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Differences in the Development of Blast Disease (*Pyricularia oryzae*) in Several Local Upland Rice Cultivars in Southeast Sulawesi, Indonesia

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Abstract

One of the important diseases in rice (*Oryza sativa* L.) is the blast disease (*Pyricularia oryzae*), which greatly affects the quality and quantity of rice production. This study aimed to determine the differences in the development of blast disease, as well as to obtain local upland rice cultivars in Southeast Sulawesi which had the lowest development of blast disease, in two different planting locations. This research was conducted in Lamomea Village, Konda District, Konawe Selatan Regency and Kambu Village, Kendari City. The research was arranged in a Complete Randomized Block Design (CRBD) consisting of 10 local upland rice cultivars of Southeast Sulawesi, namely: Tinangge (G1), Konkep (G2), Loiyo putih (G3), Waburi-buri (G4), Momea (G5), Wangkariri (G6), Bombana (G7), Wakawondu (G8), Wagamba (G9) and Bakala (G10), which were repeated 3 times. Six plant samples were taken from each plot. The variable observed was the development of blast disease, which consisted of disease severity, disease infection rate and disease progression curve. The results showed that from the planting location in Lamomea Village, the cultivar with the lowest disease progression was Konkep cultivar (G2) with disease severity of 12.59%, infection rate of 2.37% and disease progression curve of 35.59%. For cropping in Kambu Village, the cultivar with the lowest disease progression, namely the Momea cultivar (G5) had the lowest disease severity at 33.33%, the infection rate was 6.52% and the disease progression curve was 80.78%, which was lower than the other cultivars. Results of the study showed that there was an opportunity to obtain local upland rice cultivars that were relatively resistant to blast disease.

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Introduction

Rice (*Oryza sativa* L.) is a very important food crop in the world after wheat and maize (Reskiyanti, 2009). Rice is a strategic commodity in Indonesia because it can meet 63% of the total energy sufficiency and 37% of other nutrients for humans (Norsalis, 2011).

Upland rice has become an alternative in increasing rice production and is widely consumed by the public. The need for upland rice is increasing with increasing population growth. Upland rice commodity has not received major attention due to its relatively low productivity (Sumarno and Hidayat, 2007). Other factors that can reduce the production of upland rice are the presence of disease and the lack of good utilization of local upland rice cultivars. One of the important diseases in rice is blast disease (*Pyricularia oryzae*), whose infestation greatly affects the quality and quantity of rice production (Sudir *et al*., 2014).

In addition to attacking the leaves, blast disease caused by the fungus *Pyricularia oryzae* also attacks panicles and neck. Blast disease has reduced rice yields in Southeast Asia and South America by around 30-50% and resulted in millions of US dollars in losses (Hidayat *et al*., 2014). Blast is one of the most important diseases in rice around the world.

The loss of rice production due to this disease varies in various countries, such as Japan by 20–100%, Brazil 100%, India 5–10%, Korea 8%, China 14%, Philippines 50–85%, Vietnam 38–83%, Italy 22–26%, Iran 20–80% and Indonesia 50–90% (Wang *et al*., 2014).

Southeast Sulawesi has various cultivars of upland rice. The main problem faced by upland rice farmers in Southeast Sulawesi was the lack of information about cultivars with good and relatively resistant to diseases. The researcher intended to find out the resistance of 10 collections of local upland rice cultivars of Southeast Sulawesi to blast disease, by planting them in two different locations. By this research, it was hoped that local upland rice cultivars with good resistance to blast disease can be identified, so the cultivars can be used by the farmers.

Materials and methods

This research was conducted in Lamomea Village, Konda District, Konawe Selatan Regency and Kambu Village, Kendari City, from May to December 2019. The planting material used was 10 local upland rice cultivars of Southeast Sulawesi.

The research design used was a Complete Randomized Block Design (RAKL), using 10 treatments of local upland rice cultivars in Southeast Sulawesi, namely: Tinange (G1), Konkep (G2), Loiyo putih (G3), Waburi-buri (G4), Momea. (G5), Wangkariri (G6), Bombana (G7), Wakawondu (G8), Wagamba (G9) and Bakala (G10), which were repeated 3 times. For each treatment plot, 6 plant samples were taken randomly.

