UNIVERSITI PUTRA MALAYSIA

GENETIC DIVERSITY OF EGGPLANT GERMPLASM BASED ON AGRO-MORPHOLOGICAL TRAITS UNDER OPEN FIELD AND GLASSHOUSE CONDITIONS

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By

NUR NADZIRAH BINTI MAT SULAIMAN

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

July 2020

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DEDICATION

This thesis is dedicated to my lovely parents Haji Mat Sulaiman and Hajah Zakinah and my beloved family members who always kept praying for me day and night for my success. Also, to all my lecturers, friends who supported me all these years and all the teachers of life.

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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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July 2020

Chairman : Mohd Rafii bin Yusop, PhD
Institute : Institute of Tropical Agriculture and Food Security

Eggplant or brinjal (*Solanum melongena* L.) is an economically important vegetable crop worldwide. However, cultivation of eggplant in Malaysia is hindered by narrow genetic-based of commercially cultivated varieties. There is a limitation in its genetic diversity study and improvement of local variety that caused the country to depend on importation of eggplant and its seed from neighbouring countries. The main objective of this study was to evaluate the genetic diversity among 29 eggplant accessions from Malaysia, Thailand and China based on agro-morphological traits under two cropping conditions (open field and glasshouse). The specific objectives were to estimate genetic variance and heritability values of the eggplant germplasm and to select the superior accessions for further breeding programmes. The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications in; open field and glasshouse conditions. Data were collected on vegetative, yield, and yield components, and were subjected to analysis of variance (ANOVA) using SAS version 9.4.

The analysis of variance showed highly significant difference ($P \leq 0.01$) among accessions for number of primary branches (NPB), plant height (PHE), stem diameter (SDM), days to first flowering (DFF), fruit girth (FGI), diameter of fruit (DFR), fruit length (FLE), fruit length to width ratio (FLW), total number of fruits (TNF), number of fruits per bunch (NFB), average fruit weight (AFW) and fruit yield per plant (FYP). Estimated heritability values ranged from 41.56% (FYP) to 93.08% (TNF) and 26.82% (AFW) to 92.55% (TNF) under open field and glasshouse conditions, respectively. Higher vegetative traits were observed for glasshouse condition while higher mean values for yield and yield components were observed in open field cultivation. These results revealed that open field

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condition is more suitable for higher yield as compared to glasshouse condition. Additionally, highly significant correlations (P≤0.01) were observed for all traits with the fruit yield per plant except for stem diameter (SDM), days to first flowering (DFF) and number of fruits per bunch (NFB). The evaluated accessions were grouped into six primary clusters based on the assessed traits using multivariate analysis *viz*. clustering analysis. However, some accessions from different sources were clustered together which implied that there were genetic similarities between Malaysia, Thailand and China accessions. Hence, for high vigour or heterosis, hybridisation could be made between group I with groups IV or V. Out of 29 evaluated accessions, 13MR, 10ML, 3TR, 23ML and 16ML were identified as the best five accessions for yield performance. These accessions are recommended for commercial cultivation under open field condition and have the potential to be utilized in future breeding programmes for new varietal development.

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

KEPELBAGAIAN GENETIK GERMPLASMA TERUNG BERDASARKAN CIRI AGROMORFOLOGI DI BAWAH SEKITARAN LADANG TERBUKA DAN RUMAH KACA

Oleh

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Terung (*Solanum melongena* L.) adalah tanaman sayuran ekonomi yang penting di seluruh dunia. Walau bagaimanapun, penanaman terung di Malaysia adalah terbatas oleh asas genetik yang sempit daripada varieti komersial yang digunakan. Terdapat keterbatasan dalam kajian kepelbagaian genetik dan pembangunan varieti tempatan yang menyebabkan negara kita bergantung kepada pengimportan terung dan benihnya dari negara jiran. Objektif utama kajian ini adalah untuk menilai kepelbagaian genetik dalam kalangan 29 aksesi terung dari Malaysia, Thailand dan China berdasarkan ciri agromorfologi di bawah dua sistem penanaman (ladang terbuka dan rumah kaca). Objektif khusus adalah untuk menganggarkan nilai varians genetik dan heritabiliti daripada germplasma terung tersebut, dan untuk memilih aksesi yang unggul untuk program pembiakbakaan selanjutnya. Eksperimen ini menggunakan reka bentuk blok lengkap terawak (RCBD) dengan tiga replikasi bagi setiap sekitaran, iaitu ladang terbuka dan rumah kaca. Data vegetatif, hasil, dan komponen hasil telah dikumpulkan dan analisa varians (ANOVA) menggunakan SAS versi 9.4.

