UNIVERSITI PUTRA MALAYSIA

IMPACT OF SEED MATURITY AND POST HARVEST TREATMENT ON SEED QUALITY, GERMINATION PERFORMANCE AND EARLY SEEDLING DEVELOPMENT OF THREE SOYBEAN (Glycine max L. Merr.) VARIETIES

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By

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Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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By

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August 2018

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Soybean is one of the major crops in United State of America, Brazil and China. Unfavorable tropical climate such as high temperature and high relative humidity give the big impact on its production. In addition, storage condition also influences its seed quality and germination performance. This study aimed to study the impact of current practice on the seed quality, germination performance and longevity of three varieties of soybean seed which are AGS190, Cikurai and Willis that harvested at different maturity stages, seed drying and storage conditions. Seeds were planted in Ladang 2, Faculty of Agriculture, Universiti Putra Malaysia. The experiment was designed with the combination of two factors (varieties and maturity stages) and arranged in a complete randomized design (CRD) with three replicates. Data were analyzed using SAS software window version 9.4. Two-way analysis of variance (ANOVA) at p=0.05 was used to determine the different between parameter studied and followed by Least Significant Difference (LSD) at p=0.05 for mean comparison. In experiment 1, seeds were harvested at three maturity stages (R6-full seed; R7- physiological maturity; and R8-full maturity). The internal seed properties (moisture content and electrical conductivity), germination performance and early seedling growth were measured. The lowest seed quality is found at R6 due to the highest moisture content and electrical conductivity (2x higher than R7 and R8), as a result, the germination performance and early seedling growth is significantly lower. R7 is the ideal harvesting stage for all soybean varieties due to the germination performance more than 90%. AGS190 showed the lowest on the parameter studied compared to Cikurai and Willis. In experiment 2, the effects of ultra-dry and different storage condition on the seed quality, longevity and early

seeding growth were compared. Seeds were divided into non-ultra-dry and ultra-dry seeds and stored separately in room temperature (25-30 ^{o}C with relative humidity 65-70%) and cold room storage condition (10 ^{o}C with relative humidity 80-85%) for 12 months. Type of seed drying and storage condition had the significant effect (ANOVA, $P<0.05$) on antioxidant enzymes activity (SOD and CAT), deterioration process, germination performance and early seedling growth of soybean seeds. The deterioration process is slow in ultra-dry seed storage (moisture content 4%) compared with non-ultra-dry seed storage (moisture content 12%). The results showed that cold room storage and ultra–dry method is recommended for maintain the seed longevity due to low MDA content and EC. The recommended duration for seed storage is less than 4 month for maintain the longevity of soybean seed. These contents increased after storage were correlated with the reduction in activities of SOD and CAT. Seed deterioration of large seed (AGS190) was higher compared with small seeds (Cikurai and Willis). In experiment 3, seeds were harvested at harvest maturity (H1) which is 95% of the pods have reached mature brown color and 2-week delay after harvest maturity (H2). Except EC, delay harvest (H2) caused negative effects on the internal seed properties which reduced germination percentage, viability and vigor of seed and increased *Phomopsis* infection (ANOVA, $P<0.05$). No significantly different on the seedling growth of three varieties that harvested at H1 and H2 except root length of AGS190 harvested at H1 is longer than H2. The effect of non-dry seed (before drying), silica gel drying and oven-drying (40 ^{o}C) on seeds harvested from harvest maturity and 2 week delay harvest also studied. Germination percentage and EC of three varieties harvested at H1 are not significantly between non- and dried seed. Meanwhile, germination percentage, viability and vigor of dried AGS190 seed harvested at H2 lower than non-dry seed (before drying). This result is contrary with Cikurai and Willis. The finding also found that early seedling growth of dried 2-delay harvest seed lower than non-dry seed. As conclusion, maturity stage, storage condition and type of seed drying are the main factor to be counted to achieve the high germination, longevity and seedling growth and yield of soybean in Malaysian weather.

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

IMPAK KEMATANGAN BIJIBENIH DAN RAWATAN PASCATUAI KE ATAS KUALITI BIJIBENIH, PRESTASI PERCAMBAHAN DAN PERTUMBUHAN AWAL ANAK BENIH TIGA VARIETI KACANG SOYA (*Glycine max* (L.) Merr.)

