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by Sopalena, Sofian¹, J. Nurdiana

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Diversity of diseases of rice (*Oryza sativa*) in Kutai Kartanegara, Indonesia

SOPIALENA^{1*}, SOFIAN¹, J. NURDIANA²

¹Faculty of Agriculture, Universitas Mulawarman, Jl. Pasir Balengkong, Kampus Gunung Kelua, Samarinda 75123, East Kalimantan, Indonesia.
Tel./fax.: +62-541-749352,479314, *email: sopialena88@gmail.com

²Environmental Engineering Program, Faculty of Engineering, Universitas Mulawarman, Jl. Sambaliung No. 9, Kampus Gunung Kelua, Samarinda 75123, East Kalimantan, Indonesia

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Abstract. *Sopialena, Sofian, Nurdiana J. 2019. Diversity of diseases of rice (Oryza sativa) in Kutai Kartanegara, Indonesia. Asian J Agric 3: 55-62.* This research aimed to identify the diversity of diseases that are becoming the main threat to four paddy varieties in Kutai Kartanegara, Indonesia. Though similar studies have been conducted, to our knowledge, this research brings significant findings related to the diverse categories of plant diseases in the specific geographical area. The study was performed in Sidomulyo village, Anggana district using a purposive sampling method. From the selected paddy fields in the size of 2x2 square meters, the samples then were identified. Further analysis was performed on every suspected infected part of the plants. The results showed that there are five dominant plant diseases found, i.e., Blast disease, brown spot, narrow brown spot, false smut, and Sheath blight. Whereas the main cause of the diseases recorded are fungus and bacteria, i.e., *Pyricularia grisea* (Cke) Sacc., *Cercospora oryzae* Miyake., *Rhizoctonia solani* Kuhn., *Helminthosporium oryzae* L., *Ustilagoideia virens* (Cke) Tak.), and *Xanthomonas campestris* pv. *oryzae* Dye.

Keywords: Bacteria, diseases, fungus, rice

INTRODUCTION

Rice is one of the worlds' primary staple foods and provides food security for many countries (Remans et al. 2014; Hafiz et al. 2015; Zhang et al. 2017; Chang et al. 2018), including for Indonesians (Widyanti et al. 2014). However, there is still a shortage of rice production (Bantacut 2014). One of the main reasons for this issue is the reduced harvested area and thus the decrease in productivity, which mainly happened in Kutai Kartanegara and Berau regencies (Badan Pusat Statistik 2016). In 2015, rice production reached 408.78 thousand tons of dry grain (GKG), but reduced by 17.78 thousand tons compared to 2014 (Badan Pusat Statistik 2016). Therefore, it is necessary to identify the possibility of other potential lands that can be expanded into crop-based agriculture land, e.g., tidal water rice fields (Mareza et al. 2016; Setyo and Elly 2018). Besides tidal fields, agroecosystems can be identified as irrigated rice fields, rain-fed rice fields, deepwater rice fields and upland rice fields (Jayanthi et al. 2006). In East Kalimantan alone, tidal areas can be found in many places, including at Sidomulyo Village, Anggana Sub-district, Kutai Kartanegara District at about 700 ha. (Dinas Pangan, Tanaman Pangan dan Hortikultura 2017). From the existing land area, most of them have been used the paddy varieties such as Ciherang, Cimelati, and Mekongga (Susilastuti 2018). Though the use of plant-based pesticides is common among farmers (Sopialena et al. 2018b), the pathogenic microorganisms seem to be potential problems still. In this regard, this study found that

Pandan Ungu variety is rarely used due to its susceptible characteristics to pathogens.

