AGRIVITA Journal of Agricultural Science. 2016. 38(2): 174-185

COMPOSITION AND DISTRIBUTION OF *Xanthomonas oryzae* pv. *oryzae* PATHOTYPES, THE PATHOGEN OF RICE BACTERIAL LEAF BLIGHT IN INDONESIA

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Received: June 18, 2015/ Accepted: March 16, 2016

ABSTRACT

This research aimed to determine the composition and pathotype distribution of *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) in several rice producing centers in Indonesia during the growing season of 2010-2013. The studies were conducted into three phases of activities, namely: sampling and collection of infected leaves from the representative rice growing areas; isolation and purification of the *Xoo* isolates; and evaluation of composition and pathotype of *Xoo* on five rice differential varieties. Results indicated that a total of 2,658 isolates *Xoo* have been isolated from 10 provinces representing rice ecosystem in Indonesia during the growing season from 2010-2013. Evaluating these *Xoo* isolates against five differential varieties revealed that these *Xoo* isolates consisted of three pathotypes III, IV, and VIII with a total of 30, 36, and 34%, respectively. The data also indicated that two pathotypes III and IV were dominant in three provinces, while the pathotype VIII was dominant in four provinces. As mentioned previously, such information are useful in designing strategy of integrating components of technologies combined in the management of Bacterial leaf blight (BLB) occurrences in a particular endemic areas.

Keywords: composition; distribution; rice; *Xanthomonas oryzae* pv. *oryzae*

INTRODUCTION

Bacterial leaf blight (BLB) caused by *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) is one of the most important diseases in many rice producing countries in Asia, including Indonesia (Suparyono *et al*., 2004; Jeung *et al.,* 2006; Nayak *et al*., 2008). In Indonesia, this disease was found in various rice growing ecosystem and spread out from lowlands through medium and high elevation ecosystem, and from irrigated, rainfed, dryland, and swampy agroecosystems (Suparyono *et al*., 2003). Generally the bacteria infect the leaf, but under favorable condition it spreads through the leaf stalk. Infection usually starts from the tip of the leaf and then evolves into the center and into the base of the leaf. Symptoms occurred in rice crop at vegetative phase called *kresek* and occurred at generative phase called blight (Suparyono *et al.,* 2004). Pathogen infection causes leaf photosynthetic function disrupted so infected plants produce more empty grains than healthy plants (Suparyono *et al*., 2004; Shanti *et al*., 2010).

Yield losses due to the disease varies between 15 and 80% depending on the crop stage when the disease arises (Reddy and Shang-zhi, 1989; Shanti *et al.,* 2010). Qi (2009) reported in summer and autumn of 2005, epidemics of BLB were observed in China severely affecting about 28,000 hectares paddy fields (occupying 16.8% of the total rice cultivation area). In India, losses due to BLB reach from 65 to 95% (Nayak *et al.,* 2008). Suparyono and Sudir (1992) reported that damage threshold due to BLB was ca. 20% at about two weeks before harvest. Above the threshold, each 10% increase in the BLB severity the yield losses increased by 5 to 7%.

Bacterial leaf blight is difficult to control due to its high mutability of the *Xoo*. New resistant varieties were easily broken down after some cropping season of exposure (Qi and Mew, 1989; Ponciano *et al*., 2003; Suparyono *et al.,* 2004). The most effective strategy to control BLB was previously considered to be the use of resistant varieties. Unfortunately this strategy was challanged by the mutability of the *Xoo* pathotypes which were able to break down the resistant varieties. The application of this technology became limited by time and location. There were a total of 11 groups of *Xoo* pathotype reported

Cite this as: Sudir and D. Yuliani. 2016. Composition and distribution of *Xanthomonas oryzae* pv. o*ryzae* pathotypes, the pathogen of rice bacterial leaf blight in Indonesia. AGRIVITA Journal of Agricultural Science. 38(2): 174-185 Doi: 10.17503/agrivita.v38i2.588
Accredited : **SK No. 81/DIKTI/Kep/2011**
Permalink/DOI: **http://dx.doi.org/10.17503/agrivita.v38i2.588**

by Hifni and Kardin (1998), and there were three dominant *Xoo* pathotypes, i.e.: III, IV and VIII (Sudir *et al*., 2009).

The diverse of *Xoo* pathotypes also cause resistant varieties in a season at one site could be susceptible in different season at the other places (Suparyono *et al*., 2003; Suparyono *et al*., 2004; Qi, 1995; Hoang *et al*., 2008). Period of time, a resistant varieties become susceptible (fracture resistance) was determined by several factors, including the composition and dominance, the speed of pathotype changing, planting frequency, and the composition of varieties with different genetic backgrounds were planted in a certain of time and place (Ogawa, 1993; Suparyono *et al*., 2004; White and Yang, 2009). Resistant varieties will break its resistance to BLB pathogens when planted for three to four seasons consecutively (Sudir and Suprihanto, 2006). Rotation of resistant varieties to control BLB disease need to be designed carefully, as the resistant varieties can last longer in the field. This tactic requires the support of various data, especially with regard to *Xoo* pathotype profile in an agroecosystem and the resistance background of varieties to be planted.

Monitoring of composition, dominance, and *Xoo* pathotype distribution in a region and searching for new resistance genes need to be done as one of the BLB control strategy. This research aimed to determine the composition, dominance, and distribution of *Xoo* pathotype in rice producing centers in Indonesia.

MATERIALS AND METHODS

This research was conducted during the growing season from 2010 to 2013. The research activities were classified into three stages, i.e.: 1) Sample collection of rice leaves showing the symptom of BLB, 2) Isolation of *Xoo* isolates from these collected diseased leaves, and 3) Identification of *Xoo* pathotype on five rice differential varieties in the green house.

