UNIVERSITI PUTRA MALAYSIA

GENOTYPE BY ENVIRONMENT INTERACTION AND STABILITY ANALYSES OF ADVANCE BLAST RESISTANT RICE GENOTYPES DERIVED FROM CROSSING BETWEEN MR219 AND PONGSU SERIBU 2

RAIEAH SAIYEDAH BINTI SABRI

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By

RAIEAH SAIYEDAH BINTI SABRI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

June 2019

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DEDICATION

This thesis is dedicated to my father (Sabri bin Awang) and my mother (Rosnani binti Abu Samat) for their love, moral support and sacrifice throughout my study.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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June 2019

Chairperson : Professor Mohd Rafii Yusop, PhD
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Multi-environmental yield trials is vital in assessing the newly developed rice genotypes for its adaptability and stability across environments especially when the objective to release the newly developed variety for commercial cultivation. The growth performance and phenotypic variability of these genotypes are the combination of environment, genotype and genotype by environment (G×E) interaction factors, thus evaluation must be done since it creates an opportunity for an effective selection of superior genotype. In this study, 18 improved blast resistant rice genotypes developed from the crossing between MR219 and Pongsu Seribu 2 including MR219 as recipient parent were evaluated under four different environments in Peninsular Malaysia. The experiments were carried out using randomized complete block design with three replications at each environment. Data were collected on the vegetative, yield and yield component traits. Analysis of variance revealed significant differences among the genotypes, environments and G×E interaction for most of the traits under study. Low heritability (<30%) was found for all the traits. Similarly, low genetic advance was also observed for all the traits except for number of tillers per hill and number of panicles per hill. Correlation coefficients observed with yield per hectare showed a significant and positively correlated with most evaluated traits except for days to flowering, days to maturity, plant height and number of unfilled grains. Cluster analysis divided the 19 evaluated genotypes into six groups. The recipient parent, MR219 was clustered with G17 and G18. Stability analyses classified the rice genotypes into three groups based on the univariate (b_i, $S^2{}_d$, $\sigma_i{}^2$, $W_i{}^2$, YS_i) and multivariate stability statistics. The first group consisted of genotypes such as G11, G17, G118 and MR219 that were having high mean yield trait with high stability. These genotypes were widely adapted across environments. The genotypes in the second group such as G1, G6 and G8 had possessed characteristic with high mean yield trait but low stability, which are suitable for cultivation at a specific environment. The last group included genotypes having low mean yield trait but high stability for example genotypes G7, G9 and G13. Tanjung Karang 1 environment was the most suitable environment for majority of the genotypes revealed by environmental discriminate analysis using GGE biplot. This followed by Serdang and Kota Sarang Semut, meanwhile Tanjung Karang 2 was the poorest environment for the genotypes selection. From this study, superior genotypes namely G18, G17, G11, G14, and G5 had produced high yield and highly stability across diverse environments are recommended for large scale evaluation before commercial release to rice farmers.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

INTERAKSI GENOTIP DENGAN PERSEKITARAN DAN ANALISIS KESTABILAN GENOTIP MAJU PADI RINTANG KARAH DARIPADA KACUKAN MR219 DAN PONGSU SERIBU 2