The types of plant-disturbing organisms in host plants may vary (Saunders et al. 2010; Suyadi et al. 2017; Sopialena et al. 2018). In East Kalimantan, the most common pathogens experienced are *blast* (*Pyricularia grisea* (Cke) Sacc.), *hawar daun bakteri* (*Xanthomonas campestris* pv. *oryzae* Dye.), *bercak daun coklat* (*Helminthosporium oryzae* L.), and *tungro* (Sopialena and Pratiwi 2017). Disease can lead to crop failure and may attack both the vegetative and generative phases of the root, leaves, stems, or panicles of rice plants (Rodriguez et al. 2009; Gao et al. 2010; Ariyanto et al. 2013). The blast disease (*Pyricularia grisea* (Cke) Sacc.) may lead to death for rice, nursing plants, and the decrease of the quality of grain; which is mainly caused by the *H. oryzae*, whereas *hawar pelepah* or *upih* disease may cause the seeds failed to germinate (Kihoro et al. 2013; Sopialena and Pratiwi 2017). Also, there are other diseases caused by pathogens that are harmful to the plants, such as false smut disease and sheath blight (Sopialena and Pratiwi 2017). The need to fulfill the rice production and the potential of tidal land, especially in the village of Sidomulyo, Kutai Kartanegara, became the central issue for this research. Further, this identification provides a broader picture of how to combine the planting management (e.g., the use of paddy varieties) within the geographical characteristics (Stringer et al. 2016).

This study was intended to enrich the discussion on the type of diseases at different local paddy varieties for tidal fields, in particular in the area of East Kalimantan, Indonesia.

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MATERIALS AND METHODS

This research was conducted in tidal rice fields at Sidomulyo Village, Anggana Sub-district, Kutai Kartanegara District, East Kalimantan Province, Indonesia. It has climatic conditions of an average rainfall of 2051.50 m asl., a temperature of 26.80°C and relative humidity of about 60–80%. The tidal rice fields are known as the lands that experience the overflow of tidal water in a specified period. The research was conducted in the cropping areas of 1 ha crop, and the area was further divided into 50 m x 12 m. The information was collected using purposive sampling based on specific criteria, i.e., the identification of infected plants, both in vegetative and generative phases. Direct observations were performed to identify the symptoms of the diseases in four different local paddy varieties (i.e., Pandan ungu, Cimelati, Mekongga, Cigeulis). In the area of paddy tile (*ubinan*) with a size of 2x2 square meter, for each suspected part of the plants (leaf and stem) which were infected, they were cut to about 5-10 cm and analyzed in the laboratory.

To identify diseases caused by fungus, the samples of the plants were cut into small pieces first and sterilized using aquadest before soaking in a 70% alcohol solution for about 15-20 seconds. The next step was to dry the sample over the tissue, before transferring it into a cup that has contained Potato Dextrose Agar (PDA) media using nippers and left to isolate for 2-3 days. An ose of the needle and a methylene blue liquid was used to examine the growth of the fungal colonies. On the other hand, the identification of suspected diseases is because the bacteria is made through bacterial isolation to see the colony's morphological features, colonic features, bacterial cell shape, and colony color (Saunders et al. 2010). The isolation of the bacteria taken from the infected plants was conducted by preparing the media on Petri cultivation for some time waiting for it to be cool and stable.

For leaf spot or stem spot, the isolation is carried out by bringing the leaf or stem part into a plastic bag and wet cotton to keep the material from wilting. Furthermore, the diseased material was cleaned with alcohol and cut in the section between the leaves or the stems of the sick and healthy, then grown on the PDA agar media. They were then incubated until the pathogen grew and both colonies and microbes that developed were identified under a microscope. For rust disease, identification was carried out by directly scraping the rust on the rice leaf and looking directly under a microscope.

RESULTS AND DISCUSSION

The findings

The observations in the vegetative phase were performed when the plants were about 1-8 weeks, while the generative phase was conducted when the plants reached 9-14 weeks after planting. The information on the type of diseases at different paddy varieties in vegetative and generative phases was presented in Table 1.

