



**UNIVERSITI PUTRA MALAYSIA**

**GENETIC STUDIES ON PHYSIOLOGICAL TRAITS IN WHEAT  
(*Triticum Aestivum L.*) UNDER NORMAL AND WATER STRESS  
CONDITIONS**

**MOHAMMAD REZA NAROUI RAD**

**FP 2013 4**



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By

**MOHAMMAD REZA NAROUI RAD**

**Thesis submitted to the School Graduate Studies, Universiti Putra Malaysia, in  
Fulfilment of the Requirement for the Degree of Doctor of Philosophy**

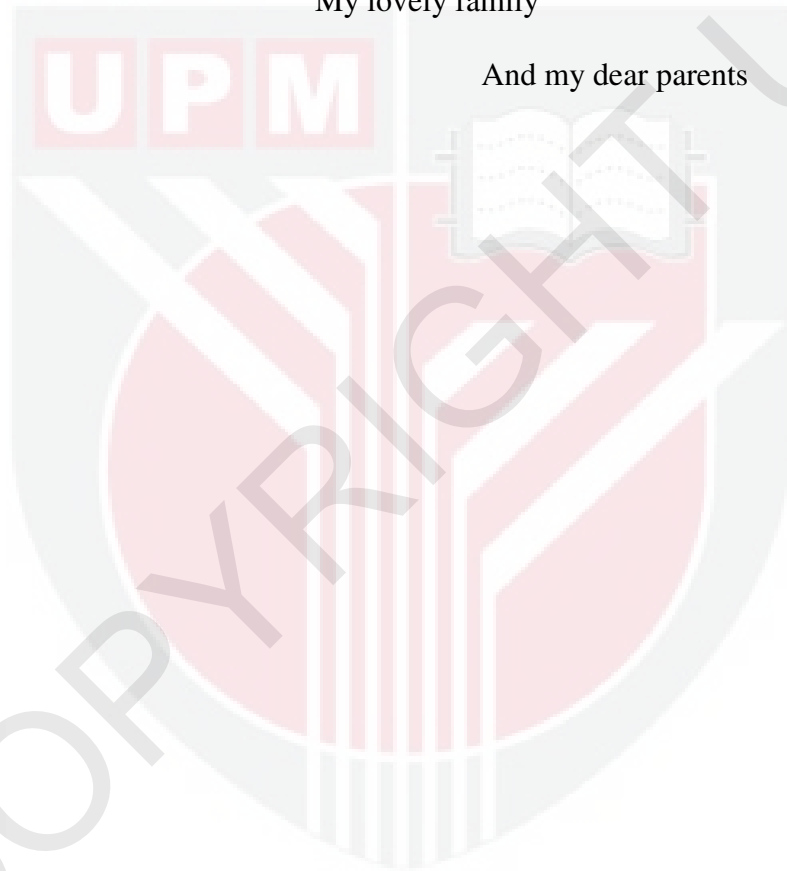
**Februray 2013**

## DEDICATIONS

To

My lovely family

And my dear parents



Abstract of thesis presented to the Senate of Universiti Putra Malaysia, in Fulfilment of the requirement for the degree of Doctor of Philosophy

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**MOHAMMAD REZA NAROUI RAD**

**February 2013**

**Chairman: Associate Professor Mihdzar Abdul Kadir, PhD**

**Faculty: Agriculture**

Drought is a worldwide problem constraining global crop production and recent global climate change has made this situation more serious for the purpose of crop production, yield improvement and yield stability under water stress conditions. The development of drought tolerant varieties is the best option to overcome this problem. Eight contrasting genotypes (four drought tolerant genotypes Irena/Babax//Pastor, S-78-11, Chamran and Veery/Nacozari and of drought susceptible and semi susceptible varieties). Tajan, Moghan<sup>3</sup>, Hamoon and Hirmand were crossed in half diallel matings at the Agriculture and Natural Resources Research Centre of Sistan, Iran. F<sub>1</sub> hybrids along with their parents were grown at the Experimental Farm of the Faculty of Agriculture, Universiti Putra, Malaysia under two conditions; irrigated and water deficit. Data were recorded for some physiological parameters and were analysed to understand the genetic mechanisms of these traits. Also, this study used molecular marker approaches in

order to analyse the molecular genetics of drought resistance in segregated populations to identify quantitative trait loci (QTL) conferring resistance against drought stress in the  $F_2$  population derived from a cross of cultivar S-78-11 (tolerant) line and cultivar Tajan (susceptible) by Bulk Segregant Analysis (BSA).

