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Performance and Pest and Disease Resistance Tests Local Genotype of Lowland Rice

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ABSTRACT

Rice is a food commodity with economic value as the main staple to maintain national and global food stability. The need for rice is in genotype with population growth, so it is necessary to increase production and productivity. The development of superior varieties requires genetic resources from local rice genotypes from West Sumatra regions, including Marapulai, Silih Baganti, Bujang Marantau, Hitam Manih, Junjuang, Mundam, Papanai and so on. Information on plant performance tests related to growth, agronomic components, and resistance to pests and diseases of local genotypes of lowland rice is still very limited. The experiment aimed to obtain local genotypes of lowland rice that had the appearance and resistance to pests and diseases. The observed growth and yield components were planting height, number of productive tillers, flowering age, ripening age, panicle length, number of seeds per panicle, number of good seeds per panicle, 1000 grain weight, and dry grain weight per ha. Pest and disease resistance variables are; brown planthopper pests, bacterial leaf blight and blast disease. Observational data were analyzed by F test at 5% level with the Least Significant Difference (LSD) at 5%. Analysis using PC software program Statistix ver 8.0. Collected data are observing pest and disease resistance based on assessment standards from the International Rice Research Institute. Based on the growth and agronomic components of the experiment, Maraplai was one of the genotypes that could be used as a superior variety, with the resistance of brown planthopper biotypes 1, 2 and 3 to making them susceptible. Marapulai local genotype has better growth and yield characteristics, as well as resistance to pests and diseases.

Keywords: *Genotype, lowland, Biotype, Blas, resistance*

1. INTRODUCTION

Rice is one of the food crop commodities that has a role and is the staple food for almost two-thirds of the world's population. It plays a strategic economic role and maintains national and global food stability. The need for rice continues to increase with the population growth rate. According to (Rahmini et al., 2012), the era of the green revolution is a basic milestone in increasing rice production globally to keep pace with population growth rates.

Badan Pusat Statistik (2022) reported that national rice production and productivity in 2019 reached 59.2 million tons (productivity 5.14 t/ha). In 2020 production was 54.6 million tons (productivity 5.13 t/ha). In 2021 production of 54.41 million tonnes (productivity of 5.23 t/ha), and 2022 production of 55.67 million tonnes (productivity of 5.23 t/ha). The data shows fluctuations in rice production nationally with more stable rice productivity and land area for cultivation which tends to decrease. Therefore, increasing rice production and productivity needs to be done to balance the demand for rice in the future, given the growth rate of Indonesia's population.

Pests and diseases are also factors that affect production decline in the tropics. Bacteria and fungi are diseases that cause rice yield losses of 10–15% (Upadhyay & Kumar, 2022) Pest and disease attacks are mainly caused by bacteria. The decline in production due to mould reached 14% (Simkhada & Thapa, 2022).

Therefore, an increase in rice production and productivity needs to be done to balance the demand for rice in the future, given Indonesia's population growth rate..

The constraints faced in rice development are; pest and disease attacks, abiotic stress, limited availability of arable land, and limited superior varieties with good production potential. Developing high-yielding lowland rice varieties is one of the strategic efforts, given the many potential local genotypes of lowland rice that have not been identified properly related to their characteristics. West Sumatra has local lowland rice genotypes cultivated by farmers and generally have not been well identified. Local genotypes of lowland rice that have been released as superior varieties are still very limited, such as Batang Piaman, Anak Daro, Kuriak Kusuik, and so on. Many local genotypes of lowland rice have not been released as superior varieties, including Maraplai, Junjuang, Bujang Marantau, Hitam Manis, Saribu Gantang, Mundam, and so on. Farmers have generally cultivated these genotypes without any identification related to their various superior traits.

According to (Ahnert SE, 2017), the development of rice genetic resources is more focused on analyzes related to important agronomic traits or characteristics. Characteristics affect growth, yield, resistance to biotic and abiotic stresses, and adaptability of each local genotype of lowland rice. Characteristics that are important for rice plants are agronomic characteristics and resistance to pests and diseases. According to (Seif et al., 2019), the characteristics of lowland rice plants can also examine the relationships between genotypes which are important for predicting the influence and yield of various local lowland rice genotypes and various breeding strategies and conservation of genetic resources.

