



UNIVERSITI PUTRA MALAYSIA

**POLLEN QUALITY, SEED YIELD COMPONENTS AND SEED QUALITY
RESPONSE TO HIGH TEMPERATURE STRESS DURING REPRODUCTIVE
DEVELOPMENT IN SOYBEAN (*Glycine max* L. Merr.)**

MYINT THU ZAR

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By

MYINT THU ZAR

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

October 2011

DEDICATION

I dedicated this Thesis to our Golden Land Union of Myanmar, my Mother University, Yezin Agricultural University (YAU), my Lovely Mom and Beloved Aunt to whom this piece of my task as an expression of my respect and admiration.



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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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October 2011

Chairperson: Associate Professor Adam B. Puteh, PhD

Faculty : Agriculture

Plant reproduction is highly vulnerable to temperature changes especially during reproductive growth stage. Although there are much research about the effect of daytime temperature during reproductive stage on soybean pollen and seed yield in temperature-controlled chambers, the effect in the field has been little explored. Long-term manipulative field experiments on temperature effect on plants are important tools to provide accurate information for revealing the impacts of climate change on crop yields and seed quality.

A field study was conducted at Universiti Putra Malaysia (UPM), in 2008 and 2009, to determine the effects of temperature stress on pollen quality, seed yield components, and seed quality. Three soybean varieties; AGS 190, Dieng, and Willis, were exposed to three temperature levels (25, 30, 35°C) at R1-R2 or at R1-R5 reproductive growth stages. Temperature treatment imposed to the plants was done by placing transparent plastic cages above the canopy.

The pollen quality determined were pollen production, pollen viability, pollen germination, pollen tube length and pollen load. Scanning Electron Microscopy (SEM) was used to evaluate the pollen morphology. Seed yield components were determined on the main stem and branches at harvest maturity growth stages (R8). Seed viability and vigour were based on standard germination (SG), 3d germination, and electrical conductivity (EC) tests.

There was a strong linear trend of pollen production, viability, germination, tube length and pollen load decrease with increase in temperature. The SEM results showed that general morphology of pollen was affected when plants were subjected to higher temperature, which resulted in flattened and collapsed pollen grains. The apertures were missing in pollens from plants exposed to temperature $>30^{\circ}\text{C}$. The pollen morphological aberrations observed in this study may contribute to poor pollen germination and shorter tube length in sensitive varieties such as in Dieng variety.

The crop growth stage during R1-R5 was shown to be sensitive to temperature increase as compared with that of crop growth stage during R1-R2. The high temperature ($>30^{\circ}\text{C}$) during R1-R5 decreased the number of pod 35- 45% for all three varieties compared with the control. The decrease in the number of pods on the main stem was in the range of 39 - 43%, whereas the decrease of pods on the branches was 41- 46%.

Willis variety produced as many pods per plant and more seeds per plant than the AGS190 and Dieng varieties under stressful conditions. Although the AGS190

variety had less individual seeds per plant, the resulting yield was greater than Dieng and Willis varieties. These results suggest that the AGS190 variety may have a better ability to produce high seed yield under high temperature stress.

Seed viability based on standard germination test was always less sensitive to high temperature stress than vigor, which suggests that seed produced in high-temperature environments could have acceptable or high level of viability, but low vigor levels. Seed vigour based on electrical conductivity test, showed a greater decline from seed developed on the branches compared with the seeds from the main stem. The highest vigour declined was observed in AGS190. The data indicate that varieties with large seed size such as AGS190 are not suitable to be planted in high temperature field conditions.

The three soybean varieties showed different response to high temperature with respect to pollen quality and seed quality. In the variety AGS190, pollen quality was good at high temperature but seed quality was low. On the other hand, for Dieng variety pollen quality was low under high temperature but seed quality was higher than AGS190. Our finding indicates that pollen quality has a significant influence on seed yield, but has no influence on seed quality in soybean.

The results strongly suggest that pollen parameters would be good indicators in determining reproductive tolerance to high temperature and in relation to seed yield potential. However, the genetic base for these differences must be further examined.