Diseases in the vegetative phase

The results of the identification process to the paddy varieties of Cimelati, Cigeulis, Pandan ungu, and Mekongga, indicated that the types of main potential diseases in the vegetative phase could be classified into three types, i.e., *hawar daun bakteri*, *blast*, and *bercak coklat*. As presented in Figure 1.A, *hawar daun* disease is caused by the infection of *Xanthomonas campestris* pv. *oryzae* Dye. It begins with the appearance of gray (yellowish) spots on the leaf edge. In its development, the symptoms will expand, forming blight, and eventually cause the leaves to dry out. This disease also attacks Cimelati, Cigeulis, and Mekongga varieties.

Table 1. The identification of rice diseases in different paddy varieties.

Variety	Growth phases	
	Vegetative	Generative
	1-8 weeks after plantation	9-14 weeks after plantation
Cimelati	1 Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.) Bercak coklat (<i>Helminthosporium oryzae</i> L.)	2 Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Bercak coklat (<i>Helminthosporium oryzae</i> L.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.)
Cigeulis	1 Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.)	2 Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Bercak coklat (<i>Helminthosporium oryzae</i> L.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.) Hawar pelepah or upih (<i>Rhizoctonia solani</i> Khun.) Bercak daun sempit (<i>Cercospora oryzae</i> Miyake.)
Pandan ungu	Bercak coklat (<i>Helminthosporium oryzae</i> L.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.)	2 Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Bercak coklat (<i>Helminthosporium oryzae</i> L.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.)
Mekongga	1 2 Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Bercak coklat (<i>Helminthosporium oryzae</i> L.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.)	Hawar daun bakteri (<i>Xanthomonas campestris</i> pv. <i>oryzae</i> Dye.) Bercak coklat (<i>Helminthosporium oryzae</i> L.) Blast (<i>Pyricularia grisea</i> (Cke) Sacc.) Hawar pelepah or upih (<i>Rhizoctonia solani</i> Khun.)

On the other hand, *Pyricularia grisea* (Cke) Sacc. blast caused blast infection (Figure 1.B). It started with the onset of symptoms on the leaves in the form of spots such as rhombus with a pointed tip. The center of the spots is gray or whitish, with a reddish-brown or brown edge. This disease attacks varieties Cimelati, Cigeulis, Pandan ungu, and Mekongga. The disease *H. oryzae* attacks the leaves of rice plants, with brown, oval-shaped brown spots spread evenly on the leaf surface with gray or white dots, gray or white dots in the middle of the spots. Young spots are dark brown or purplish-shaped size of sesame seeds. Different from *Xanthomonas campestris* pv. *oryzae* Dye, this disease attacks the Cimelati, Pandan ungu, and Mekongga varieties, as shown in Figure 1.C.

Disease in the generative phase

On the other hand, in the generative phase, there are at least six main different diseases that are identified (i.e., *Hawar daun bakteri*, *Blast*, *Bercak coklat*, *Gosong palsu*, *Hawar pelepah/lupih*, and *Bercak daun sempit*). *Hawar daun bakteri* was indicated from the leaves that are colored gray to yellow, folded, and rolled. In a severe state, the entire leaf rolls, withers, and dies. Cimelati, Cigeulis, Pandan ungu, and Mekongga varieties are susceptible to this strike (Figure 2.A).

While the plants were affected by the blast (Figure 2.B-C), the symptoms were indicated by the appearance of shaped leaves like a rhombus and a pointed tip (blast leaves). The center of the spots are gray or white. It usually has brown or reddish-brown edges and heavily influences all the paddy varieties, i.e., Cimelati, Cigeulis, Pandan ungu, and Mekongga. Also, Figure 2.D shows the symptoms of *H. oryzae* which caused the leaves to have oval-shaped brown spots which spread evenly on the surface of leaves with gray or white dots. Similar to *Pyricularia grisea* (Cke) Sacc., *H. oryzae* may attack the

four paddy varieties, i.e., Cimelati, Cigeulis, Pandan ungu, and Mekongga.