Oleh

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Ogos 2018

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Kacang soya adalah salah satu tanaman utama di Amerika, Brazil dan China. Iklim tropika seperti suhu dan kelembapan relatif tinggi memberikan impak besar kepada pengeluaran bijibenih kacang soya. Di samping itu, kaedah penyimpanan bijibenih juga mempengaruhi kualiti dan percambahan kacang soya. Kajian ini bertujuan mengkaji kesan amalan pertanian semasa terhadap kualiti bijibenih, percambahan dan pertumbuhan anak pokok tiga jenis varieti bijibenih kacang soya iaitu AGS190, Cikurai dan Willis yang dituai pada kematangan yang berbeza. Kacang soya ditanam di Ladang 2, Fakulti Pertanian, Universiti Putra Malaysia. Eksperimen direka dengan gabungan dua faktor (varieti dan peringkat kematangan) dan diatur secara rekabentuk rawak lengkap (CRD) dengan tiga replikasi. Data dianalisa menggunakan perisian SAS versi window 9.4. Two-way ANOVA diguna untuk menentukan perbezaan antara parameter dan diikuti dengan LSD bagi perbandingan antara purata pada p = 0.05. Di dalam percubaan 1, bijibenih kacang soya dituai pada tiga peringkat kematangan iaitu matang (R6-bijibenih penuh; R7 - kematangan fisiologi dan R8-kematangan sepenuhnya). Ciri-ciri biji benih (kandungan kelembapan dan kekonduksian elektrik), prestasi percambahan dan pertumbuhan awal anak benih diukur. Kajian mendapati kualiti bijibenih paling rendah pada R6 disebabkan kandungan kelembapan dan kekonduksian elektrik adalah tertinggi (2x lebih tinggi berbanding R7 dan R8) yang menyebabkan peratus percambahan dan pertumbuhan anak benih awal paling rendah berbanding R7 dan R8. R7 adalah peringkat penuaian yang ideal untuk ketiga-tiga varieti kerana peratus percambahan lebih dari 90%. Kajian ini juga menunjukkan AGS190 menunjukkan keputusan yang paling rendah pada parameter yang dikaji. Dalam eksperimen yang kedua, kesan

pengeringan dan kaedah penyimpanan bijibenih ke atas kualiti bijibenih, vigor dan pertumbuhan awal anak benih ke atas ketiga-tiga varieti kacang soya dilakukan. Bijibenih dikeringkan dengan pengeringan biasa dan ultra pengeringan dan disimpan di dalam suhu bilik (25 hingga 30°C dengan kelembapan relatif 65-70%) dan di dalam bilik sejuk (10°C dengan kelembapan relatif 80-85%) selama 12 bulan. Kesan yang signifikan (ANOVA, P <0.05) terhadap aktiviti enzim antioksidan (SOD dan CAT), proses "deterioration", prestasi percambahan dan pertumbuhan awal benih kacang soya. Proses "deterioration" adalah perlahan pada anak benih dalam ultra pengeringan (kandungan kelembapan 4%) berbanding penyimpanan benih biasa (kandungan kelembapan 12%). Penyimpanan bijibenih pada suhu bilik sejuk dan pengeringan secara ultra adalah disyorkan untuk mengekalkan kepanjangan umur bijibenih. Tempoh yang disyorkan untuk simpanan bijibenih adalah kurang dari 4 bulan kerana kadar proses "deterioration' sangat tinggi selepas 4 bulan. Bijibenih bersaiz besar (AGS190) lebih tinggi berbanding benih kecil (Cikurai dan Willis. Dalam eksperimen yang ketiga, bijibenih dituai pada dua peringkat iaitu pada fisiologi matang (H1) iaitu 95% daripada pod benih berwarna coklat dan 2 minggu selepas matang/pascatuai (H2). Kecuali EC, pascatuai (H2) menyebabkan peratus percambahan, vigor dan viabiliti bijibenih menurun dan jangkitan *Phomopsis* bertambah (ANOVA, P <0.05). Tiada perbezaan yang signifikan dalam pertumbuhan awal anak benih ketiga-tiga varieti kacang soya yang dituai pada kedua-dua peringkat H1 dan H2 kecuali panjang akar pada anak benih AGS190 yang dituai pada H1 lebih panjang daripada H2. Kesan pengeringan iaitu benih tanpa pengeringan, pengeringan silika gel dan pengeringan oven (40ºC). Peratusan percambahan dan EC oleh bijibenih yang dituai pada H1 adalah tidak signifikan. Sementara itu, peratusan percambahan, viabiliti and vigor bijibenih AGS190 yang dituai pada H2 yang dikeringkan mengggunakan gel silika dan pengeringan oven kering lebih rendah daripada benih tanpa pengeringan (sebelum pengeringan). Keputusan ini bertentangan dengan Cikurai dan Willis. Kajian juga mendapati bahawa pertumbuhan awal bijibenih pascatuai yang dikeringkan lebih rendah daripada benih tanpa pengeringan. Sebagai kesimpulan, peringkat penuaian, kaedah penyimpanan bijibenih dan jenis pengeringan bijibenih adalah faktor utama yang perlu diambilkira untuk mendapatkan percambahan, kepanjangan umur dan pertumbuhan anak benih dan hasil kacang soya yang maksimum yang ditanam di dalam cuaca Malaysia.

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I certify that a Thesis Examination Committee has met on 9 August 2018 to conduct the final examination of Ali Imad Mahmood on his thesis entitled "Impact of Seed Maturity and Post Harvest Treatment on Seed Quality, Germination Performance and Early Seedling Development of Three Soybean (*Glycine max* L. Merr.) Varieties" 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 Doctor of Philosophy.