The observation variable was the development of blast disease in upland rice, including:

Disease severity

Determination of disease severity using a scoring scale based on the Standard Evaluation System for Rice (IRRI, 1996) and is calculated using the following formula:

$$IP = \frac{\sum (nv)}{NV} \times 100\%$$

Notes:

IP = Intensity of disease

n = Number of plants in each category of damage

v = The scale value of each category of damage

N = The number of sample plants observed

V = The highest scale value of the damage category

Disease infection rate

According to Susanto *et al.* (1995) the rate of disease infection can be calculated using the following formula:

$$r = \frac{2,3}{t} \left(log \frac{1}{1-Xt} - log \frac{1}{1-X0}\right)$$

Notes:

r = infection rate

Xo = proportion of initial disease

Xt = Proportion of disease at time t

t = Interval of observation time

Disease progress curve

According to Gilligan (1990) the disease progression curve can be calculated using the following formula:

$$\text{LDBKPP} = \sum_{i=1}^{n-1} \left(\frac{X_i + X_{i+1}}{2}\right)(t_{i+1} - t_i)$$

Notes:

Xi = 1st observation data

Xi + 1 = Observation data i + 1

ti = time of 1st observation

ti + 1 = Time of observation i + 1

Statistical analysis

The data obtained were analyzed using analysis of variance (ANOVA), followed by the LSD (Least Significant Difference) at the 95% confidence level.

Results and discussion

Recapitulation of the results of the various effects of treatment of 10 types of local upland rice cultivars (*Oryza sativa* L.) Southeast Sulawesi on the development of blast disease (*Pyricularia oryzae*) in two different planting locations, showed that the treatment of 10 types of upland rice cultivars had a significant and/or very significant effect. on the severity of disease in the Lamomea Village plantations at the age of 6 and 12 MST, in Kendari City at the age of 6 and 12 MST, the rate of disease infection and the curve of disease progression at the two planting sites.

Table 1. Mean severity (%) of blast disease in 10 local upland rice cultivars in Lamomea Village and Kambu Village.

Treatment	Mean Blast Disease Severity (%)*							
	6 WAP				12 WAP			
	Lamomea		Kambu		Lamomea		Kambu	
Tinangge (G1)	2.22	a	20.00	c	36.3	d	37.78	ab
Konkep (G2)	2.96	a	8.15	a	12.59	a	39.26	ab
Loiyo Putih (G3)	8.14	cd	8.89	a	34.81	d	57.04	d
Waburi-buri (G4)	8.88	d	18.52	c	37.77	d	39.26	ab
Momea (G5)	2.96	a	8.89	a	15.55	ab	33.33	a
Wangkariri (G6)	3.70	ab	11.85	ab	15.55	ab	52.59	d
Bombana (G7)	11.8	e	9.63	a	45.18	e	43.70	bc
Wakawondu (G8)	7.40	cd	8.15	a	27.40	c	52.59	d
Wagamba (G9)	2.96	a	9.63	a	20.00	b	39.26	ab
Bakala (G10)	5.92	bc	16.30	bc	27.40	c	49.63	cd
BNT 0,05	2.84		5.35		5.79		8.50	

* Notes: The numbers followed by different letter notations in the same column are significantly different based on the LSD test of 0.05. WAP = Week after planting.

In its growth, plants often experience interference from various disease-causing pathogens, including fungi, bacteria, viruses, nematodes, and phytoplasm. In general, plants can survive pathogenic infections with a combination of self-defense properties, namely (1) structural properties that function as physical barriers and inhibit pathogens from entering and developing in plants, and (2) biochemical reactions that occur in plant cells and tissues that produce substances toxic to pathogens or create conditions that inhibit the growth of pathogens.

The combination of structural properties and biochemical reactions used for defense for plants differs between each system of host-pathogen combinations (Goodman *et al*., 1986).

The results showed that among the 10 local upland rice cultivars tested showed different disease severities, namely the Momea cultivar with an average percentage of 33.33% in Kelurahan Kambu, while in Lamomea Village the lowest disease severity was Konkep cultivar with a percentage of disease severity. Amounting to 12.59% (Table 1).

The cultivar with the highest disease severity in Kambu was Wangkariri cultivar with an average percentage of 52.59%, while in Lamomea Village it was Bombana cultivar with an average percentage of disease severity of 45.18%. Therefore, it is suspected that Konkep and Momea cultivars may have relatively good structural or biochemical defense systems, which are different from the susceptible cultivars of Wangkariri and Bombana. However, it is not known as the resistance mechanism that succeeded in inhibiting the development of the pathogen P. oryzae in Konkep and Momea cultivars. In accordance with the opinion of Taufik (2011), each plant has a different resistance response to pathogenic infections. Differences in resistance responses may be caused by differences in plant morphology or genetics, or perhaps differences in the chemical content or secondary metabolites possessed by each plant.

Tabel 2. Mean (%) rate of blast disease infection in 10 local rice cultivars in Lamomea Village and Kambu Village.

Treatment	Average Disease Infection Rate (%)*			
	Lamomea		Kambu	
Tinangge (G1)	7.11	e	8.00	ab
Konkep (G2)	2.37	a	7.11	a
Loiyo Putih (G3)	6.07	d	11.56	d
Waburi-buri (G4)	7.11	e	7.41	ab
Momea (G5)	2.96	a	6.52	a
Wangkariri (G6)	4.00	b	9.93	bc
Bombana (G7)	8.44	f	8.15	ab
Wakawondu (G8)	5.04	c	9.19	bc
Wagamba (G9)	2.82	a	7.11	a
Bakala (G10)	5.33	c	10.07	cd
BNT 0,05	0.71		2.02	

* Notes: The numbers followed by different letter notations in the same column are significantly different based on the LSD test of 0.05.