The results of the genetic analysis and graphical analysis revealed that the over dominant action of genes for height, chlorophyll *a*, *b*, (*a+b*), chlorophyll content, chlorophyll fluorescence, stomatal conductance, cell membrane stability, flag leaf area, proline content, relative water content (RWC) and plant grain yield remained unchanged under irrigated and rain-fed conditions. Sometimes the graphical analysis did not match the genetics components and this contradiction in the graphic representation and the components of variance appeared to be due to residual heterozygosity in the parents.

Recessive and dominant gene controlled for chlorophyll *a* and RWC under irrigated and stress conditions and for Veery/Nacozari gene control from the dominant gene for chlorophyll content in the first generation changed to recessive gene control under the rainsfed conditions. Under special conditions (irrigated or stress) some traits like chlorophyll *a* and RWC have tended to be controlled by both recessive and dominant genes. It was also found that gene activity for many characters remained unchanged in different environments. The mean squares due to GCA and SCA were highly significant for all the traits in the  $F_1$ ,  $F_2$  and  $F_3$  generations with an exception of SCA for the chlorophyll content in first generation and GCA for flag leaf area. The general reduction of heterosis in the  $F_2$  generation was due to a decrease in heterozygosity through allelic fixation. Generally, predicted or expected inbreeding depression was higher than that observed for all traits, except for

chlorophyll fluorescence. Cultivars S-78-11 and chamran was the best combiner for the reduction of stomatal conductance and grain yield under drought stress in three generations. In irrigated conditions, cross Veery/Nacozari×Hirmand had good performance of grain yield, but, in stress conditions, the crosses Irena×chamran and S-78-11×chamran had high values for the SCA.

A total of 41 SSR primer pairs were used to screen the parents; five polymorphic primer pairs were identified which showed polymorphisms between parents, and three of them strongly amplified polymorphic bands among the F<sub>2</sub> population. The continuous distribution of the RWC in the F<sub>2</sub> population ranged from 62% to 86%. In this study, frequency distributions were examined to detect the extent of phenotypic variations occurring with high and low RWC. The linkage relationship between the SSR markers Xgwm182, Xgwm292, and Xgwm410 and the RWC as an indicator of drought tolerant genes was estimated using an F<sub>2</sub> population derived from S78-11 × Tajan. The segregation ratio of the tolerant and the susceptible plants for tolerance to drought fitted the expected ratio of 1:2:1, indicating a co-dominant inheritance of this trait.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah.

**KAJIAN GENETIK TERHADAP SIFAT-SIFAT FISIOLOGI PADA  
GANDUM (*Triticum Aestivum.L*) BERKEADAAN NORMAL DAN DI  
PENGARUH TEGANGAN AIR**

**Oleh**

**MOHAMMAD REZA NAROUI RAD**

**Februari 2013**

**Pengerusi: Profesor Madya Dr Mihdzar Abdul Kadir, PhD**

**Fakulti: Pertanian**

Kemarau merupakan sesuatu masalah yang besar yang telah mengekang penghasilan tanaman secara global dan ketidakstabilan iklim kebelakangan ini telah menyebabkan situasi bertambah serius dalam penghasilan, peningkatan dan kestabilan hasil tanaman di pengaruh tegangan air, maka penghasilan varieti yang mempunyai toleransi terhadap kemarau adalah pilihan yang terbaik. Lapan genotip berbeza (empat bagi toleransi terhadap kemarau, Irena/Babax//Pastor, S-78-11, Chamran dan Veery/Nocorazi dan tidak tahan kepada kemarau dan separa tahan kemarau Tajan, Moghan3 Hamoon dan Hirmand telah dikacuk melalui pengacukan separa dialel di Pusat Penyelidikan Pertanian dan Sumber Alam Sistan-Iran. Hibrid  $F_1$  bersama-sama dengan tanaman induk telah ditanam di ladang eksperimen Universiti Putra Malaysia di dua keadaan iaitu keadaan pengairan dan keadaan kekurangan air. Data dicatat bagi beberapa parameter fisiologi dan telah dianalisis