Sample Collection of Rice Leaves Showing the Symptom of Bacterial Leaf Blight

Observations and sampling of diseased leaves were carried out from several rice planting location in North Sumatera, South Sumatera, Lampung, Banten, West Jawa, Central Jawa, Yogyakarta Special Province, East Jawa, South Sulawesi, and West Nusa Tenggara. These ten provinces were selected as the site representing the development and composition of pathotype of *Xoo* as they are considered to be the main rice-producing areas in Indonesia where the disease is endemic. Depending on the availability of the rice crop stages, samples were taken from three to five districts per province, and from three sub-districts per district. Based on the paddy crop stages two diseased leaves showing BLB symptoms per hill were taken from 20 hills of approximately 0.1 to 0.5 ha of sampling site.

Each sampling site of the rice fields was arbitrarily divided into three parts, each was designated as replicates. Sampling hills were diagonally assigned as the five sample points, from which diseased leaves were sampled. Samples were wrapped in a paper envelope. Notes indicating location, rice varieties, plant growth stage, sampling date, and disease severity, were established. Samples were then taken into the laboratory for the 2nd steps of activities of the experiment, i.e.: isolation of *Xoo.*

Isolation of *Xanthomonas oryzae* pv. *oryzae*

Isolation of *Xoo* from leaf tissues was done in the Laboratory of Plant Pathology of the Indonesian Center for Rice Research, Sukamandi, Subang, West Java, Indonesia by using the leaf streak method (Suparyono *et al*., 2003). Infected rice leaves were cut into pieces measuring of approximately 1 mm in size over leaf area located between infected and healthy tissues and then were washed in sterile distilled water. The *Xoo* washing water was collected in erlenmayer glass, and desiganated as the main *Xoo* solution. This *Xoo* solution were then diluted to 10^{-6} dilutions, from which an approximately 1 cc of the dilluted *Xoo* were pippeted and streaked in petri-dishes containing potato sucrose agar medium (bacto agar 20 g, sucrose 20 g, potato 300 g, distilled water 1000 ml). Characteristics of *Xoo* which obtained showing small round colonies, mucoid, and yellowish. *Xoo* single colony was transferred to a medium PSA slant as a pure culture, for further experiments steps i.e.: pathotype identification. Purified isolates of *Xoo* was incubated for two to three days in the laboratory.

Identification of *Xanthomonas oryzae* pv. *oryzae* Pathotype

1. **Differential Varieties and Experimental Design**. Identification of pathotype of *Xoo* isolate was done based on the interrelationship between the bacteria isolates and five rice differential varieties. In this study, five differential varieties possesing different genetic background, namely Kinmaze, Kogyoku, Tetep, Wase Aikoku, and Java 14, were utilized. Kinmaze does not posses resistant gene; Kogyoku posses two dominant resistance genes (*Xa-1*, and *Xa-12*); Tetep posses two dominant resistant genes (*Xa-1* and *Xa-2*)*;* Wase Aikoku posses two dominant resistant genes *Xa-3* and *Xa-12*; and Java 14 posses three dominant resistant genes *Xa-1*, *Xa-2*, and *Xa-12* (Suparyono *et al.,* 2003; Nayak *et al*., 2008). These five differential varieties were grown in pots of 15 cm in diameters and 20 cm height, containing top soils enriched with organic manures and NPK fertilizers. One of the 15-day old seedling was transplanted to a pot. The plants were irrigated 1-2 times/day and were fertilized with urea, phosphorous, and potassoium at the rates of 1.56, 0.63, and 0.31 g per pot respectively. The experiments were arranged in a randomized block design. Experimental units consisted of 15 pots/isolate with one hill/pot.
2. **Inoculum and Inoculation Procedures** Isolates of *Xoo* were isolated from naturally diseased leaves collected from 10 provinces of rice growing centers. Inoculum was prepared by transferring approximately 1 cc of the diluted *Xoo* streaked in petri plates containing potato sucrose agar (PSA) medium. Cells from two day-olds PSA cultures were suspended in a 0.1 M NaCl buffer solution and adjusted to 10^8 cfu per ml. Inoculation of *Xoo* isolates were conducted in a glass house using five rice differential varieties. Rice plants at the maximum tillerring stage were inoculated 5 cm from the tip of the leaf. Inoculations of *Xoo* suspension were done by wounding the leaves through clipping method (IRRI, 2014).
3. **Disease Rating and Identification of Pathotype.** Disease severity were measured on leaf basis at two to four weeks after inoculation by measuring the length of symptoms developed on each differential variety. Disease severity value was obtained as the ratio between the length of leaves with symptoms and the length overall leaves. Mean disease ratings were converted into percentages by taking value of each leaf and performed in percentage (%). Resistance reaction of each differential variety was classified as resistant (R) when the mean severity value on the differential variety was ≤11%, and as susceptible (S) when the mean severity value was ≥ 12 % (Suparyono *et al*., 2003). Pathotype of *Xoo* was determined based on Kozaka system. Pathotype of *Xoo* was grouped based on interaction between the *Xoo* isolates tested and five rice differential varieties (Table 1). Pathotype III was high virulent against Kinmaze, Kogyoku, and Tetep but low virulent against Wase Aikoku and Java 14. Pathotype IV was virulent to all Japanese differential varieties. While pathotype VIII was high virulent against Kinmaze, Kogyoku, Tetep, and Wase Aikoku but low virulent against Java 14 (Sudir *et al*., 2009). The data were presented in the form of map composition and distribution of the existing pathotype.

RESULTS AND DISCUSSION

A total of 2,658 *Xoo* isolates have been successfully isolated from diseased rice leaves obtained from 10 provinces of rice producing centers in Indonesia. Based on their interaction with the five differential varieties, these isolates were classified as III, IV, and VIII pathotypes. Table 2 revealed that the composition and distribution of these three *Xoo* pathotypes in the 10 provinces rice producing centers in Indonesia, were varied. It was shown that pathotype III dominated in three provinces such as Yogyakarta, South Sulawesi, and South Sumatra; pathotype IV dominated also in three provinces such as North Sumatera, Lampung, and West Nusa Tenggara; while pathotype VIII dominated in four provinces included West Java, Banten, Central Java, and East Java. Three pathotypes IV, VIII, and III presented in nearly similar degree of composition, 36, 34, and 30%, respectively (Table 2).