Oleh

RAIEAH SAIYEDAH BINTI SABRI

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Percubaan hasil pelbagai persekitaran adalah penting dalam menilai genotip padi yang baru dibangunkan untuk kesesuaian dan kestabilannya dalam persekitaran yang berbeza terutama apabila matlamatnya adalah untuk pengeluaran varieti baharu untuk penanaman secara komersial. Prestasi pertumbuhan dan kepelbagaian fenotip bagi genotip ini adalah merupakan kombinasi faktor genotip, persekitaran dan interaksi genotip dan persekitaran (G×E), oleh itu penilaian mesti dilakukan kerana ia memberi peluang untuk pemilihan genotip unggul. Dalam kajian ini, 18 genotip maju padi rintang karah yang dihasilkan dari kacukan antara varieti MR219 dan Pongsu Seribu 2 termasuk MR219 sebagai induk penerima telah dinilai di empat persekitaran yang berbeza di Semenanjung Malaysia. Eksperimen ini telah dijalankan menggunakan rekabentuk blok penuh terawak dengan tiga replikasi di setiap persekitaran. Pengumpulan data dilakukan pada ciri vegetatif, hasil dan komponen hasil. Analisis varians menunjukkan terdapat perbezaan yang bererti di kalangan genotip, persekitaran dan interaksi G×E untuk kebanyakan ciri yang dikaji. Semua ciri menunjukkan nilai heritabiliti yang rendah (<30%). Begitu juga, kemajuan genetik yang rendah juga didapati untuk kesemua ciri kecuali bilangan anak pokok serumpun dan bilangan tangkai serumpun. Pekali korelasi bagi ciri hasil sehektar menunjukkan mempunyai hubungan positif yang bererti dengan kebanyakan ciri yang dinilai kecuali untuk hari berbunga, hari ke kematangan, ketinggian pokok dan bilangan bijian yang tidak terisi. Analisa kluster telah membahagikan 19 genotip yang dinilai kepada enam kumpulan. Induk penerima, MR219 adalah sama kluster dengan G17 dan G18. Analisa kestabilan mengklasifikasikan genotip padi tersebut kepada tiga kumpulan berdasarkan kestabilan statistik univariat (b_i, S^2_d, σ_i^2, W_i^2, YS_i) dan multivariate. Kumpulan pertama terdiri daripada genotip seperti G11, G17, G118 dan MR219 yang mempunyai sifat hasil purata serta kestabilan yang tinggi. Genotip ini mempunyai kebolehsesuaian yang luas di pelbagai persekitaran. Genotip dalam kumpulan dua pula seperti G1, G6 dan G8 mempunyai sifat hasil purata yang tinggi tetapi kestabilan yang rendah, yang mana mempunyai kebolehsesuaian di sesuatu persekitaran tertentu. Kumpulan terakhir

termasuk genotip yang mempunyai sifat hasil purata yang rendah tetapi kestabilan yang tinggi seperti genotip G7, G9 dan G13. Persekitaran Tanjung Karang 1 merupakan persekitaran yang paling sesuai untuk kebanyakan genotip yang telah di kenalpasti melalui analisis diskriminatif persekitaran menggunakan GGE biplot. Ini diikuti oleh Serdang dan Kota Sarang Semut, manakala Tanjung Karang 2 adalah persekitaran terburuk untuk pemilihan genotip. Dari kajian ini, genotip unggul iaitu G18, G17, G11, G14, dan G5 yang memberikan hasil yang tinggi serta kestabilan tinggi di pelbagai persekitaran adalah disyorkan untuk penilaian berskala besar sebelum pengesyoran komersial kepada pesawah padi.

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

MET	Multi environmental trial
G × E	Genotype by environment interaction
ANOVA	Analysis of variance
PCV	Phenotypic coefficient of variation
GCV	Genotypic coefficient of variation
GA	Genetic advance
h^2_B	Broad-sense heritability
GGE	Genotype main effects plus genotype × environment interaction model
AMMI	Additive main effect and multiplicative interaction effect
AEC	Average environment coordinate
SAS	Statistical analysis software
SVD	Singular value decomposition
SASG×E	SAS genotype × environment interaction analysis program
M	Mean of trait
b_i	Regression slope
S^2_d	Deviation from regression
W^i	Wrickle's ecovalence
YS_i	Kang's yield stability statistics
σ_i^2	Shukla's variance
IRRI	International Rice Research Institute

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Rice (*Oryza sativa* L.) is a staple food for over 3 billion of the world population majority in Asia continent. Its role at present and future global food security is important due to the number of daily calories and protein intake (Prasad et al., 2017). Rice is subjected to many controls and interventions from the government in order to attain food self-sufficiency while ensuring a good price for farmers and secured price for consumers (Tobias et al., 2012). Over the years, there is a continuous increased in human population and also consumption of rice due to people's desire for well balanced and healthy diet. This had caused vast gap between rice demand and its production, thus creating a need to increase the current rice yield potential (Conforti, 2011). However, rice productivity and sustainability are constrained particularly by biotic and abiotic stresses which will be further aggravated by climate change, weather variability, and water shortage (Maclean et al., 2013).

In Malaysia, rice is completely guarded by subsidize, price control, and import tariffs (Vengedasalam et al., 2011) because it is heavily influenced by social, economic and political sensitivity (Ramli et al., 2012). Rice demand has been increasing on yearly basis in Malaysia. The current mean yield of Malaysian rice production was 4.03 t/ha (USDA, 2017). This output can only meet 72.3% of its local demands (Department of Statistics Malaysia, 2017) with production of 2.2 million tons of rice annually, eventhough there was an increased in area harvested and rice production from 2015 to 2016 (FAOSTAT, 2017). Malaysia lacks comparative advantage in paddy production and limited available land area for rice production compared with bordering countries like Vietnam and Thailand, consequently, the country needs to depend on imported rice to fulfill its level of self-sufficiency (SSL) (Arshad et al., 2011). Production shortfall is forecast to encourage Malaysia to step-up imports over the course of 2018.