Likewise, data on the rate of disease infection in the two locations showed that the Konkep cultivar was the cultivar with the lowest disease infection rate in Lamomea Village with a percentage of 2.37% and Momea Cultivar in Kambu Village with a percentage of 6.52% (Table 2). Meanwhile, the lowest total disease progression curve was in Lamomea Village, namely the Konkep cultivar of 35.59% and the Momea cultivar in Kambu Village at 80.78% (Table 3). The resistance of varieties that are only determined by one gene (*monogenic resistant*) is easy to break. The formation of resistant varieties that have more than one gene (*polygenic resistant*) with a longer resistance (*durable resistance*) is needed to deal with the dynamic diversity of blast pathogen populations (Ou, 1985). In the process of infection, a plant variety may not be infected by pathogens if the cell surface does not have a specific recognition factor that can be recognized by the pathogen (Agrios, 2005). Infection of leaves after the maximum tillering phase usually does not cause too much yield loss, but infection at the beginning of growth often causes puso, especially susceptible varieties (Yulianto and Subiharta, 2009). Infection with blast disease on rice leaves forms rhombic-shaped spots. In humid and warm environmental conditions, leaf spot symptoms will spread. If several leaf spots expand and coalesce, the infected rice leaves dry out and the plant dies.

One of the factors that influence the severity of blast disease intensity is the climate factor. Climate data from the Meteorology, Climatology and Geophysics Agency (BMKG) of Ranomeeto Station in 2019 shows that the monthly average temperature data between May-September is 25.0 - 26.1°C. This causes the rate of blast disease in Lamomea Village to be high, as well as in Kambu Village, the average monthly temperature between May - September 2019 is 25.8 - 26.7°C (BPS Sultra, 2020). Nandy *et al.*, (2010) proved that the optimum temperature for conidium germination and apresorium formation is 25-30°C. The fungus that causes blast disease takes 6–10 hours to infect plants. The optimum temperature for pathogenic infection is 25 - 26 ° C. According to Santoso and Nasution (2008), the incubation period for blast disease is 5 - 6 days at a temperature of 26 - 28 ° C.

The optimum temperature during the infection process is the same as the optimum temperature for mycelial growth, sporulation, and spore germination.

Tabel 3. Mean development curve of blast disease (%) in 10 local upland rice cultivars in Lamomea Village and Kambu Village.

Treatment	Development curve of blast disease (%)			
	Lamomea		Kambu	
Tinangge (G1)	92.63	d	120.04	bc
Konkep (G2)	35.59	a	87.44	a
Loiyo Putih (G3)	92.63	d	134.85	cd
Waburi-buri (G4)	100.04	d	127.44	bc
Momea (G5)	38.56	a	80.78	a
Wangkariri (G6)	54.85	bc	142.26	d
Bombana (G7)	114.11	e	110.41	b
Wakawondu (G8)	69.67	c	143.00	d
Wagamba (G9)	40.78	ab	84.48	a
Bakala (G10)	65.96	c	146.70	d
BNT 0,05	20.15		12.02	

* Notes: The numbers followed by different letter notations in the same column are significantly different based on the LSD test of 0.05.

Another factor that can bring the blast inoculum to the land in Lamomea Village is because it is a new land for planting upland rice, which is the lowest seed pathogen. Yulianto (2017) states that blast is a disease carried by seeds (seed-borne pathogen), so to prevent its development in non-endemic areas it is recommended not to use seeds that come from endemic areas. Meanwhile, the planted area in Kambu Village is an area that is often planted with upland rice which is endemic with blast disease so that the inoculums of this disease can come from the soil or alternative hosts around the land, in addition to environmental conditions that support the development of blast disease. Based on the results of this study, there is an opportunity to get local upland rice cultivars that are resistant to blast disease (*P. oryzae*). The results obtained give hope that the local cultivars used in this study have the potential to become resistant cultivars in planting locations, especially in the areas of Kambu and Lamomea Villages.

Conclusion

Based on the results and discussion, it is concluded that the 10 local upland rice cultivars tested at two different planting locations, there were differences in disease progression, including disease severity, disease infection rate and disease progression curves. In Lamomea Village, the cultivar with the lowest disease progression was Konkep cultivar (G2) with disease severity of 12.59%, disease infection rate of 2.37% and disease progression curve of 35.59%. Whereas in Kambu village, the cultivar with the lowest disease progression was Momea cultivar (G5) with disease severity of 33.33%, disease infection rate of 6.52% and disease progression curve of 80.78%, which was lower than the other cultivars.

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