Table 1. Pathotype grouping of *X. oryzae* pv. *oryzae* isolates based on interaction between the *X. oryzae* pv. *oryzae* isolates and five rice differential varieties

No.	Differential variety	Resistance Genes	Differential variety**Xoo* isolate interaction											
1	Kinmaze	None	S	S	S	S	S	R	S	S	S	S	S	R
2	Kogyoku	*Xa-1, Xa-12*	R	S	S	S	R	R	S	S	S	R	S	R
3	Tetep	*Xa-1, Xa-2*	R	R	S	S	R	S	S	S	R	S	R	R
4	Wase Aikoku	*Xa-3 (Xa-12)*	R	R	R	S	S	R	R	S	S	S	S	S
5	Java 14	*Xa-1, Xa-2*, and *Xa-12*	R	R	R	S	R	R	S	R	R	R	S	R
Xoo Pathotype Grouping			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII

Remarks: R=resistance, disease severity ≤11%; S = susceptible, disease severity ≥12% (Sudir *et al*., 2009)

Table 2. Composition and domination of *X. oryzae* pv. *oryzae* pathotype in 10 rice producing centers in Indonesia

No.	Province	*Xoo* Isolates	*Xoo* Pathotype Groups		
			III (%)	IV (%)	VIII (%)
1	West Java	624	181 (29)	204 (33)	239 (38)
2	Banten	68	18 (26)	11 (16)	39 (57)
3	Central Java	517	114 (22)	158 (31)	245 (47)
4	D.I. Yogyakarta	107	52 (49)	23 (21)	32 (30)
5	East Java	348	101 (29)	88 (25)	159 (46)
6	South Sulawesi	176	102 (58)	41 (23)	33 (19)
7	North Sumatera	245	72 (32)	150 (58)	23 (10)
8	South Sumatera	116	67 (58)	28 (24)	21 (18)
9	Lampung	225	48 (21)	112 (50)	65 (29)
10	West Nusa Tenggara	232	47 (20)	118 (51)	67 (29)
	Total	**2,658**	**802 (30)**	**933 (36)**	**923 (34)**

In West Java Province, a total of 624 isolates obtained from 10 districts representing rice producing. These isolates consisted of 181 isolates (29%) pathotype III, 204 isolates (33%) pathotype IV, and 239 isolates (38%) pathotype VIII (Figure 1). *Xoo* pathotype III found dominated in five districts i.e. Cianjur, Sukabumi, Tasikmalaya, Kuningan, and Bogor; pathotype IV dominated in four districts i.e. Karawang, Indramayu, Cirebon, and Bekasi; while pathotype VIII dominated in two districts i.e. Subang and Indramayu. It appeared that the existing pathotype VIII dominated in West Java Province.

From Banten Province, a total of 68 *Xoo* isolates collected from four sampling districts. Compositions of the isolates were 18 (26%) isolates as pathotype III, 11(16%) isolates as pathotype IV, and 39 (57%) isolates as pathotype VIII (Figure 1). In this province, pathotype VIII dominated in four districts i.e. Serang, Rangkasbitung, Lebak, and Pandeglang; pathotype III and IV distributed in nearly uniform in the four districts observed. Generally appeared that the existing isolates of *Xoo* in Banten Province identified as pathotype VIII.

From Central Java Province, a total of 517 isolates obtained from 17 districts representing rice producing areas in Central Java. Compositions of the isolates were 114 (22%) isolates as pathotype III, 158 (31%) isolates as pathotype IV, and 245 (47%) isolates as pathotype VIII (Figure 2). In this province, pathotype III dominated in Batang district; pathotype IV was in four districts i.e. Pemalang, Pekalongan, Batang, and Jepara; while pathotype VIII dominated in 11 districts i.e. Brebes, Kudus, Pati, Rembang, Cilacap, Banyumas, Kebumen, Boyolali, Sukoharjo, Sragen, and Karanganyar. It was observed that pathotype VIII dominated in Central Java Province.

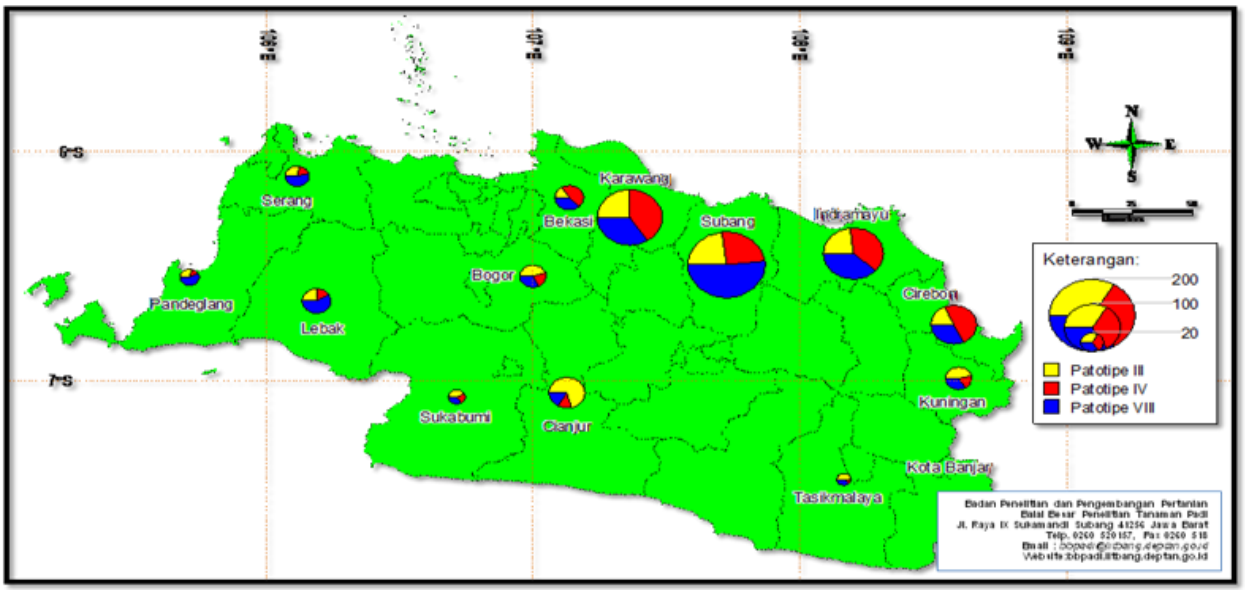

Figure 1. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in West Java and Banten Provinces