As one of the significant factors, rice blast disease is seriously threatening high production of rice (Divya et al., 2014). It is a recognized dangerous disease for rice plant worldwide that is caused by the blast fungal, *Magnaporthe oryzae* (Kato, 2001; Ou, 1985). Blast disease can reduce rice yield at about 10 - 20% in susceptible varieties, but the loss can be more than 80% in serious conditions (Koutroubas et al., 2009). Nasruddin & Amin (2012) report the use of integrated management strategy which includes resistant cultivar, suitable date of planting, and fungicide to control blast disease. However, this disease happens due to the interaction of a favourable environment, a susceptible genotype and a virulent pathogen. Hence, the utilization of resistant cultivar is a favourable way to decrease the use of destructive pesticides (Bevitori & Ghini, 2014; Miah et al., 2013). Molecular markers have been intensively used to pyramid beneficial and multiple alleles to develop new rice blast resistant varieties (Miah et al., 2015;

Tanweer et al., 2015; Jayawardana et al., 2014). This approach is the most cost-effective and environmental safety in order to manage rice blast disease (Mackill & Bonman, 1992).

An evaluation on the performance of the improved genotypes is needed before the selection of ideal genotype. This is because the phenotypic performance and adaption to adverse environments are influenced by the genotype (G), environment (E), and genotype × environment (G×E) interaction (Falconer, 1975). Furthermore, variation in their performance is more significant due to higher proportion of this G×E interaction than genotypic main effects (Kang, 2004; Inthapanya et al., 2000; Wade et al., 1999). This G×E interaction is described as the differential response in respective genotypes performance in dissimilar or unpredictable environments (Cooper et al., 1996). Therefore, an evaluation of the newly developed genotypes in varies environmental conditions is required to maximize the influences of the environment, and precisely measure the response of these advanced lines tested in multiple environments. Genotype selection based on stability and adaptability in multiple environmental conditions is important before the recommendation for large cultivation (Oladosu et al., 2017; Xavier et al., 2017; Islam et al., 2016b; Tariku et al., 2013).

1.2 Problem Statements

Blast disease is becoming a devastating problem to rice production since it caused several yield losses on yearly basis. With an increasingly challenging in environment, it gave a tremendous worries since it greatly affect the production of food crops (Arunrat & Pumijumnong, 2015; Wheeler & Von Braun, 2013). In addition, these factors can change pathogen developmental rates and also modified the growth, metabolism and resistance of the host plants. Malaysia has taken serious actions on development of new improved variety that suits with Malaysia's climate to pave way for continuous increase in rice production. However, the newly develop improved genotypes with similar yield may have different degrees of stability due to G×E interaction. Therefore, before releasing or commercializing the new improved variety, selection of an ideal variety that is most stable or giving consistent performances across wide range of environments is required. Selection is possible due to the existence of strong genotypic differences between genotypes for this G×E interaction, thus creating chances to select variety which is more stable in adverse environments.

Multi-Environmental Trial (MET) is a vital strategy in evaluating the improved breeding lines to determine genotype with stable yield for a particular area basis or relatively across a wild areas. So, in this study, progenies (BC_2F_2 generation) from the crosses of MR219 and Pongsu Seribu 2 that was developed using marker-assisted backcross breeding from the previous study was presented for preliminary field trials.

1.3 Significance of Study

Development of improved rice varieties that suitable for climate change with high yield potential, and increased pests and disease resistant is needed to fulfill the increased rice demand. An assessment on these genotypes performance is required for superior genotypes selection. This MET is needed due to the inconsistency in phenotypic response and stability of genotypes at each environment caused by the effects of G×E interaction. So, this study will help to reveal the ideal genotype with high yield and stable over tested environments among the improved genotypes. A new blast-resistant rice variety can be established that suitable for Malaysian cultivation either for a broad or specific environment. Furthermore, this newly developed variety will help to increase the genetic diversity of rice varieties in Malaysia.

1.4 Objectives of Study

The objectives of this study are:

i) To assess the growth, yield performances and stability of the advance blast resistant rice genotypes evaluated under four different environments.
ii) To identify environment with high discriminative and representative ability among the test environments that suitable for cultivation of the advance blast resistant rice genotypes.
iii) To select superior genotypes with high mean yield and stable across environments among the advance blast resistant rice genotypes prior to commercial cultivation.

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