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

**KESAN SUHU TINGGS TERHADAP KUALITI DEBUNGA, KOMPONEN
HASIL DAN KUALITI BIJI BENIH TERHADAP SUHU TINGGI SEMASA
PEMBANGUNAN REPRODUKTIF TANAMAN KACANG SOYA
(*Glycine max* L. Merr.)**

Oleh

MYINT THU ZAR

Oktober 2011

Pengerusi: Profesor Madya Adam B. Puteh, PhD

Fakulti: Pertanian

Pembiakan tumbuhan adalah sangat peka kepada perubahan suhu terutamanya semasa peringkat reproduktif tanaman. Walaupun banyak penyelidikan menggunakan bilik suhu terkawal telah dilakukan untuk menentukan kesan suhu siang hari pada peringkat reproduktif terhadap debunga kacang soya dan hasil benih tetapi kajian kesan suhu di lapangan jarang dilakukan. Eksperimen jangka panjang di lapangan yang mengkaji kesan memanipulasi suhu terhadap tumbuh-tumbuhan adalah kaedah penting untuk menghasilkan maklumat tepat untuk merungkai kesan perubahan iklim ke atas hasil tanaman dan kualiti benih.

Satu kajian di lapangan yang komprehensif telah dijalankan di Universiti Putra Malaysia (UPM), pada tahun 2008 dan 2009, untuk menentukan kesan interaktif tegasan suhu kepada kualiti debunga, komponen hasil benih, dan kualiti benih. Tiga jenis kacang soya; AGS190, Dieng, dan Willis, terdedah kepada tiga tahap suhu (25,

30, 35°C) pada peringkat pembiakan R1-R2 atau R1-R5. Rawatan suhu yang dikenakan kepada tumbuh-tumbuhan dengan meletakkan sangkar plastik telus di atas kanopi.

Ciri kualiti debunga yang diukur terdiri daripada hasil pengeluaran debunga, daya maju debunga, percambahan debunga, panjang tiub debunga dan beban debunga. Mikroskop Elektron Imbasan (SEM) digunakan untuk menilai morfologi debunga. Komponen hasil benih telah ditentukan pada batang utama dan pada cabang di peringkat pertumbuhan tanaman matang (R8). Daya maju benih dan tenaga telah ditentukan berasaskan piawai percambahan (SG), tetrazolium (TZ) percambahan 3d, dan ujian kekonduksian elektrik (EC).

Terdapat tren penurunan linear yang ketara antara penghasilan, keberhasilan dan percambahan debunga, panjang tiub dan beban debunga dengan peningkatan suhu. Kadar pembentukan biji benih yang rendah disebabkan oleh masalah melepaskan debunga atau kurang daya maju debunga atau debunga dengan tiub pendek. Keputusan SEM menunjukkan bahawa morfologi am debunga terjejas apabila tumbuhan telah dikenakan suhu yang lebih tinggi, yang menyebabkan bijirin debunga diratakan dan rebah. Bukaan debunga telah hilang pada debunga tumbuhan yang terdedah kepada suhu > 30°C. Kecacatan morfologi debunga yang diperhatikan dalam kajian ini boleh menyumbang kepada kadar percambahan debunga yang rendah dan tiub debunga yang pendek bagi varieti sensitif seperti Dieng.

Peringkat pertumbuhan R1-R5 telah menunjukkan kepekaan yang lebih tinggi terhadap kenaikan suhu berbanding dengan peringkat pertumbuhan R1-R2. Suhu

tinggi ($> 30^{\circ}\text{C}$) pada R1-R5 mengurangkan bilangan pod dengan kadar 35-45% untuk semua varieti berbanding kawalan. Pengurangan bilangan buah pada batang utama adalah dalam lingkungan 39-43%, manakala pengurangan bilangan buah pada cabang adalah 41-46%. Varieti Willis menghasilkan sama banyak buah sepokok dan lebih banyak biji benih daripada AGS190 dan Dieng dalam keadaan tegasan suhu. Walaupun varieti AGS190 mempunyai kurang bilangan biji benih bagi setiap pokok, hasil biji benihnya adalah lebih tinggi daripada jenis Dieng dan Willis. Keputusan ini menunjukkan bahawa AGS190 mungkin lebih berupaya untuk menghasilkan lebih biji benih dalam keadaan tegasan suhu tinggi.