Testing resistance to pests and diseases is an important factor in developing superior varieties, in addition to plant growth and yield. Pests and diseases, such as the brown planthopper caused by *Nilaparvata lugens* Stal, affect plant productivity. According to (Senewe et al., 2020), the brown planthopper attacks the rice stalks and sucks out the juices resulting in the stems drying out and dying. According to (Rahmini et al., 2012), the use of susceptible rice varieties is one-factor causing brown planthoppers' emergence in paddy fields.

Diseases that attack rice plants also vary, including leaf blight caused by the bacterium Xanthomonas oryzae pv oryzae. According to (Naqvi, 2019). (Sopialena et al., 2021), bacterial leaf blight attacks the leaves, the flowering phase, which results in a yield loss of 50 to 70%. Blast disease is one of the important diseases in rice plants. According to (Fernandez & Orth, 2018), blast disease in rice is caused by a fungus that causes damage to plant organs such as leaves, stems and grain, which is the most damaging. A results in a decrease in grain yields ranging from 10 to 30%. The fungus infects plant organs such as leaves, stems, nodes, necks, and panicles during the seed filling of rice plants. Pests and diseases that attack rice plants require various strategies including developing superior varieties that resist pests and diseases. The research aims to obtain local lowland rice genotypes that have good growth, yield and resistance to pests and diseases.

2. MATERIALS AND METHODS

Experiments on performance testing and resistance testing of local genotypes of lowland rice were carried out in paddy fields and greenhouses. The experiment was carried out from September 2019 to January 2020.

The materials used in the experiment were six local genotypes of lowland rice consisting of; Marapulai, Siliah Baganti, Bujang Marantau, Hitam Manis, 1000 Gantang and Junjuang, Urea, SP-36, KCl, meter, fanfare, and stationery.

The experiment used a non-factorial Randomized Block Design (RBD) with four replications. The treatments were six local lowland rice genotypes: Marapulai, Siliah Baganti, Bujang Marantau, Hitam Manis, 1000 Gantang and Junjuang.

Rice seeding is done by cultivating six plots measuring (50 cm x 50 cm) and then the seeds are sown. The land used for planting is processed by levelling, and plots measuring 4 x 5 meters are made. Transferred seed to the field 20 days after seeding as many as 2 stems per planting hole with a 25 x 25 cm planting area.

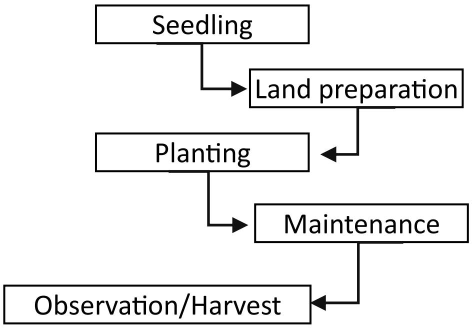

Fig 1. Flowchart of the implementation of lowland rice local genotype tests

Fertilization is done by giving Urea as much as 150 kg/ha. SP-36 as much as 100 kg/ha, and KCl as much as 200 kg/ha. Gave fertilizer was given twice, namely at the time of planting, 100 kg/ha of Urea, 100 kg/ha of SP-36, and 100 kg/ha of KCl. Follow-up fertilizer 30 days after planting (dap), giving Urea as much as 50 kg/ha and KCl as much as 100 kg/ha.

The observed variables included agronomic variables: plant height, number of productive tillers, age at the start of flowering, age at maturity, number of grains per aisle, number of full grains per panicle, and grain weight. Variables observed for pest and disease attacks include; resistance to brown planthopper, leaf blight and blast disease.

Pest and disease attacks in the field were observed throughout plant growth with the scoring method according to the standard assessment of (International Rice Research Instiitute, 2013).

Table 1. Criteria for assessing pest and disease attacks

Score	Criteria	Reaction
0	None infected	Very Resistant
1	Infection <1 %	Resistant
3	Infection 1 – 5 %	Moderatly Resistant
5	Infection 6- 25 %	Moderate
7	Infection 26 – 50 %	Vulnerable
9	Infection >50 %	Very Vulnerable

Source : (International Rice Research Instiitute, 2013)

The analyzed observational data from each agronomic variable with the F test and the Least Significant Difference (LSD) follow-up test. The data were analyzed using the PC software program Statistix Ver. 8.0.