Analisa varians menunjukkan perbezaan yang sangat ketara ($P \leq 0.01$) di antara aksesi untuk ciri bilangan dahan utama (NPB), ketinggian pokok (PHE), lilitan batang (SDM), bilangan hari berbunga pertama (DFF), lilitan buah (FGI), diameter buah (DFR), panjang buah (FLE), nisbah panjang ke lebar buah (FLW), jumlah bilangan buah (TNF), bilangan buah sejambak (NFB), purata berat buah (AFW) dan hasil buah sepokok (FYP). Anggaran nilai heritabiliti adalah dari 41.56% (AFW) hingga 93.08% (TNF) dan 26.82% (AFW) hingga 92.55% (TNF) masing-masing di bawah sekitaran ladang terbuka dan rumah kaca. Didapati bahawa ciri-ciri vegetatif adalah lebih tinggi untuk sekitaran

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rumah kaca, dan sebaliknya didapati bahawa nilai min yang lebih tinggi untuk ciri hasil dan komponen hasil bagi penanaman di ladang terbuka. Keputusan ini menunjukkan bahawa sistem penanaman ladang terbuka adalah lebih sesuai untuk penghasilan yang lebih tinggi berbanding dengan rumah kaca. Tambahan pula, korelasi yang sangat ketara ($P \leq 0.01$) telah dicerap untuk semua ciri dengan ciri hasil buah sepokok kecuali dengan ciri diameter batang, bilangan hari berbunga pertama dan bilangan buah sejambak. Aksesi dinilai tersebut telah dikelaskan kepada enam kluster utama berdasarkan ciri-ciri yang dinilai menggunakan analisa multivariat iaitu analisa kluster. Walau bagaimanapun, beberapa aksesi dari sumber yang berbeza berada dalam kluster yang sama, yang menunjukkan terdapat persamaan genetik antara aksesi Malaysia, Thailand dan China yang terlibat. Oleh itu, untuk kecergasan atau heterosis tinggi, penghibridan boleh dibuat antara kumpulan I dengan kumpulan IV atau V. Daripada 29 aksesi yang telah dinilai, 13MR, 10ML, 3TR, 23ML dan 16ML dikenal pasti sebagai lima aksesi terbaik untuk prestasi hasil. Aksesi terung tersebut adalah disyorkan untuk penanaman komersial di bawah sekitaran ladang terbuka dan juga mempunyai potensi untuk digunakan dalam program pembiakbakaan pada masa hadapan untuk penghasilan varieti baharu.

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

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LIST OF ABBREVIATIONS

%	Percentage
˚C	Degree Celsius
C	Condition
ANOVA	Analysis of Variance
cm	Centimetre
CV	Coefficient of Variation
EGGNET	European Eggplant Genetic Resources Network
GCV	Genotypic Coefficient of Variation
Gb	Gigabases
g	Gram
IBPGR	International Boards for Plant Genetic Resources
kg	Kilogram
l	Litre
LSD	Least Significant Difference
ml	Millilitre
MSE	Mean Square Error
NTSYS	Numerical Taxonomy Multivariate Analysis System
PCA	Principal Component Analysis
PCV	Phenotypic Coefficient of Variation
SEM	Standard Error of Mean
MS	Mean Square
UPGMA	Unweighted Pair Group Method using Arithmetic Average
SAS	Statistical Analysis System

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CHAPTER 1

INTRODUCTION

1.1 Background

Eggplant (*Solanum melongena* L.) belongs to the family of Solanaceae which comprises of other significant crops species such as chilli (*Capsicum annuum* L.), tomato (*Solanum lycopersicum* L.), tobacco (*Nicotiana tabacum* L.), and potato (*Solanum tuberosum* L.). It is one of the major vegetables in worldwide and among the most essential staple vegetables in ASEAN countries, especially in Malaysia.