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

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LIST OF ABBREVIATIONS

µM	Micromolar
µmol	Micromole
AOSA	Association of Official Seed Analysts
AVRDC	Asia Vegetable Research and Development Center
CAT	Catalase
CRD	Complete Randomized Design
CVG	Coefficient of Velocity of Germination
DAA	Days after Anthesis
EC	Electrical Conductivity
FAO	Food and Agriculture Organization
G	Gram
GI	Germination index
GP	Germination percentage
GRI	Germination rate index
H1	2-week delay
HM	Harvest maturity
ISTA	International Seed Testing Association
LSD	Least Significant Deference
M	Molarity
MC	Moisture content
MDA	Malondialdehyde
Mg	Milligram
MGT	Mean Germination Time
mM	Millimolar

Mmol	Millimole
Mol	Mole
Nmol	Nanomole
PM	Physiological Maturity
RH	Relative Humidity
ROS	Reactive Oxygen Species
Rpm	Revolution per minute
SDW	Seedling Dry Weight
SFW	Seedling Fresh Weight
SL	Seedling Length
SOD	Superoxide Dismutase
SVI	Seedling vigor index
TZ	Tetrazolium test
UPM	Universiti Putra Malaysia
UV	Ultra Violet
w/v	Weight per volume
w/w	Weight per weight

CHAPTER 1

INTRODUCTION

1.1 Background

Soybean (*Glycine max* (L.) Merr.) is one of the most important crops in the world. Soybean is widely produced in the tropical, sub-tropical as well as the temperate region. It is high in quality as a source of protein for human and animal diets which is the oil and protein content estimated to be about 20-22% and 40-45%, respectively. In addition, its seeds are rich in digestible nutrients and possess high Ca, Fe, P and vitamin content (Rahman et al., 2011; Akter et al., 2014). Due to high protein and oil content, soybean seeds are very susceptible to degradation before harvest and also during processing and storage.

A few factors effects on the soybean seed quality which are harvesting time, drying method, storage condition, and storage temperature. Moreover, the stage of maturity of soybean seed also essential in determining its quality, and its longevity in storage (Ghassemi-Golezani et al., 2011).

Isaac et al. (2016) postulated that harvesting time is a critical step in soybean seed production because seed deterioration begins in the field, during harvesting or after harvesting. Therefore, harvesting time is one of the important factor that should be counted in soybean seeds production. Drying is part of the seed life which allows the storage of the seeds and staying in a different environment. Many studies indicated that drying is crucial to maintain the quality of seeds and also to improve their storage capacity (Wang et al., 2003; Li et al., 2007).

Seed storage is an important process of plant production to avoid unfavorable environmental conditions and reduce the acceleration of the deteriorations, which is started after harvest. It is inevitable stage due to intervening period between harvesting and the natural onset of conditions in the next growing season.

1.2 Problem Statements and Justification of study

Soybean seed is structurally weak and easily subject to damage (Delouche et al., 1973). Its seeds have a short life and cannot be up for more than one growing season. Its quality declined faster than other agronomic seeds. In addition, exposure to environmental factors increase the deterioration process

in soybean seed eventually, reduce the ability of the seed to survive. Annual losses because of deterioration can be as much as 25% of the harvested crop.

Meanwhile, there are over 1000 varieties of soybeans that come in many sizes, shapes, and colors. Selecting the right soybean variety is crucial for high grain yield and is the foundation of an effective management plan. Soybean maturity, and disease tolerance are two of the most important traits to consider when selecting a variety. Although weather conditions cannot be predicted for the growing season, selecting the right variety can help minimize weather-related risks. The rapid increase of global atmospheric concentration of CO_2 and other greenhouse gases has induced the global warming. The growth, development, yield, and quality of soybean are subject to all these changes of climatic conditions. This scenario affected the soybean production. On other hand, the demand soybean seed in worldwide is high, therefore, preservation of its seed is important. This requires seeds retain good initial quality and high potential to be stored for long periods (Alice, 2014).

Due to that, it is important to obtain the ideal maturity stage that maintain its longevity, quality and reduce the deterioration process of soybean seed. To date, the ideal storage conditions for soybean seeds are still unknown. Due to these factors, this study focus on the importance of using ultra drying technique in soybean seeds storage that harvested at different stages of maturity, and dried at different moisture content.

1.3 Objectives of study

The main aim is to study seed quality and deterioration attributes of three soybean varieties which are as affected by different maturity stage, moisture content, seed drying and storage conditions. The specific objectives are:

1. To compare the quality of three varieties of soybean seeds that harvested at different maturity stages.
2. To study the longevity of three soybean varieties in relation to ultra-dried and different storage condition.
3. To determine the effect of delay harvest seeds and different drying conditions on seed quality of three soybean varieties.

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