3. RESULTS AND DISCUSSION

Plant Growth and Yield Components

Plant height, number of productive tillers, flowering age, and maturity of the several local strains of paddy rice tested varied in appearance. The Marapulai genotype had the appearance of plant height, a number of productive tillers, age of flowering, and age of maturity compared to other local lowland rice genotypes. The average phenotype performance of lowland rice local genotypes using the Least Significant Different (LSD) test at the 5% level is presented in Table 2.

Table 2. Average plant height (cm), number of productive tillers (saplings), age of flowering (dap), and age of ripening (dap) of several local rice genotypes

Local genotype	Plant height (cm)	Number of productive tillers (tillers)	Flowering age (dap)	Harvest ripe age (dap)
Marapulai	135,10 b	15,90 a	115,25 a	143,75 a
Junjuang	129,65 c	14,30 b	90,00 c	125,00 d
Bujang Marantau	133,68 b	15,03 a	105,00 b	134,75 b
Siliah Baganti	139,15 a	14,75 a	85,50 d	126,00 d
Saribu Gantang	149,88 a	14,03 b	91,50 c	131,50 c
Hitam Manis	130,88 c	14,63 a	113,75 a	144,25 a
KK (%)	1,10	3,80	2,95	2,95

Numbers followed by lowercase letters are not significantly different according to LSD at the 5% significance level.

The local rice genotypes of Saribu Gantang and Silih Baganti had relatively the same higher growth, followed by the Marapulai, Bujang Marantu, Hitam Manis and Junjuang genotypes. In addition to plant height growth, differences can also be seen in the number of productive tillers. The Marapulai genotypes were able to produce more productive tillers, but they were relatively the same as the Bujang Marantau and Hitam Manis genotypes, respectively, with 15.90, 15.03 and 14.63 tillers. The productive tillers produced by the Silih Baganti, Junjuang and Saribu Gantang genotypes were less, namely 14.75 and 14.03 tillers. The age of flowering and maturity of the strains tested also showed differences. The Marapulai and Hitam Manis genotypes had a longer flowering period (113-115 dap) and a longer maturity but were relatively the same (143-144 dap). The flowering age of the Bujang Marantau genotype is 105 dap with a maturity of 134 dap. The Saribu Gantang, Junjuang, and Silih Baganti genotypes showed shorter flowering and ripening ages.

The high growth of paddy rice plants is one of the factors that is influenced by genetic factors. Genetic factors influence the growth of different plant heights. (International Rice Research Instiitute, 2013), has classified the height growth of rice plants into three groups, namely short length (> 90 cm), medium height growth (91-125 cm), and high growth (> 126 cm). Based on these groupings, the local strains of lowland rice tested were classified as high (129-149 cm). Local rice genotypes generally have higher growth compared to superior varieties. The length of the internodes strongly influences the high growth characteristics. Longer stem segments result in higher plant growth compared to shorter stem segments. According to (Nazirah et al., 2016), genetic structure differences are one factor that affects the height growth of lowland rice plants.

In addition to high growth, the difference in the number of productive tillers is one of the important variables related to plant productivity. Productive tillers are tillers capable of producing panicles. Genotypes that can produce more productive panicles and tillers are important indicators in the formation of high-yielding varieties. Tests of the local lowland rice genotypes showed that the Marupalai, Bujang Marantau, and Hitam Manis genotypes were potential genotypes capable of producing more productive tillers. It is because, genotypically, each tested genotype has a different ability to produce panicles for each growing tiller. According to (Park et al., 2020); (Mogiso & Tarekegn, 2022), tillers are one of the important agronomic characteristics affecting rice plants' production. Rice tillers greatly determine the number of panicles which are a component of lowland rice yields. According to (Wijayanto et al., 2022), one factor that influences the number of productive tillers is the number of stem segments of each lowland rice genotype.