On the other hand, the symptoms of *Cercospora oryzae* Miyake began with the stricken leaves having narrow patches lengthwise, reddish-brown, parallel to the leaf bone, and commonly attacking the *Cigeulis* variety (Figure 3.A). Whereas, as shown in Figure 3.B, the infection of *Rhizoctonia solani* Kuhn on the plant as indicated by the spotted formation on a gray-shaped oval-gray midrib and then gray-white with a brown fringe. This disease was typically found on the sheath or the leaf midrib, and sometimes on leaf strands if the conditions were supportable for the development of pathogens. This disease was commonly found in the varieties of Cigeulis, Pandan ungu, and Mekongga. Further, as seen in Figure 3.C, the symptoms of *Ustilaginoidea virens* (Cke) Tak were indicated by the strained rice seeds turning into golden spores (sometimes green). In most cases, this disease attacks Cimelati variety, and only a few grains of rice were discovered on the panicle.

Based on the results of the macroscopical observations, the colony of the bacteria *Xanthomonas campestris* pv. *oryzae* Dye was identified by the appearance of rounded convex with a yellow surface area, as presented in Figure 4.A and 4.B. While Figure 4.C presented the isolation of microcystic observation of *bacilli* colony from fungus *Pyricularia grisea* (Cke) Sacc. Based on the microscopic observation, the fungus seemed to have a long, sparse, single, and gray-colored conidiophore, which formed a conidium at the end. As shown in Figure 4.D, conidium looked like an oval with a pointed tip and was insulated into three-room with gram-negative color (red). While Figure 4.E indicated the colonies of *H. oryzae*, which appeared to be white on the fourth day. With microscopic observation, this fungus was seen to have a slightly curved *Conidia* (curve), enlarged in the center, smeared, brownish, and germinated from both end cells (Figure 4.F).

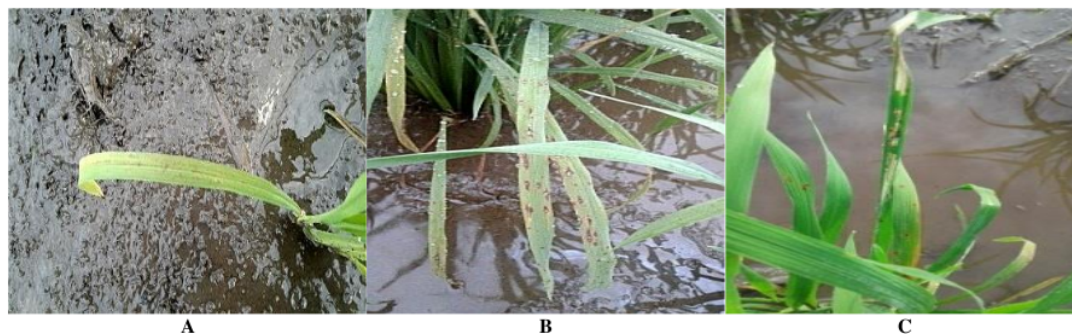


Figure 1. A. The symptom of *hawar daun bakteri* in vegetative phase. B. The symptom of *blast* in vegetative phase. C. The symptom of *bercak coklat* in vegetative phase.



Figure 2.A. The symptom of *hawar daun bakteri* in generative phase, B. The symptom of *blast* leaves, C. The symptom of neck blast, D. The symptom of *bercak coklat* in generative phase.



Figure 3.A. The symptom of *bercak daun sempit* in generative phase. B. The symptom of *hawar pelepah/lupih* in generative phase. C. The symptom of *gosong palsu* in generative phase.

As seen in Figure 5.A and 5.B, the colony of the fungus *C. oryzae* appeared to be grayish and was white-colored on the fourth day. By using microscopic observation, the fungus seemed to have cylindrical conidia which consisted of 3-10 septa, brown conidiophore, and growing on individual patches, where the conidium was formed on top of a conidiophore. While Figure 5.C and 5.D implied the colonies of the *R. solani* fungus. It was likely to be white, and this fungus was capped with hyphens in and many branches. The colony of *U. virens* appeared to be grayish-brown on the fourth day. Microscopically, this fungus has a spore, spiked, and germinated by forming a smaller

secondary conidium and hyaline where the wind propels the conidium. Further, the highest spore production occurs at night where the hyphae are attached. The form is an oval-shaped lump and has propagules (Figure 5.E-F).