Eggplant is highly diverse in terms of agro-morphological characterization with different colour (blackish, purple, yellow, and milky white) and fruit shapes (egg-shaped, long, and round). These distinct features are the major criteria for grouping eggplant into different varieties. For differentiation of varieties especially wild or hitherto accessions, there is a need for exploring all its agro-morphological characteristics and detail screening from various agro-climatic conditions in mitigating the food insecurity challenges (Harouna *et al*., 2020).

An agro-morphological characterization is the first step in exploring eggplant genetic diversity and there are wide variation in eggplant habitats, vegetative, yield and yield component traits (Ullah *et al*., 2014). The agro-morphological marker was found interesting and best applied by plant breeders due to easy scoring, inexpensive and rapid method. The investigation of these qualities required non-complex tools and equipments and it could be acquired without explicit biochemical or molecular methods (Riley *et al*., 1996). Morphological characterization could be aided with competent multivariate tools like principal component analysis (PCA) (Nwangburuka *et al*., 2011), clustering and discriminate analysis for assessing the genetic diversity of germplasm that has been introduced in heterogeneous crops (Oyelola, 2004). In addition, clustering analysis study by Ulaganathan and Nirmalakumari (2015) was utilized in grouping prior scattered materials, while Principal Component Analysis (PCA) can be utilized to resolve the link between the variables and genotype classification (Kaufman and Rousseeuw, 2009) together with pattern analysis in which a collective use of methods ordinating and classifying for investigating the structure of fundamental basis among germplasm (Oladosu *et al*., 2017). The evaluation of genetic diversity and adaptation to climatic conditions using agronomic traits has been the focus of research in the last few decades (Daunay *et al*., 2001a). Recently, research focus has shifted to taste, texture, and appearance alongside the nutrient compositions (Causse *et al*., 2010). Similarly, there is a significant improvement in eggplant breeding towards the

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improvement of fruit quality, fruit yield, disease resistance and adaptation with stable yield across growing areas.

Eggplant has been found suitable as a model crop that can be grown in heterogenous macro-environment (Kumar *et al*., 2016). Based on this evidence, knowledge of suitable cropping condition is a prerequisite for cost-effective eggplant production. In any geographical area, the prevalent cropping condition is the aggregate results of the previous decisions by individuals, communities or government and their agencies. Hence, crop adaptability to seasons, species, land use efficiency and plant growth resources such as irrigation, climate, tradition, and experiences are among determinant factors for efficient production. In the context of Malaysia, conventional open field and glasshouse cropping conditions are the two most widely used methods for eggplant cultivation.

1.2 Problem statement and justification of study

Despite strong evidence of eggplant as an important vegetable crop worldwide, there is limited research on the genetics and molecular studies on eggplant in Malaysia. A more tremendous gap when the overlapping eco-geographical distributions (Levin *et al*., 2005) and morphological plasticity (Okoli, 1998) of this large and complex genome are detected (Lester and Hasan, 1991; Daunay and Hazra, 2012). In Malaysia, lack of eggplant genetic diversity study, conservation, and preservation of high yielding varieties are among the contributing factors for insufficient local production. These have cost the country importation of eggplant and its seed from neighbouring countries. High production cost is another factor, for example in 2018, the cost of production of eggplant was 38,462 (MYR) with Benefit-Cost Ratio (BCR) of 1.2 which is considered very low as compared to other crops (DOA, 2018a). This low output could be attributed to the inefficiency of the cultivation practices or cropping conditions that build the pillars in agriculture production. Thus, there is a need for measures towards effective eggplant cropping practices that are currently practised in Malaysia namely; open field and glasshouse cropping conditions. None of the studies was focusing on eggplant genetic variation simultaneously comparing plant performance between these conditions to give insight in achieving an elevated level of production.

The research questions for this study is to find out the level of variation in genetic diversity among local-type and the commercial eggplant accessions. Apart from that, the relationship between the aspect of phenotypic characterization and conditions were also the main key research questions in this study.

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1.3 Objective of the study

The general objective of the study was to evaluate the genetic diversity among 29 eggplant accessions from Malaysia, Thailand and China based on agro-morphological traits under two cropping conditions (open field and glasshouse). However, the specific objectives of this study were:

I. To estimate genetic variance and heritability values of 29 eggplant germplasm.
II. To select the superior eggplant accessions for further breeding programmes in varietal development.

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