The difference between the age of flowering and maturity is also an important variable that distinguishes the local paddy rice genotypes. Environmental factors and plant genetic factors influenced the differences in the tested genotypes. According to (Nasution et al., 2018), differences in the flowering age of rice plants are caused by environmental factors such as temperature, sunlight, humidity and internal factors related to plant genetic factors. According to (Wijayanto et al., 2021), the ripening age for local strains of paddy rice is also related to the flowering age. Longer flowering age causes plants to enter the ripe harvest phase, such as in the Marapulai and Hitam Manis genotypes. In contrast, the flowering age is fast, followed by a faster harvest age, as in the Junjuang genotype.

Panicle length, number of grains per panicle, number of full grains, the weight of 1000 grains, and dry grain weight of local lowland rice genotypes observed and analyzed showed a significant effect. The average Least Significant Different (LSD) test results at the 5% level are presented in Table 3.

Table 3. Average panicle length (cm), number of grains per panicle (grain), number of full grains (grain), 1000 grain weight (g), and dry grain weight (t/ha) in several local genotypes of lowland rice

Local Genotype	Panicle length (cm)	Number of grains per panicle (grains)	The number of rice grains per panicle (grains)	Weight of 1000 grains (g)	Dry grain weight (t/ha)
Marapulai	28,10 a	369,88 a	295,28 a	20,67 b	7.08 a
Junjuang	25,90 c	219,98 bc	181,65 bc	22,52 a	6.18 b
Bujang Marantau	25,81 c	226,83 c	183,15 c	20,35 b	6.85 b
Siliah Baganti	25,60 c	185,78 e	126,35 e	24,11 a	6.69 b
Saribu Gatang	25,44 c	217,78 d	167,13 d	20,43 b	5.19 c
Hitam Manis	26,84 b	276,53 b	217,95 b	20,02 b	6.37 b
KK (%)	1,2	2,4	2,95	3,17	2,13

Numbers followed by lowercase letters are not significantly different according to LSD at the 5% significance level.

The panicle length of the tested local strains of lowland rice showed significant differences. Maraplai is one of the genotypes with a longer panicle of 28.10, followed by the Hitam Manis line with a panicle length of 26.84 cm. Junjuang, Bujang Marantau, Silih Baganti, and Saribu Gantang strains have panicle lengths of 25.90 cm, 25.81 cm, 25.60 and 25.44 cm, respectively. The number of grains and good grains per panicle differed significantly from the genotype tested. The Maraplai line produced more grain, namely 369.88 grain and 295.28 good grain, followed by the Hitam Manis line, which produced 276.53 grain and 217.95 good grain. Silih Baganti is a line that produces less grain, namely 185.76 grain and 126.35 grain, with good quality. The weight of the 1000 paddy rice local strains tested differed. Silih Baganti had a heavier grain weight (24.11 g) followed by Junjuang (22.52 g). In comparison, the other genotype was followed successively by Marapulai (20.67 g), Saribu Gantang (20.43, Bujang Marantau (20.35 g) and Hitam Manis (20.02 g). The difference in the yield components affected the dry grain weight per hectare produced. Marapulai produced a heavier dry grain weight of 7.08 t/ha, followed by Bujang Marantau (6.85 t/ha), Silih Baganti (6.69 t/ha), and Hitam Manis (6.37 t/ha). The Saribu Gantang strain produces a lighter dry grain weight of 5.19 t/ha.

Fig. 1. Length penicle some genotype local lowland rice

Panicle length, number of unhusked grains and good grain per panicle tend to pithy grains weight per hectare. Malai is a place where grain is formed and developed. Long panicles provide opportunities for forming more grain, whereas short panicles are also formed less. According to (Tang et al., 2017), the grain produced in each panicle has a close relationship with an increase in rice yields compared to other observational variables. Many studies also show that increasing the number of grains per panicle is the main way to increase rice yields (Huang et al., 2019).

Pest and disease resistance

Brown Planthopper Pests

Resistance to brown planthopper local lowland rice genotypes tested in biotypes 1, 2 and 3 had different resistance levels. Resistance to planthoppers Biotypes 1, 2, and 3 of the local lowland rice genotypes are presented in Table 4.