Discussion

Hawar daun bakteri

In this study, it was revealed that the bacteria which caused the *hawar daun bakteri* (HBD) disease is *Xanthomonas campestris* pv. *oryzae* Dye. The bacteria of *Xanthomonas campestris* pv. *oryzae* Dye. is a significant disease in many rice-producing countries. The main reason

is that HDB can reduce the rice yields at a different level of degrees, depending on the growth stage of the infected plants, and the surrounding environment (Sopialena and Palupi 2017). Regarding the characteristics, *Xanthomonas* is a slimy colony and produces yellow xanthomonadin pigments (Cao et al. 2018). HDB disease often occurs in the rainy season, especially when there is a strong wind, which plays a role in the transmission and its spreading. Meanwhile, persistently irrigated crops may create environmental conditions that lead the disease to better develop (Bansal et al. 2017). Similarly, the cropping arrangement, which is too rigid, provides a massive influence on the development of the disease. Conversely, planting with a far distance also allows the transmission from one plant to another. The jolt and tipping between the infected leaves and the healthy ones may trigger the rate of pathogen infection.

According to Abadi (2003), the characteristics of bacteria are short stems, rarely seen in pairs, and having a size of $(1-2) \times (0.8-1) \mu\text{m}$. It has one polar flagellum with a size of $6-8 \mu\text{m}$ which serves as a mobile device. These bacteria are characterized by a narrow host range (Albuquerque et al. 2011) and are considered aerobic and can produce *extracellular polysaccharides* (EPS) which have an essential influence to cause the exudate which may infect the leaves. *Xanthomonas* are slimy colonies and generate a yellow pigment that may differ from another genus, i.e., *Pseudomonas* sp. *Xanthomonas* enter the plant tissue through the hydathodes which may happen at the leaf edge, broken roots, or the cut of the leaves. Seeds, farming tools, infected tillers, and weeds could be the primary cause of the bacterial inoculum, and the moisture on the leaf surface can dissolve the bacterial cells and make them spread freely. Akhavan et al. (2013) and Karavina et al. (2011) suggest that wind, rain, and irrigation channels may help the spread of the inoculum also. The bacteria can survive in the soil for 1-3 months, or 7-8 months in the seed.