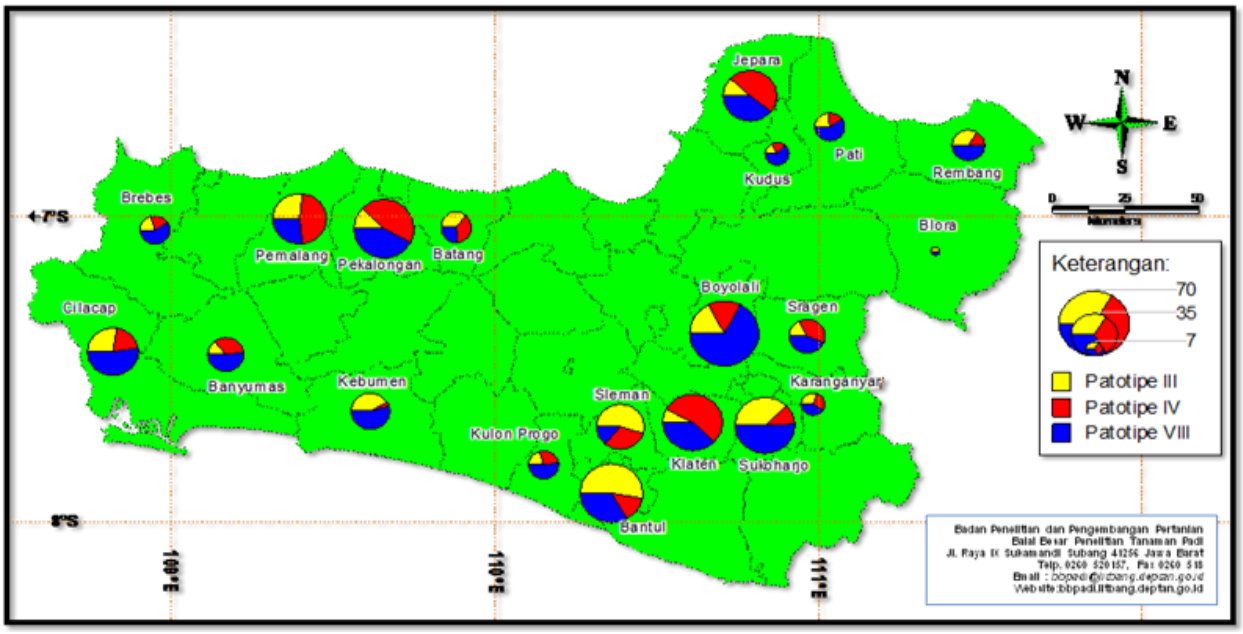

Figure 2. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in Central Java and Yogyakarta Provinces

In Special Province of Yogyakarta, a total of 107 *Xoo* isolates collected from the three representing districts. These isolates consisted of 52 (49%) isolates pathotype III, 23 (21%) isolates pathotype IV, and 32 (30%) isolates pathotype VIII (Figure 2). *Xoo* pathotype III dominated in two districts i.e. Sleman and Bantul; *Xoo* pathotype IV dominated in Kulonprogo district; while *Xoo* pathotype VIII presented in the dominated in three districts of this Province at nearly the same proportion. It was concluded that *Xoo* pathotype III dominated in Special Province of Yogyakarta.

While in East Java Province, a total of 348 *Xoo* isolates obtained from 21 districts sampled in East Java. These isolates consisted of 101 (29%) isolates pathotype III, 88 (25%) isolates pathotype IV, and 159 (46%) isolates pathotype VIII (Figure 3). The data indicating that *Xoo* pathotype III dominated in four districts i.e. Jombang, Banyuwangi, Malang, Nganjuk, and Bojonegoro. *Xoo* pathotype IV dominated in six districts i.e. Lumajang, Blitar, Tulungagung, Trenggalek, Madiun, and Kediri. *Xoo* pathotype VIII dominated in 13 districts, i.e. Mojokerto, Pasuruan, Probolinggo, Lumajang, Situbondo, Bondowoso, Jember, Ponorogo, Magetan, Ngawi, Mojokerto, Nganjuk, and Bojonegoro. It was shown that *Xoo* pathotype VIII dominated in East Java Province.

South Sulawesi Province. A total of 176 *Xoo* isolates were obtained from the 10 districts sampled in South Sulawesi. These isolates consisted of 102 (58%) isolates pathotype III, 41 (23%) isolates pathotype IV, and 33 (19%) isolates pathotype VIII (Figure 4). *Xoo* pathotype III dominated in eight districts i.e. Bone, Soppeng, Wajo, Sidrap, Barru, Pangkep, Pinrang, and Luwu; *Xoo* patotipe IV dominated in Maros district; and *Xoo* patotipe VIII dominated in Palopo district. The data indicated that except in the two districts i.e. Maros and Palopo, *Xoo* pathotype III dominated pathotype in all districts of South Sulawesi.

From North Sumatra Province, a total of 245 *Xoo* isolates obtained from 10 districts sampled in North Sumatera Province. These isolates consisted of 72 (32%) isolates pathotype III, 150 (58%) isolates pathotype IV, and 23 (10%) isolates pathotype VIII (Figure 5). *Xoo* pathotype III dominated in four districts i.e. Serdang Bedagai, North Tapanuli, South Tapanuli, and Toba Samosir; *Xoo* patotipe IV dominated in seven districts i.e. Deli Serdang, Binjai, Langkat, Simalungun, Asahan, Central Tapanuli, and Toba Samosir; and *Xoo* patotipe VIII dominated in Batubara district. It appeared that *Xoo* pathotype IV dominated in North Sumatra Province.