Table 4. Resistance to brown planthopper pests of local strains of lowland rice in Greenhouses, 2017 growing season (GS)

Local genotype	Biotype I		Biotype 2		Biotype 3	
	Scala	Criteria	Scala	Criteria	Scala	Criteria
Marapulai	5	SV	5	SV	5	SV
Junjuang	5	SV	7	V	7	V
Bujang Marantau	3	VV	5	SV	5	SV
Siliah Baganti	3	VV	5	SV	5	SV
Saribu Gantang	5	SV	5	SV	5	SV
Hitam Manis	5	SV	5	SV	5	SV

Description: H = hold; SR= somewhat resistant; SV = somewhat vulnerable, and V = vulnerable; VV = very vulnerable..

Tested The resistance level of local genotypes of lowland rice was tested on pathotype III. All genotypes were included in the criteria for being susceptible (AR) on a scale of 4. However, in testing with pathotypes IV and V, all genotypes changed to very susceptible criteria (SR) on scales 7, 8, and 9. The change from susceptible to highly susceptible showed a decrease in the resistance of the local genotype of lowland rice to bacterial leaf blight at the generative stage. It is due to changes in the characteristics of the bacterium Xanthomonas oryzae pv. Oryzae is a bacterial leaf blight pathogen with changes in characteristics, followed by stronger BLB pathogenicity. Characteristics are changed from pathotypes III to pathotypes IV and VIII. It causes plant resistance to bacterial leaf blight (BLB) to change from moderately resistant to very susceptible. According to (Sudir, 2012); (Dianawati, 2015),, the level of pathogenicity occurs due to changes in characteristics with the presence of the pathogenic ability of Xanthomonas oryzae pv. Oryzae forms a new pathotype that has a higher level of pathogenicity. It causes a decrease in plant genotypic resistance, apart from the emergence of new pathotypes.

The resistance to bacterial leaf blight of the local genotypes of lowland rice tested was also strongly influenced by the growth stage of the plants. According to(Sudir & Yuliani, 2016), BLB disease causes yield losses that vary, depending on the stage of the disease-infected plant. According to (Mumpuni & Rohmah, 2021), bacterial leaf blight can attack at various plant growth stages, including seeds, vegetative, and generative stages. In addition, environmental conditions (Ansari et al., 2020). (Puspitasari, 2014), states that plant organs are infected through leaf wounds or natural openings, such as stomata, and even damage leaf chlorophyll. The vegetative stage is one of the stages with higher growth activity of plant cells and tissues, such as the growth of roots, stems and leaves. Roots, stems and leaves grow optimally and can increase plant resistance to BLB. In addition to plant morphology, genetic factors strongly influence disease resistance. (Sudewi et al., 2020) explained that genetic factors are one of the factors that determine plant resistance to pests. Different genotypes have different genetic factors, both superior rice and local varieties. The potential of local genotypes of lowland rice in the development of plants resistant to brown planthopper pests needs to be investigated..

BLB resistance in the generative stages of the local genotypes of the tested lowland rice had resistance levels based on various criteria, ranging from susceptible (S), susceptible (R) and very susceptible (SR) to pathotypes III, IV and VIII. Resistance test results of lowland rice local genotypes against BLB pathotypes III, IV and VIII at the generative stage are presented in Table 5.

Table 5. Resistance test of lowland rice genotypes against bacterial leaf blight (BLB) using pathotypes III, IV and VIII at the generative stage

Genotype local	Pathotype III			Pathotype IV			Pathotype VIII		
	Rata-rata (%)	Scala	Criteria	Rata-rata (%)	Scala	Criteria	Rata-rata (%)	Scala	Criteria
Marapulai	8,11	4	SV	39,76	7	HS	18,24	6	R
Junjuang	12,75	5	V	50,62	8	HS	22,93	6	R
Bujang Marantau	10,98	5	V	62,70	8	HS	24,12	6	R
Siliah Baganti	8,27	4	SV	53,04	8	HS	24,01	6	R
Saribu Gantang	5,30	4	SV	37,17	7	HS	20,85	6	R
Hitam Manis	10,59	5	V	55,87	8	HS	20,46	6	R

Description: T = hold; AT= somewhat resistant; AR = somewhat vulnerable; R = susceptible, SR = very susceptible.