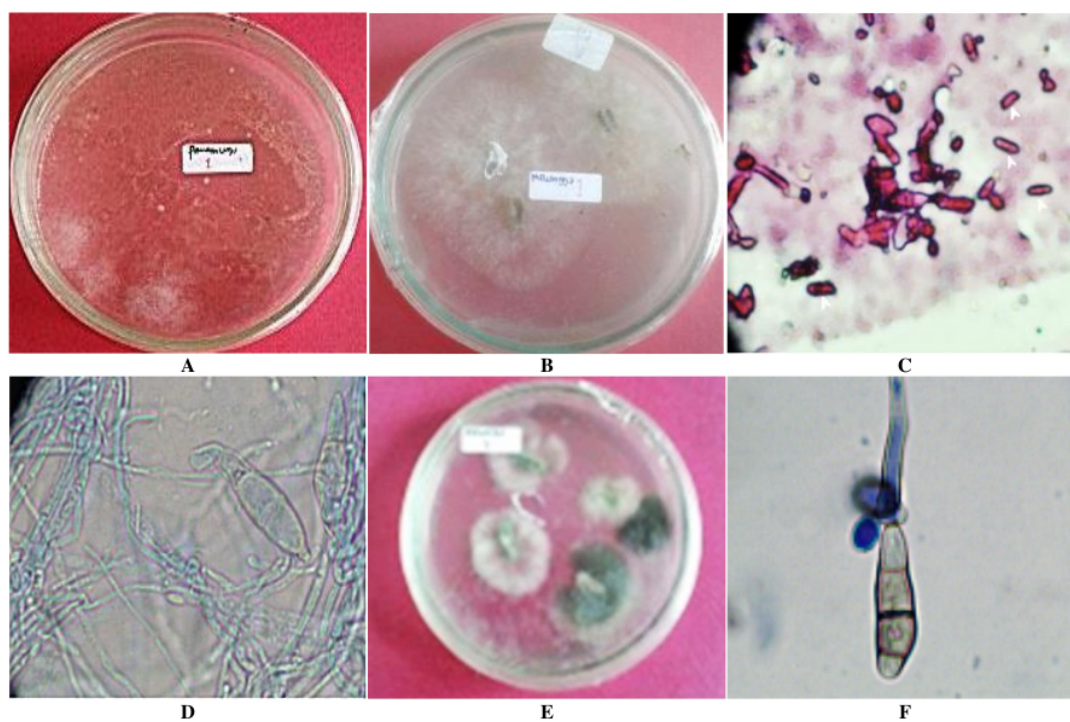


Figure 4. A. The colony of *Xanthomonas campestris* pv. *oryzae* Dye. B. *Pyricularia griseae* (Cke) Sacc. colony. C. Bacilli bacteria in gram-negative color (400x). D. *Pyricularia griseae* (Cke) Sacc. (400x) conidia. E. Fungus colony *Helminthosporium oryzae* L., F. *Helminthosporium oryzae* L. (400x) conidia.