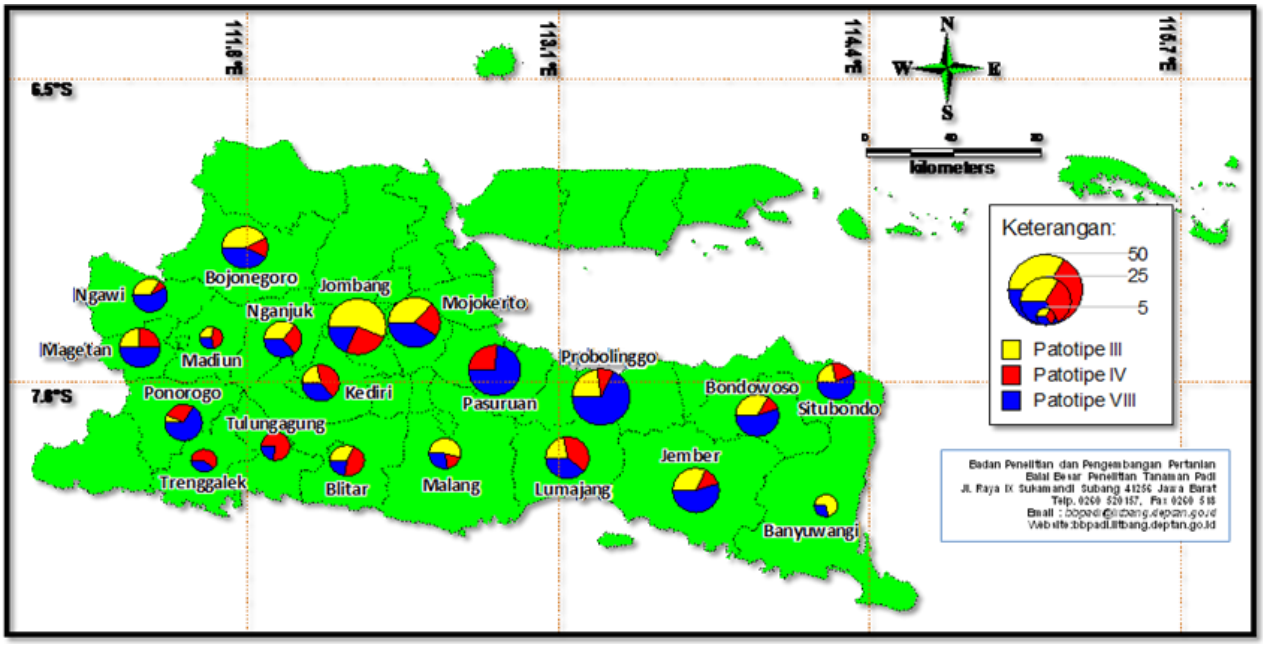

Figure 3. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in East Java Provinces

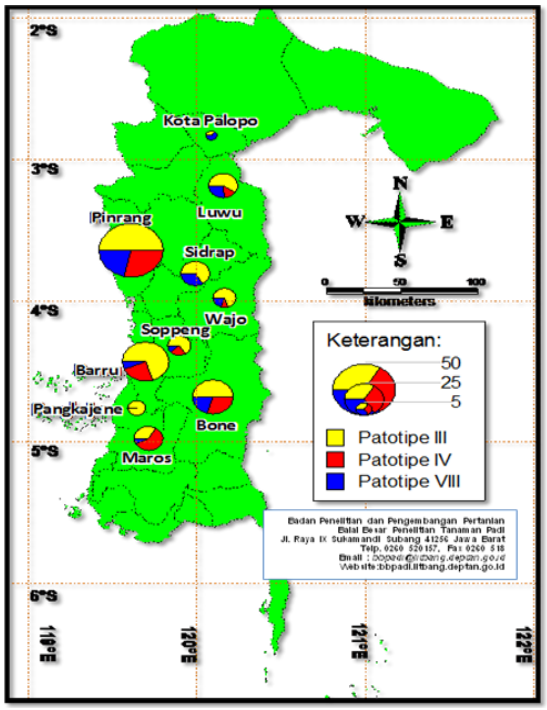

Figure 4. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in South Sulawesi Provinces

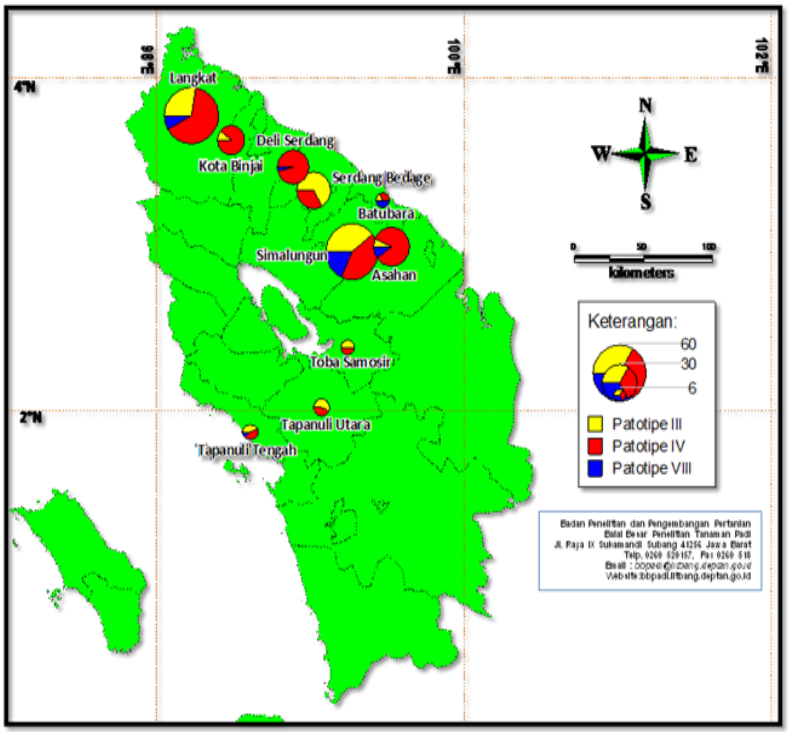

Figure 5. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in North Sumatera Provinces