The resistance level of lowland rice local genotypes to BLB using pathotype III was divided into three criteria. Marapulai, Silih Baganti and Saribu Gantang had moderately vulnerable (AR) criteria on a scale of 4. In contrast, Junjuang, Bujang Marantau, and Hitam Manis had a vulnerable criteria (R) on a scale of 5. The BLB resistance level on pathotype IV was all genotypes tested on very susceptible (SR) criteria on scales 7 and 8. BLB resistance level on pathotype VIII, all local genotypes tested were on vulnerable criteria (R) on scale 6. Marapulai, Silih Baganti and Saribu Gantang genotypes had better BLB resistance on that pathotype III compared to the more susceptible. BLB in pathotype IV and pathotype VIII of all local genotypes of lowland rice changed to highly susceptible (SR) and susceptible (R), respectively.

Characteristics a of the pathotype of the bacterium *Xanthomonas oryzae* pv.

Oryzae have different levels of pathogenicity, so the resistance produced by local lowland rice genotypes is also different. Pathotype IV has a high level of pathogenicity compared to pathotype VI. According to (Fatimah & Prasetiyono, 2020), one of the factors that determine plant resistance to BLB pathotypes is genetic factors.

Blast disease resistance

Resistance of local genotypes of lowland rice to two races of blast disease caused by the fungus Pyricularia grisea (Cooke) Sacc using race 033 and race 173 has different criteria and scales. The response of the genotypes tested was in the range of scales 3, 5, and 7 on the criteria for resistance (AT) and susceptibility (R) for race 033 and scales 3, 5, 7, and 9 for race 173. Resistance tests of lowland rice local genotypes against race 033 and 173 are presented in Table 5.

Table 5. Resistance reaction of Payakumbuh lowland rice varieties to 2 races of Blast disease caused by *Pyricularia oryzae* fungus

Genotype local	Reaction to *Pyricularia grisea*			
	Ras 033		Ras 173	
	Scala	Criteria	Scala	Criteria
Marapulai	3	AT	5	R
Junjuang	3	AT	3	AT
Bujang Marantau	5	R	7	R
Siliah Baganti	7	R	7	R
Saribu Gantang	5	R	5	R
Hitam Manis	3	AT	5	R

Description: T = hold; AT= somewhat resistant; AR = somewhat vulnerable; and R = vulnerable.

Local genotypes of lowland rice have different levels of resistance to blast disease. Junjuang is a genotype with a level of resistance with moderately resistant criteria (AT) on a scale of 3 in both races tested. Marapulai and Hitam Manis with a resistance level of moderately resistant criteria with a scale of 3 only in race 033, while the genotypes of Bujang Marantau, Silih Baganti, Saribu Gantang are at the vulnerable criteria (R) on a scale of 5 and 7.

The resistance level of the tested genotypes showed that each genotype had a different response to race. According to (Acharya et al., 2019),, the different levels of resistance to blast disease in rice plants are due to the specific characteristics of the host genotype of Pyricularia grisea (Cooke) Sacc. The race characteristics of P. oryzae greatly determine the level of pathogenicity to rice plants. According to (Utami et al., 2016), the virulence properties of the P. oryzae race easily adapt to plant and environmental conditions. (Kawasaki-Tanaka et al., 2016), also explained that the racial characteristics of P. oryzae could occur due to differences in cultivated rice genotypes. Because the level of rice genotypic diversity will also encourage the development of the P. oryzea race.

4. CONCLUSION

Based on the experiments conducted, it was concluded that the local genotypes of lowland rice tested based on height growth were classified as tall (> 126 cm). Marapulai is one of the better genotypes based on yield components. In addition to growth and yield components, resistance to pests, Marapulai, Saribu bushel, and Black Sweet are somewhat susceptible to Biotypes 1, 2, and 3. Resistance to bacterial leaf blight in the vegetative and generative phases, somewhat susceptible to Pathotype III, and very susceptible to both pathotypes IV and VIII. The reaction of resistance to blast disease, Marapulai and Hitam

Manis were slightly resistant to Ras 033, but susceptible to Ras 173. Based on growth, yield components, and pest and disease resistance, Marupulai is one of the local lowland rice genotypes that have the potential to be developed into strains.

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