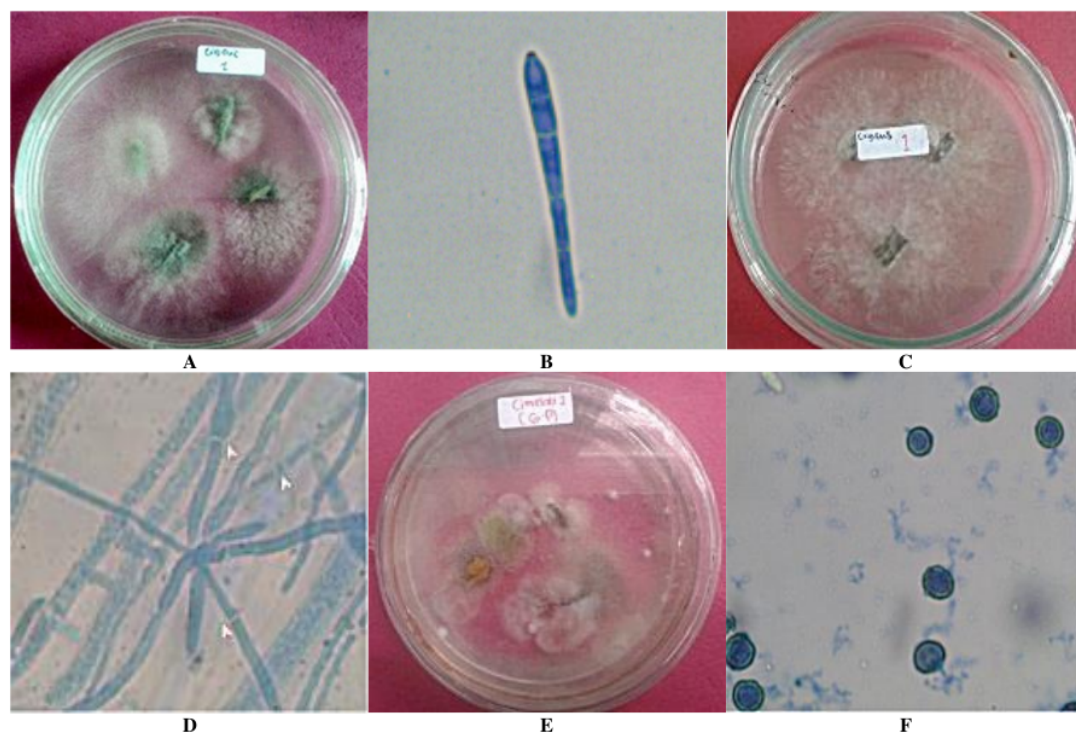


Figure 5. A. *Cercospora oryzae* Miyake colony, B. *Cercospora oryzae* Miyake (400x) conidia, C. *Rhizoctonia solani* Kuhn. colony, D. *Rhizoctonia solani* Kuhn. (400x) hypha, E. *Ustilagoidea virens* (Cke) Tak colony, F. *Ustilagoidea virens* (Cke) Tak. (400x) spores.

Blast (Pyricularia grisea (Cke) Sacc.)

Pyricularia grisea (Cke) Sacc. is found on all the paddy varieties in tidal rice fields and may infect either in the vegetative and generative phases. *P. oryzae* showed good growth at room temperature and optimum temperature ranging from 25-30°C (Channakeshava and Pankaja 2018). *P. grisea* works by disturbing the growth process. It initially infected the young leaves and forced the leaves to become dry and die. When the disease attacks in the growth phase, it is likely to cause *puso* (crop failure), particularly for vulnerable varieties. However, it does not result in excessive yield loss if the infection occurs in the phase of tiller development. The use of Si application also indicated a positive effect to reduce the intensity of leaf and neck blast attack, in particular for Ciharang variety (Siregar et al. 2016). Also, Amir et al. (2003) reported that the blast neck might potentially damage the rice crop if there is ample moisture at the beginning of flowering; either happening in morning or afternoon. In such climatic conditions, the temperature is not the limiting factor. At a temperature of 30-32°C, the neck blast is still capable of forming itself. There was a report mentioning that in Southeast Sulawesi, neck blast has infected the IR42 variety (at the average paddy age is two months) within the area of 300 ha. The main reason is that it was planted with

a relatively high population, and there was a lot of dew/moisture at the beginning of the flowering season.

Bercak coklat (Helminthosporium oryzae L.)

Helminthosporium oryzae appeared to attack the four local paddy varieties either in the vegetative or generative stage. According to Iqbal et al. (2015), the main indication of the disease was seen on leaves and later found on young seedling and panicle branches in older plants. The most severe symptoms come into sight approximately one month before the harvest. *Bercak coklat* affects the leaves and grains which could reduce the quality. The infection passes through stomata or directly to the epidermal cell wall after forming appressoria. The fungus may survive longer in plant tissue, depending on the supporting environment (Hafiz et al. 2015). The conidia of *H. oryzae* has specific characteristics, i.e., having a brown color, insulated into 6-17 parts, cylindrical shape, slightly curved, and somewhat widened in the middle. Environmental factors, i.e., wind speed and sunshine hours are the most decisive factor for epidemic development (Biswas et al. 2018). Further, *H. oryzae* lives as a parasite, which may destroy the sprouts and fruit, and cause a blemish on the host's leaf. The life cycle of this disease begins with a fungal conidium propagated by the wind and infection occurs through the

mouth of the skin, while a new symptom may emerge 30 days or more after infection.

Bercak daun sempit (Cercospora oryzae Miyake)

This study found that *C. oryzae* appeared in the Cigeulis variety and occurred in the generative phase. According to Mahmud et al (2018), *C. oryzae* is a harmful disease because it could damage the production, by drying the leaves before the time and harming the midrib. The spots mostly increased at seedlings. In severe attacks, *bercak daun sempit* is visible on leaves, stems, and flowers. However, when the plant starts to ripen, heavy symptoms begin to appear on the flag leaves. In most cases, the severe symptoms cause the leaves to dry out. The infections which happen in the midrib and stem, may initiate the stem and rot leaves which make the plant collapse (Wahyuno et al. 2017).