From South Sumatra Province, a total of 116 *Xoo* isolates were successfully collected from 6 districts of South Sumatera. These isolates consisted of 67 (58%) isolates as pathotype III, 28 (24%) isolates as pathotype IV, and 21 (18%) isolates as pathotype VIII (Figure 6). *Xoo* pathotype III dominated in four districts i.e. Ogan Komering Ilir, Ogan Komering Utara, Ogan Komering Ulu, and Lahat. *Xoo* patotipe IV dominated in Muara Enim district, while *Xoo* patotipe VIII dominated Banyuasin district. The data indicated that pathotype VIII dominated in South Sumatra Province.

Lampung Province. A total of 225 *Xoo* isolates were obtained from 8 districts of Lampung province. These isolates consisted of 48 (21%) isolates as pathotype III, 112 (50%) isolates as pathotype IV, and 65 (29%) isolates as pathotype VIII (Figure 7). *Xoo* pathotype III dominated in two districts i.e. Pringsewu and North Lampung Utara, *Xoo* patotipe IV dominated in four districts i.e. Lampung Tengah, South Lampung, East Lampung, and Pesawaran. *Xoo* patotipe VIII dominated in three districts i.e. North Lampung, Metro, dan Bandar Lampung. It revealed that *Xoo* pathotype IV dominated in Lampung Province.

West Nusa Tenggara Province. A total of 232 *Xoo* isolates have been successfully isolated from 6 districts of West Nusa Tenggara. These isolated consisted of 47 (20%) isolates as pathotype III, 118 (51%) isolates as pathotype IV, and 67 (29%) isolates pathotype VIII (Figure 8). *Xoo* pathotype III dominated in Central Lombok district; *Xoo* patotipe IV dominated in four districts i.e. West Lombok, East Lombok, Mataram, and Sumbawa; and *Xoo* patotipe VIII found dominated in North Lombok district. The data indicated that *Xoo* pathotype IV dominated in Lampung Province.

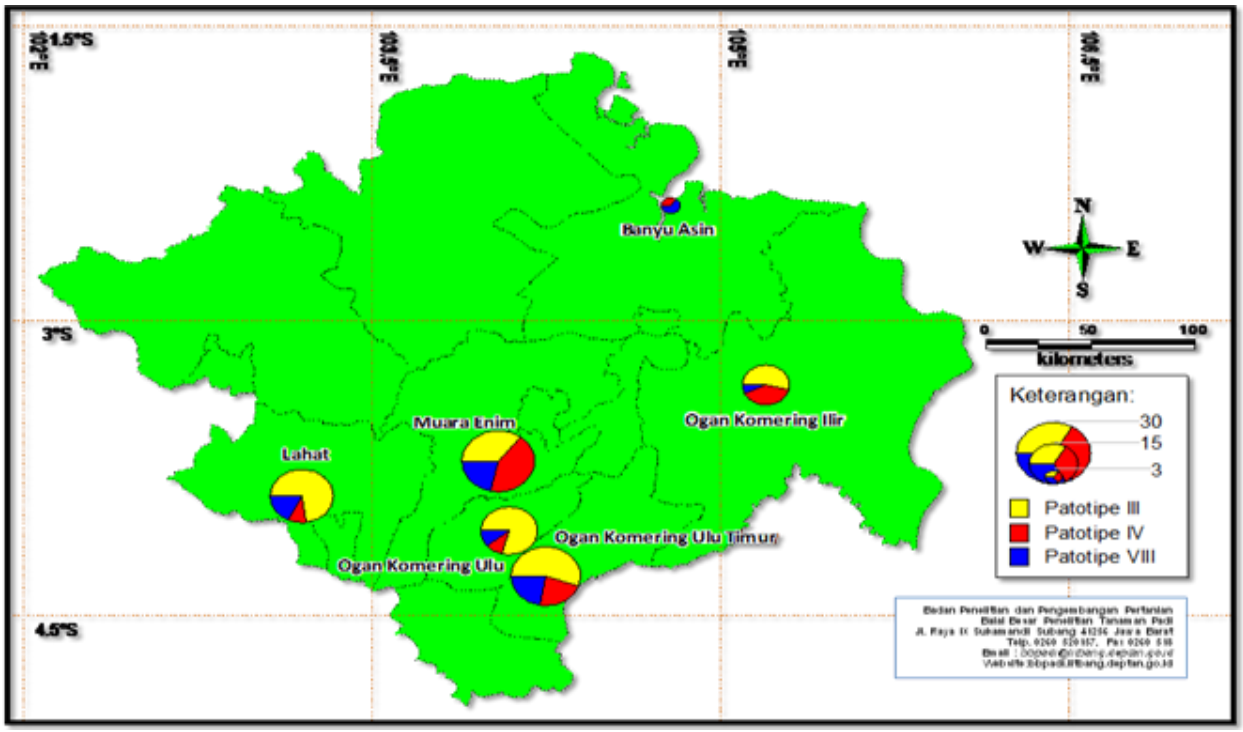

Figure 6. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in South Sumatera Provinces

