing countries in Asia. Bacterial leaf blight disease, caused by the bacterial pathogen *Xanthomonas oryzae pv oryzae*, has a wide distribution in the tropics and sub-tropics. This research was aimed to determine the distribution of the disease in North Sumatera. The research experiment was conducted using the survey method to calculate the incidence and severity of disease in rice crops in seven locations. The highest disease incidence was found in Sumber Tani Village, Batubara District, and in Talawi Siabal Abal Village, Sipahutar District of North Tapanuli with a disease incidence of 100%. The highest percentage of disease severity was found in Siabal Abal Village, Sipahutar District of North Tapanuli, with a percentage of 82% severity.

1. Introduction

Rice (*Oryza sativa* L.) is the main staple crop for most people of Indonesia. Indonesia as a country with a large population faces challenges in fulfilling its food needs. Therefore, food security policies are a main focus in agricultural development [1]. One of the major constraints faced by farmers in the process of increasing production is the emergence of plant pests, including pests, diseases, and weeds. The damage caused by pests can reach 20% - 25% annually [2].

Bacterial leaf blight (BLB) is one of the important diseases of rice plants caused by the bacterial pathogen *Xanthomonas oryzae pv oryzae* (*Xoo*) [3]. BLB can affect rice crops both in the highlands and lowlands, but particularly in lowland rice, and often appears during the rainy season [4]. The symptoms of crackle and blight begin at the edge of the leaf which shows a greyish colour and the leaves become dry. In susceptible rice varieties, symptoms become systemic and resemble burning symptoms [5]. Pathogens infect rice plants on the leaves through wounds or natural openings in the form of leaf stomata and where they cause leaf chlorophyll damage [6]. If the transmission of the disease occurred in the generative phase, the grain filling process is less than perfect [7].

*Xoo* has spread to several countries in most continents including Asia, Africa, Australia and the Americas. However, these bacteria are mostly found in Asia and parts of West Africa, especially in India, China, and Indonesia, where the population had spread to epidemic [8]. In Indonesia, the spread of *Xoo* increased from year to year. In 2004, the rice area infected by BLB was over 37,000 ha, and around 32% higher than the previous year [9]. Yield loss caused by BLB disease in Indonesia reached
70-80%. This value is quite high when compared with the values found in India (6-60%) or Japan (around 20%) [10].

To obtain a more detailed and accurate estimate of BLB occurrence in North Sumatera, the research described here aimed to determine the distribution of BLB in seven locations in North Sumatra.

2. Materials and methods

2.1. Location
The research locations were determined by sampling at seven locations in North Sumatra. Determination of the locations was determined based on data searches from the Central Statistics Agency to obtain an overview of the locations to be surveyed, and information from the local community including: 1) Suka Maju village, Sunggal district, Deli Serdang, 2) Pahlawan village, North Binjai district, Binjai, 3) Sumber Tani village, Talawi district, Batubara, 4) Saribujawa village, Dolok Pangaribuan District, Simalungun, 5) Siabal abal village, Sipahutar district, North Tapanuli, 6) Huta Bagasian village, Dolok Sanggul district, Humbang Hasundutan, and 7) Lumban Lobu village, Porsea district, Tobasa.

2.2. Sampling method
Samples were taken diagonally starting from a point towards the opposite shape of two diagonal grooves. There were 12 plots in one diagonal groove, each measured 1 x 1 M and contained 16 clumps of rice [10] [11].

2.3. Disease incidence and severity observation
Observations on the disease incidence and disease severity were carried on the number of plants per clump on each small plot to score visual symptoms. And then BLB incidence and severity was calculated by using the formula:

\[
DI = \frac{a}{b} \times 100\% 
\]

Note:
DI : Incidence of BLB disease
a : Number of plants infected by BLB disease
b : number of observed plants

[12].

2.4. Interview
Interviews with farmers were conducted to determine land-related information such as on land size, age of the plants, the number of plants per clump, and the number of plants per plot.

3. Results and discussion

3.1. Disease incidence
The rice plants in each observed location showed symptoms of bacterial leaf blight disease. The typical symptoms of this disease are discolouration at the edges of the leaves become grey (Fig 1). The symptoms of crackle and blight begin at the edge of the leaf, are greyish in colour and the leaves become dry (Fig 1). In susceptible varieties, the symptoms become systemic and similar to symptoms of burning. If infection occurs during flowering, grain filling is incomplete or absent [13].
Fig 1. Comparison of healthy and bacterial leaf blight infected leaf on rice on four locations in North Sumatra, A. Hutabasan village, B. Lumban Lobu village, C. Saribujawa village, D. Siabal Abal village

Table 1. Disease incidence of bacterial leaf blight (%) in seven locations in North Sumatra

| No | Locations                                      | Rice varieties | Average of disease incidence (%) |
|----|-----------------------------------------------|----------------|----------------------------------|
| 1  | Suka maju village, Sunggal district, Deli Serdang | IR32           | 9.0                              |
| 2  | Pahlawan village, Binjai district, Binjai      | IR64           | 89.0                             |
| 3  | Sumber Tani village, Talawi district, Batu Bara| Ciherang       | 100.0                            |
| 4  | Saribujawa village, Panribuan district, Simalungun | Ciherang     | 73.0                              |
| 5  | Siabal abal village, Sipahutar district, North Tapanuli | Br. Tambun   | 100.0                            |
| 6  | Huta Bagasan village, Dolok Sanggul district, Humbang Hasundutan | Siharompang | 99.0                              |
| 7  | Lumban Lobu village, Tobasa district, Porsea  | Arias          | 98.0                              |