The disease usually transmits through the air and an alternating host. The hot air temperature and interspersed with rain are likely to accelerate the growth of the fungus, of which the fungus generates *bercak daun sempit* (Purnomo 2013). The infection happens through stomata, and new symptoms may appear about 30 days or more after the contamination. The symptoms pass slowly, even for young plants. However, the time of formation and filling of the panicles is the most vulnerable time for the entire stage.

Hawar pelepah/upih (Rhizoctonia solani Kuhn.)

Rhizoctonia solani came across in Cigeulis variety, Pandan ungu, and Mekongga and occurred in the generative phase. What is more, many species of *Rhizoctonia* cause important diseases (Bolton et al. 2010; Madbouly et al. 2014). It can subsist in the soil, where the perennial plants existing and can transform into dormant structures when the host plant is unattainable (Tirtana 2013). Though the dispersion of the pathogens can pass through the parts of plants that are buried in the soil, seeds also further the spreading across rainwater, irrigation flows or floods. The use of agricultural tools that contaminated these pathogens from the soil turned out to be a common way of dispersal. The ideal temperature for most of this fungus is 15-18°C. However, a small number of them can grow up to 35°C. The consequence of *hawar pelepah* infection is decelerating plant growth. When it grows in Potato Dextrose agar medium (PDA), the mycelium will initially appear white, and gradually the color of mycelium turns into light brown to old.

Gosong palsu (Ustilagoideae virens (Cke) Tak.)

Ustilagoideae virens was found in *Cimelati* variety and happen in the generative phase. It is a disease-causing pathogenic fungus, formerly also known as *U. virens*. Conidia are seen in an oval shape, very small, and have several green spore balls from sclerotia in the middle. The sclerotia can endure in the winter and flourish by spring. The fungus seems to be a solid, soft, and yellow-covered membrane, and the color changes from yellow to orange, yellowish-green, and eventually into a greenish-black.

Gosong palsu diseases occur in rice grains. The fungus turns the panicle grains into a greenish-yellow spore where

it looks like velvet. The spores are initially small and visible among the glomes and covered with a membrane because of further growth. The color of the spore ball becomes orange, then turns greenish to greenish. At this stage, when the surface of the spore bulb is broken, the outer layer of the ball will consist of mature spores along with the remaining fragments of mycelium. It has three layers of which, for the outermost layer, the green spore is blackish, the middle layer is orange, and the inner layer is yellow. According to Fan et al (2015) pathogen, *U. virens* produces a toxin known as Ustiloxins. Ustiloxins are tetrapeptides and Ustiloxins A-F is isolated from *gosong palsu* spore water extract. Toxins cause mycotoxicosis and may inhibit brain tubulin polymerization at micromolar concentrations. Pathogens can produce sclerotia in the life cycle stage, which germinate and produce Asco spores that will infect at the beginning of flowering. The continued rate of infection is an important part of the cycle of *gosong palsu* disease.

Gosong palsu diseases are prevalent in humid weather. In relatively high humidity, low temperature, and precipitation accompanied by cloudy days during flowering rice plants are favorable for the fungus *U. virens*. *Gosong palsu* disease develops in the rice husk and turns the rice endosperm into a large fungal sclerotium, which protrudes to the outside, golden yellow. Usually, in one panicle, there are only a few grains of rice that are exposed to the conidium emitted by wind and spores are present in the air around the night, while in the daytime very little. In general, the infection can occur, before or after the fertilization in panicle seed.

To this end, this study provided a better understanding of the types of paddy diseases and its natural occurrence in four different paddy varieties in Kutai Kartanegara, Indonesia. The information is useful for the farmers to predict and identify the management of the appropriate diseases to paddy planting. *Gosong palsu* was commonly found in *Cimelati* variety, but *hawar pelepah/upih* emerged in Cigeulis, Pandan ungu, and Mekongga varieties. Further, Cigeulis was susceptible to *bercak daun sempit*, while the rest of four paddy varieties were susceptible to *bercak daun coklat*, *blast*, and *hawar daun bakteri*.

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