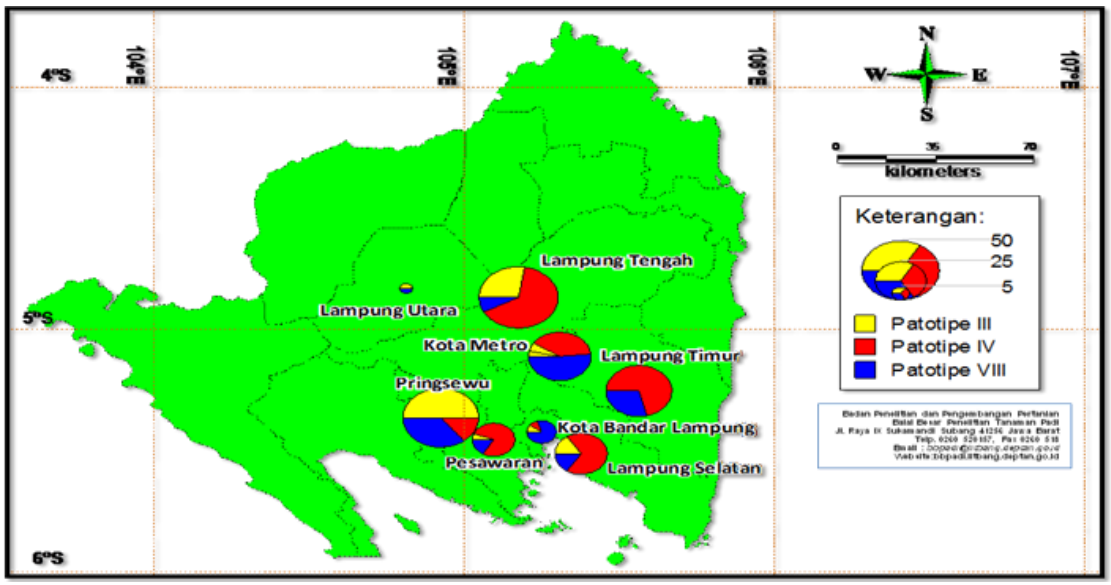

Figure 7. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in Lampung Provinces

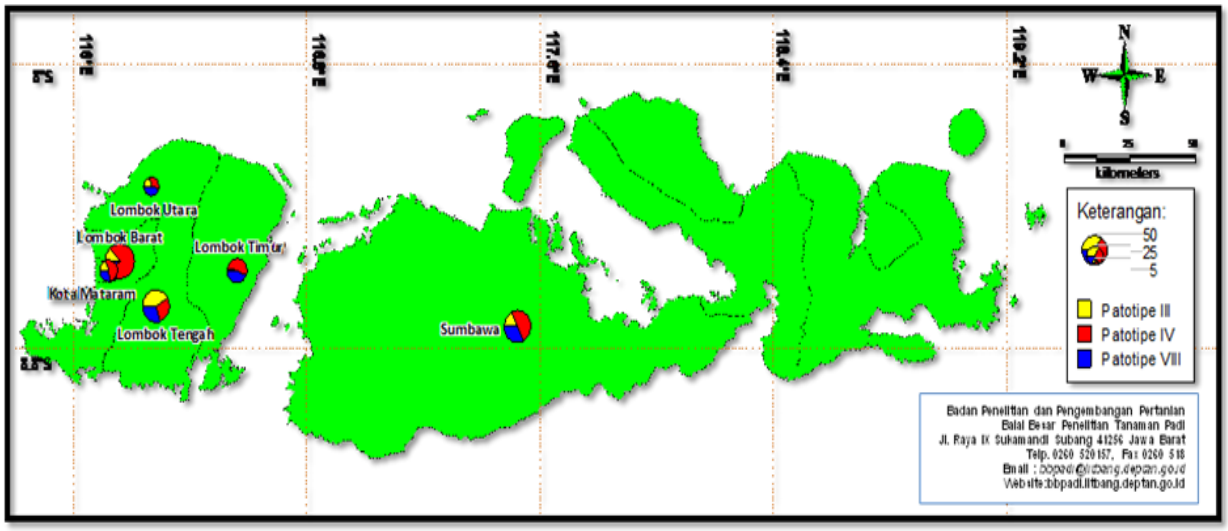

Figure 8. Distribution mapping of *X. oryzae* pv. *oryzae* pathotype in West Nusa Tenggara Provinces

Based on the interaction between various *Xoo* isolates collected from different rice growing centers and the differential varieties possesing different genetic background for resistant to the *Xoo* bacteria, a distinct variation of reactions were observed. The observation indicated that *Xoo* isolates in Indonesia consisted of pathotype III, IV, and VIII in which their composition and dominance varied by location. *Xoo* pathotype III were highly virulent to the Kinmaze, Kogyoku, and Tetep, but were low virulent to Wase Aikoku and Java 14. *Xoo* pathotype IV was *Xoo* highly virulent to all differential varieties, while *Xoo* pathotype VIII were those *Xoo* isolates that were highly virulent to Kinmaze, Kogyoku, Tetep, and Wase Aikoku, but were low virulent to Java 14. Suparyono *et al*., (2003) reported that pathotype IV was more virulent than the two pathotypes VIII and III.

The results of this research indicated that the composition and distribution of *Xoo* pathotype in Indonesia varied, and were consistent with those reported by Suparyono *et al*., (2004) and Sudir *et al*., (2009). They reported that *Xoo*

pathotype VIII was most dominant and a very wide distribution area both in the lowlands and moderate. Meanwhile, *Xoo* pathotypes III and IV were pathotypes contained in certain areas, particularly in the lowlands.

Hifni (1995), also reported that during 1980s, *Xoo* pathotype in Indonesia was dominated by pathotype III, The dominance was replaced by pathotype IV in the early of 1990s. Suparyono *et al*., (2004), reported in the early of 2000s, *Xoo* bacterial population in Java dominated by pathotype VIII. Although quantitatively was different, it was apparent that pathotype VIII dominated in all locations except in Yogyakarta province. Data obtained from this research were consistent with the results reported by Suparyono *et al*., (2004). This report showed that *Xoo* pathotype VIII dominated in Java. These information revealed that during the period of 2004-2007 the dominance of *Xoo* pathotype in Java Island has not changed. Based on the results of this research, breeding programs in Indonesia in the future, the selection of rice germplasm, and evaluation of promising lines should be directed to obtain the varieties that resistant to the three pathotypes, especially VIII.