untuk mengkaji mekanisme genetik bagi sifat-sifat tersebut. Di dalam penyelidikan ini juga, penanda molekul telah digunakan untuk menganalisis genetik molekul bagi sifat ketahanan kemarau dalam populasi segregasi untuk mengidentifikasi sifat loci kuantitatif yang memberikan ketahanan terhadap tegangan kemarau pada populasi  $F_2$  yang terhasil dari kacukan tanaman S-78-11 (toleran) dan kultivar Tajan (sensitif) melalui analisis segregasi besar.

Keputusan analisis genetik dan analisis grafik menunjukkan tindakan dominasi berlebihan bagi gen untuk sifat ketinggian, klorofil  $a$ ,  $b$ ,  $(a+b)$ , kandungan klorofil, kejelasan klorofil, konduktans stomata, kestabilan membran sel, keluasan permukaan daun, kandungan proline, kandungan air relatif dan hasil butiran tanaman tidak berubah dibawah pengaruh pengairan dan hujan. Kadangkala terdapat ketidaksepadanan antara analisis grafik dengan komponen genetik dan percanggahan di perwakilan secara grafik dan komponen varians ini terbukti disebabkan oleh sisa heterozigot pada tanaman induk. Gen resesif dan dominan terkawal bagi klorofil  $a$  dan kandungan air relatif di pengaruh pengairan dan ketegangan dan bagi gen terkawal Veery/Nacorazi dari dominan untuk kandungan klorofil bagi generasi pertama berubah kepada gen resesif terkawal di pengaruh hujan. Bagi keadaan tertentu (pengairan atau tegangan) beberapa sifat seperti klorofil  $a$  dan kandungan air relatif mempunyai kecenderungan untuk dikawal oleh kedua-dua gen resesif dan dominan. Tindakan gen bagi pelbagai sifat juga turut tidak berubah bagi pelbagai keadaan. Kultivar S-78-11 dan chamran merupakan penggabung terbaik bagi pengurangan konduktans stomata dan hasil butiran tanaman di pengaruh tekanan kemarau untuk tiga generasi. Di pengaruh pengairan, kacukan Veery/Nacorazi  $\times$  Hirmand mempunyai prestasi yang bagus untuk hasil bijiran tetapi di pengaruh tegangan, kacukan Irenaxchamran dan S-78-11  $\times$  chamran



mempunyai nilai SCA yang tinggi. Sebanyak 41 pasangan primer SSR telah digunakan untuk penyaringan induk; lima pasangan primer polimorfik telah dikenalpasti dalam polimorfisme antara induk, dan tiga telah mengamplifikasikan jalur polimorfik yang kuat antara populasi  $F_2$ .

Pengagihan secara berterusan oleh RWC didalam populasi  $F_2$  adalah diantara 62 hingga 86 %. Dalam kajian ini, frekuensi pengagihan telah dikaji untuk mengenalpasti setakat mana variasi fenotip berlaku melalui RWC yang tinggi dan rendah. Perkaitan hubungan antara penanda SSR (Xgwm182, Xgwm292, dan Xgwm410) dan RWC sebagai penunjuk untuk gen toleran kemarau telah dianggarkan menggunakan populasi  $F_2$  yang terhasil dari S78-11  $\times$  Tajan. Nisbah segregasi bagi tanaman yang toleran dan tanaman yang terdedah pada toleran kepada kemarau bersepadanan dengan nisbah 1:2:1, menunjukkan perwarisan tahap resistan adalah berdasarkan gen co-dominan tunggal.