Table 1 shows the results of disease incidence of bacterial leaf blight in seven locations in North Sumatra. The highest percentage of disease incidence was found in the Sumber Tani village, Talawi district of Batubara and Siabal Abal village, Sipahutar district of North Tapanuli (100%). The lowest percentage of disease incidence was found in the Suka Maju village, Sunggal district of Deli Serdang (9%). This was due to *Xoo* offensive attack in all phases of rice but the most typical symptoms appeared during the generative phase. There are two kinds of BLB disease symptoms, including the symptoms of which occur in young plants, aged less than 30 days after planting called ‘kresek’, while the symptoms in plants during and after tillering are called blight. Kresek is the most damaging symptom of BLB disease, while the most common symptoms are the symptoms of blight [14].

The disease incidence in Siabal Abal village reached 100%. Temperature and rainfall play an important role in bacterial leaf blight disease development. Garret *et al.* [15] stated that climate change affects the level of disease through genomic, cellular, physiological levels of plant and pathogen. “Kresek” disease-causing bacteria on rice *X. oryzae pv. oryzae* have an optimum temperature at 30°C.

The disease incidence was different in each location. The pattern of crops cultivated in the particular locations influence the disease incidence and plant disease epidemiology [16]. For example, single crop without rotation being cultivated every year may result in the accumulation of the pathogen isolates as well as pathogen inoculum for a plant disease [17]. Additionally, the altitudes of the locations also affect the disease incidence. Because the optimum temperature for bacterial development is between 25-30 ºC, the disease is more prevalent in lowland area [18]. this might caused by the difference of the latent period of each strain of bacteria presenting different symptoms.
The latent period is influenced by environmental factors such as temperature and humidity conditions, the nature of the inoculum population and strains, host susceptibility, the age of the host tissue, and the presence of competing populations, which is termed as disease triangle [19].

The disease symptoms from four locations (Fig 1) were slightly different. It is suspected that there was diversity of Xoo isolates in their respective host varieties of each location. There are several pathotypes of Xoo based on the response to five different rice varieties (Kencana, PB5, Tetep, Kuntulan, and Java 14) which show different disease intensity [20].

3.2. Disease severity
Disease severity was calculated for all locations using the previous formulae [21] and categorized using the following disease scale [22], 0 : healthy leaf; 1: 1-5% of leaf edge change colour; 3: 6-12% of leaf edge change colour; 5: 13-25% of leaf edge change colour; 7: 26-50% of leaf edge change colour; 9: 51-100% of leaf edge change colour.

The highest percentage of disease severity was found in the Siabal abal village, Sipahutar district of North Tapanuli (82%), followed by Sumber Tani village, Talawi district of Batubara (76%) (Table 2). The lowest percentage of disease severity was found in Suka Maju village, Sunggal district of Deli Serdang (1%) (Table 2, Fig 2). Each variety has a different percentage of disease severity possibly because of genetic variation, for example in resistance genes. Without having resilience properties, the plant will experience severe infection by pathogens. Resistance of plants is largely controlled by genes, so that it can be inherited to its offspring. The development of resistance genes in plants is the result of long-standing coevolution between the host and the pathogen [22].

The plant ages of rice plants in the seven observed locations were different and therefore the response of disease severity was also different. This is because Xoo bacterial symptoms are different in every phase of the rice plants. Nino-Liu et al. [8] stated that the Xoo inoculated rice varieties showed the appearance of elongated spots with wavy edges of the tips of the leaves growing along the edge of the leaf and then developed into blight and change colour to pale yellow. BLB is categorized as airborne pathogen, which transmitted through the air. The environmental factors influence the spread of disease via the effects of wind and friction between the leaves. In its development, BLB causes blight symptoms and finally the leaves dry [23]. High rainfall with strong wind influence the bacterial multiplication then the bacteria can easily enter the injured tissue [24]. When moist (especially in the morning), groups of bacteria in the form of golden yellow grains can be easily found on the leaves that show symptoms of blight. Wind and precipitation can disturb this bacterial mass leading to disease transmission. However, bacteria cannot survive long in the seeds, so that the disease is generally inherited by subsequent generations [25].

| No | Locations                                       | Rice varieties | Average of disease severity (%) |
|----|------------------------------------------------|----------------|---------------------------------|
| 1  | Suka maju village, Sunggal district, Deli Serdang | IR32           | 1.0                             |
| 2  | Pahlawan village, Binjai district, Binjai       | IR64           | 20.0                            |
| 3  | Sumber Tani village, Talawi district, Batu Bara | Ciperang       | 76.0                            |
| 4  | Saribujawa village, Panribuan district, Simalungun | Ciperang     | 12.0                            |
| 5  | Siabal abal village, Sipahutar district, North Tapanuli | Br. Tambun | 82.0                            |
| 6  | Huta Bagasan village, Dolok Sanggul district, Humbang Hasundutan | Siharompan | 43.0                            |
| 7  | Lumban Lobu village, Tobasa district, Porsea    | Arias          | 17.0                            |

Table 2. Disease severity of bacterial leaf (%) in seven locations in North Sumatra
4. Conclusions
The highest disease incidence was found in Sumber Tani village, Talawi district of Batubara and Siabal Abal village, Sipahutar district of North Tapanuli with a disease incidence of 100%. The highest percentage of disease severity was found in Siabal Abal village, Sipahutar district of North Tapanuli with a percentage of 82% severity.

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