Several factors that influence pathotype variation and changes such as adult-plant resistance, mutation, and heterogeneous nature that existing in the pathogen population (Agrios, 1988). All three of these factors greatly influence the pathotype population dynamics, disease severity, and yield losses due to disease (Suparyono *et al*., 2003). Hwang *et al*., (1987), defined adult-plant resistance as the resistance properties that appear when the plant had reached the generative phase. Resistance properties which appear on the plant at generative phase influence *Xoo* populations. A similar phenomenon may occur as a result of the mutation process. Another possibility was a character existence that is natural heterogeneity of a microorganism's population. Sudir and Suprihanto (2008), reported that the growth stages of rice plants affect the diversity of *Xoo* pathotype composition. Pathotypes III, IV, and VIII were found during tillering, flowering, and ripening growth stages of the rice plants. Pathotype VIII was dominant in the growth phase of tillering and flowering, while *Xoo* pathotype III was dominant at the ripening stage.

Single cropping resistant varieties continually is one factors affecting accelerate the emergence of a new *Xoo* pathotype development as single resistant variety cropping result in very strong selection pressure which causes the fracture of varieties resistance (Ogawa, 1993; Semangun, 1995). Diversity of *Xoo* pathotype composition was also influenced by the composition of rice varieties that were grown (Suparyono *et al*., 2003). During the planting period of 2010-2013, the rice varieties grown by farmers were dominated by Ciherang (47.0%), IR64 (19.7%), local varieties (6.8%), and other varieties (4.0%).

Environmental factors, such as wet and dry seasons affect the pathotype diversity of *Xoo*. Suparyono *et al*., (2003) in the dry season of 2001, revealed that a balanced existence of *Xoo* pathotypes III and VIII were observed, at the proportion of 42.7 and 42.0%, respectively in West Java, Central Java, Yogyakarta Special Province, and East Java. In the following season, was during the rainy season of 2001/2002, the balanced existance of *Xoo* groups III and VIII, was no longer exist. It has changed, in which the pathotype VIII was dominant, followed by pathotype IV and III, with the proportion of 63, 29, and 9%, for pathotype VIII, IV, and III, respectively. Changes in virulence were likely influenced by environmental conditions, especially relative humidity (RH). *Xoo* Bacteria thrive in conditions of high humidity (≥90%) and temperature between 25-30^{o}C (Ou, 1985).

Information obtained from this research were expected to be useful as a guide to varieties zoning strategy in rice producing centers in Indonesia as a basis for recommendation of planting resistant varieties for BLB disease control according to *Xoo* pathotype that presence in the field. For example, in endemic areas of *Xoo* pathotype III was recommended planting varieties that were resistant to *Xoo* pathotype III. The same recommendation also can be applied for endemic areas of *Xoo* pathotype IV and VIII.

Indonesian Agency for Agricultural Research, Ministry of Agriculture, Indonesia has released a number of rice varieties that resistant to certain *Xoo* pathotypes, including the varieties of Memberamo, Cibodas, Ciherang, Sintanur, Cigeulis, Inpari 5, Inpari 6, Inpari 7, Inpari 8, and Inpari 16 until Inpari 28 resistant to *Xoo* pathotype III. Inpari 4 resistant to *Xoo* pathotype III and VIII. While Angke, Conde, Ciujung, Inpari 6, and Inpari 17 resistant to *Xoo* pathotype III, IV and VIII (ICRR, 2013). For BLB endemic areas,

especially during the wet season which was very favorable for the development of bacterial leaf blight disease, should be planted rice varieties that had resistance to *Xoo* pathotype III, IV, and VIII such as the varieties of Angke, Conde, Ciujung, Inpari 6 Jete, and Inpari 17 (ICRR, 2013). A variety as a host of pathogens is one of the elements that determine the epidemic. Host who has a high level of resistance does not provide opportunities for pathogens to thrive (Zadoks and Schein, 1979). Suitability planting of varieties with pathotype of pathogens in a region, a positive impact on the effectiveness of BLB disease control, so that disease can be suppressed, duration of varieties resistance against BLB disease can be extended, yield losses can be reduced, and farmers' income can be increased (Sudir *et al*., 2009).

CONCLUSIONS AND SUGGESTIONS

Based on virulence against five differential varieties, *Xoo* isolates in Indonesia consists of three pathotypes III, IV, and VIII with a diverse composition and distribution between sites. In general, from 2,658 *Xoo* isolates that isolated from 10 rice producing provinces in Indonesia obtained 802 isolates (30%) pathotype III, 933 isolates (36%) pathotype IV, and 923 isolates (34%) pathotype VIII. *Xoo* pathotype III was dominant in the Provinces of Yogyakarta, South Sulawesi, and South Sumatra. *Xoo* pathotype IV was dominant in the provinces of North Sumatra, Lampung, and West Nusa Tenggara. *Xoo* pathotype VIII was dominant in West Java, Banten, Central Java, and East Java.

Mapping of *Xoo* pathotype composition and distribution in 10 provinces in Indonesia can be used as a reference to control bacterial leaf blight disease with resistant varieties based on the relationship between the nature of varieties resistant to *Xoo* pathotype in the field. In the area with dominant of *Xoo* pathotype III was recommended to planting varieties that were resistant to *Xoo* pathotype III such as Memberamo, Cibodas, Ciherang, Sintanur, Cigeulis, Inpari 5, Inpari 6, Inpari 7, Inpari 8, and Inpari 16 until Inpari 28. In the dominant area of *Xoo* pathotype IV suggested to plant resistant varieties against *Xoo* pathotype IV such as Ciujung, Conde, Angke, Inpari 1, Inpari 6, and Inpari 17. In the dominant area of *Xoo* VIII pathotype suggested to plant resistant varieties against *Xoo* pathotype VIII such as Conde, Angke, Inpari 1, Inpari 4, Inpari 6, Inpari 17, and Cimelati.

ACKNOWLEDGMENTS

The authors would like to thanks to Mr. Suwarji and Mr. Umin Sumarlin for technical work in the laboratory and the field. The authors also thanks to Dr. Suparyono and Dr. Aris Hairmansis were willing to review this article. Sincerely thank to Indonesian Center for Rice Research for supporting funds and facilities.

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