Tenaga benih berasaskan ujian kekonduksian menunjukkan penurunan yang lebih ketara pada biji benih atas cabang berbanding dengan biji benih atas batang utama. Penurunan yang paling tinggi ialah pada variety AGS190. Ini menunjukkan varieti yang berbiji benih saiz besar seperti AGS190 tidak sesuai di tanam di lapangan bersuhu tinggi. Varieti soya menunjukkan tindak balas berbeza terhadap suhu tinggi dari segi kualiti debunga dan kualiti biji benih. Varieti AGS190 menunjukkan kualiti debunga yang tinggi tetapi kualiti biji benih yang rendah. Sebaliknya variety Dieng menunjukkan kualiti debunga yang rendah tetapi kualiti biji benih lebih baik daripada AGS190. Penemuan ini menunjukkan kualiti debunga mempengaruhi hasil biji benih tetapi tidak mempengaruhi kualiti biji benih kacang soya.

Keputusan kajian ini menunjukkan dengan jelas bahawa parameter debunga menjadi petunjuk yang baik dalam menentukan toleransi pembiakan terhadap suhu tinggi dari segi daya pengeluaran hasil biji benih. Walau bagaimanapun, asas genetik untuk menerangkan perbezaan ini perlu dikaji dengan lebih mendalam.

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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 degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Adam B Puteh, PhD

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Nur Ashikin Psyquay B. Abdullah, PhD

Senior Lecturer
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Mohd. Ridzwan A. Halim, PhD

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

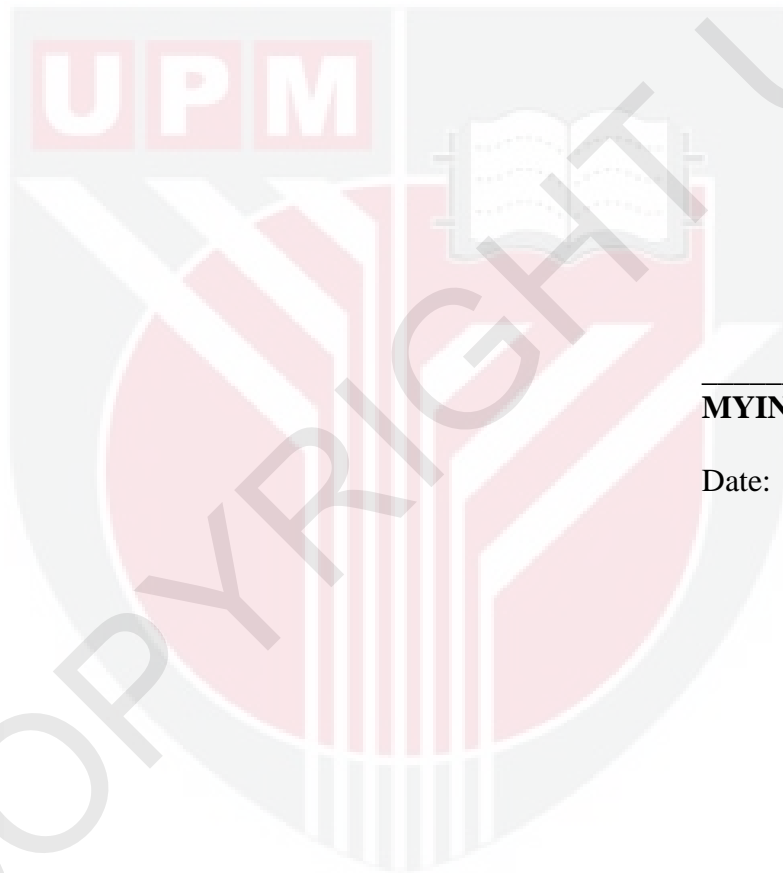
BUJANG BIN KIM HUAT, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

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



MYINT THU ZAR

Date: 21 October 2011



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