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I certify that a Thesis Examination Committee has met on 28 february 2013 to conduct the final examination of Mohammad Reza Naroui Rad on his thesis entitled “Genetics Studies on Physiological Traits in Wheat(*Triticum Aestivum L.*) under Normal and Water Stress Conditions” in accordance with the universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A)106] 15 March 1998. The committee recommends that the student be awarded the relevant degree of Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

**Maheran Abdul Aziz, PhD**

Associate Professor  
Faculty of Agriculture Technology  
Universiti Putra Malaysia  
(chairman)

**Tan Soon Guan, PhD**

Professor  
Faculty of Biotechnology  
Universiti Putra Malaysia  
(Internal Examiner)

**Faridah Qamaruz Zaman, PhD**

Associate Professor  
Institute of Bioscience  
Universiti Putra Malaysia  
(Internal Examiner)

**Pushendra Kumar Gupta, PhD**

Professor  
Faculty of Agriculture  
University of Meerut  
(External Examiner)

---

**SEOE HENG FONG , PhD**

Professor and Deputy Dean  
School of graduate studies  
Universiti putra Malaysia

Date:

This thesis was submitted to the senate of Universiti Putra Malaysia and has been accepted as fulfilment the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

**Mihdzar Abdul Kadir , PhD**

Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Chairman)

**Mohd Rafii Yusop , PhD**

Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Hawa ZE Jaafar , PhD**

Associate Professor  
Faculty of Agriculture  
Universiti Putra Malaysia  
(Member)

**Mohammad Reza Naghavi , PhD**

Associate Professor  
Faculty of Agriculture  
University of Tehran  
(Member)

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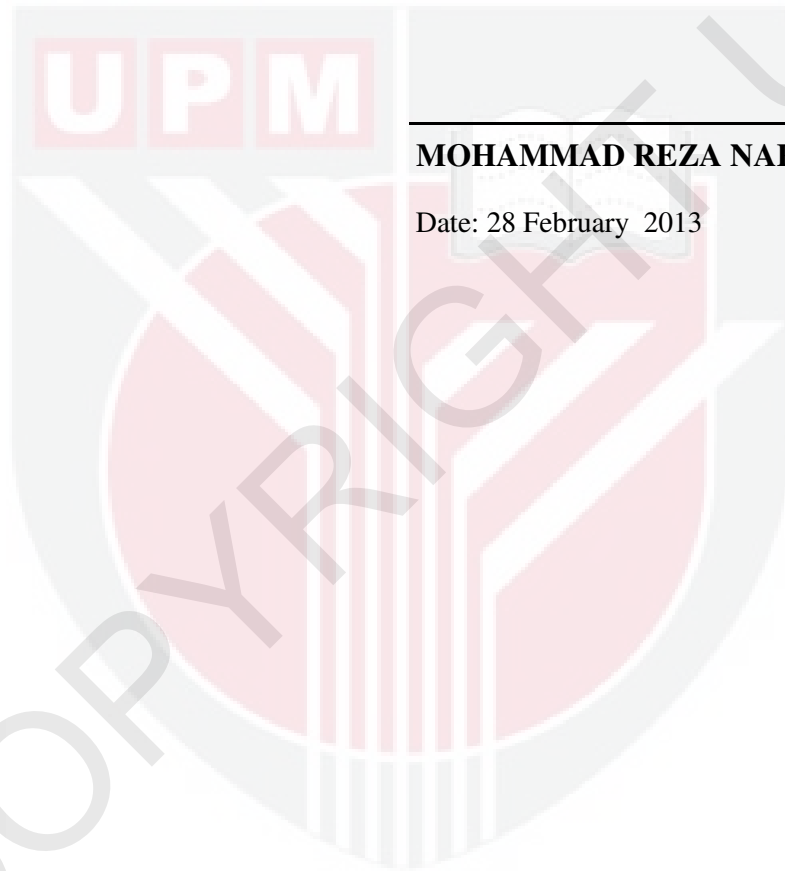
**BUJANG BIN KIM HUAT , PhD**

Professor and Dean  
School of graduate studies  
Universiti putra Malaysia

Date:

## DECLARATION

I declare that the thesis is my original work except for the quotations and citations which have been duly acknowledged. I also declare that it has been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



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**MOHAMMAD REZA NAROU RAD**

Date: 28 February 2013

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