UNIVERSITI PUTRA MALAYSIA

# *HUSK, BACTERIAL LEAF BLIGHT, AND WEEDY RICE CLASSIFICATION IN PADDY SEEDS USING IMAGING TECHNIQUES*

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# HUSK, BACTERIAL LEAF BLIGHT, AND WEEDY RICE CLASSIFICATION IN PADDY SEEDS USING IMAGING TECHNIQUES

By

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**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Sciences**

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**Chairman:** **Siti Khairunniza bt Bejo, PhD**
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Seed is the foundation in every agricultural product. Paddy normally contains impurities and contaminations such as weedy rice (WR), infected seed, husk, straw, and others after harvesting from field. To produce good quality certified paddy seeds, it must contain minimum impurity and free from WR, insects, disease, and other matters. In current practice, various types of machines were used to separate impurities. Furthermore, it requires seven to 30 days to detect Bacterial Leaf Blight Disease (BLB) symptoms. These methods were not practical and time consuming. Therefore, the aim of this study is to detect impurities using image processing techniques. Husk, BLB, and WR taken from Variant 1 (V1), Variant 2 (V2), and Variant 3 (V1) were studied. Thermal imaging technique was used to detect husk to differentiate between husk and paddy seeds by analysing the changes of heat reflectance between them due to the differences of internal properties. FLIR E60 thermal camera (FLIR System, West Mailing, Kent, United Kingdom) was used to capture thermal images. Heating treatment was applied for 180s, followed by a cooling treatment for 60s. The results show that average mean pixel values of paddy seeds were higher compared with husks due to higher thermal conductivity of paddy seeds and lower thermal conductivity of husks. Mean pixel values at 25s cooling gave a suitable indicator to separate between seeds and husks. The technique can be used to detect husk with 100% success rate for 20% husk and 40% husk, 98.33% for 60% husk and 97.67% for 100% husk, while 94.33% for 100% seeds. Meanwhile, visible imaging was used for BLB and WR classification because there were differences in colour properties, not in heat reflectance. A Samsung NX2000 digital camera (Samsung, South Korea) was used to capture images of paddy seeds, BLB-infected seeds, and WR seeds. Then, an image segmentation and noise removal were applied. In BLB detection, mean pixel values of 12 colour properties – (Red (R), Green (G), Blue (B), Hue (H), Saturation (S), Value (V), Green Leaf Index (GLI), Green-red Vegetation Index (GRVI), Kawashima Index ($I_{KAW}$), Principal Component Analysis Index ($I_{PCA}$), Red-green Ratio Index (RGRI) – were extracted and analysed using independent-sample t-test. Statistical results show a reliable difference between BLB-infected seeds and healthy paddy seeds for G, B, S, GRVI, and VARI. The technique can be used to detect BLB-infected seeds with 88.33%, 100.00%, 95.55%, and 96.33% success rate for 20% BLB, 40% BLB, 60%

BLB and 100% BLB, respectively. Mean pixel values of these 12 colour properties and two physical properties (area and major axis length) were used to detect WR. Statistical results show a reliable difference between WR and paddy seeds for area, major axis length, GLI, and RGRI. Classification model was developed based on the analysis of the data and results show the average successful detection of 99.25%. In conclusion, the image processing techniques can be used to detect the impurities of paddy seeds caused by husks (using thermal imaging), BLB (using visible imaging), and WR (using visible imaging and physical properties). The proposed image processing approach is more practical and less time consuming compared with the current practice of detection.

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

**MENGKLASIFIKASIKAN SEKAM PADI, PENYAKIT HAWAR DAUN DAN PADI ANGIN MENGGUNAKAN TEKNIK PENGIMEJAN**

Oleh

**NORAZLIDA JAMIL**

**Julai 2016**

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Benih adalah asas dalam setiap produk pertanian. Padi kebiasaannya mengandungi kotoran dan bendasing seperti padi angin, benih yang dijangkiti penyakit, sekam, jerami dan lain-lain selepas dituai. Dalam usaha untuk menghasilkan kualiti benih padi yang baik, benih padi mesti mengandungi jumlah bendasing yang minimum dan bebas daripada padi angin, serangga, penyakit dan perkara lain. Dalam amalan semasa, pelbagai jenis mesin digunakan mengasingkan bendasing. Tambahan pula, ia memerlukan 7-30 hari untuk mengesan gejala penyakit hawar daun. Kaedah-kaedah ini tidak praktikal dan memakan masa. Oleh itu, tujuan kajian ini adalah untuk mengesan bendasing menggunakan teknik pemprosesan imej. Sekam, benih berpenyakit hawar daun dan padi angin yang diambil dari Varian 1 (V1), Varian 2 (V2) dan Varian 3 (V1) telah dikaji. Teknik pengimejan haba telah digunakan untuk mengesan sekam disebabkan oleh perbezaan sifat dalaman antara sekam dan padi untuk membezakan perubahan pantulan haba di antara mereka. Kamera haba FLIR E60 (Sistem FLIR, West Mailing, Kent, United Kingdom) telah digunakan untuk menangkap imej haba. Rawatan pemanasan telah diberikan selama 180s, diikuti dengan rawatan penyejukan selama 60s. Keputusan menunjukkan bahawa purata nilai piksel min benih padi adalah lebih tinggi berbanding sekam kerana kekonduksian haba benih padi yang lebih tinggi dan kekonduksian haba sekam yang lebih rendah. Min nilai piksel pada 25s penyejukan memberikan petunjuk sesuai untuk memisahkan antara benih padi dan sekam. Teknik ini boleh digunakan untuk mengesan sekam dengan 100% kadar kejayaan 20% sekam dan 40% sekam, 98,33% untuk 60% sekam dan 97,67% untuk 100% sekam, manakala 94.33% untuk 100% benih. Sementara itu, pengimejan tampak telah digunakan untuk mengklasifikasikan benih berpenyakit hawar daun dan padi angin kerana terdapat perbezaan dalam sifat-sifat warna, tidak dalam pantulan haba. Sebuah kamera digital Samsung NX2000 (Samsung, Korea Selatan) telah digunakan untuk menangkap imej benih padi, benih berpenyaki hawar daun dan benih padi angin. Kemudian, satu segmentasi imej dan penyingkiran bunyi telah digunakan. Dalam pengesanan benih berpenyakit, nilai piksel dua belas sifat warna (Merah (R), Hijau (G), Biru (B), Hue (H), Ketepuan (S), Nilai (V), Indeks Hijau Daun (GLI), Indeks Vegetasi Hijau-merah (GRVI), Indeks Kawashima (Ikaw), Indeks Prinsip Komponen Analisis (IPCA), Indeks Nisbah Merah-hijau (RGRI) telah diambil dan dianalisis menggunakan bebas-sampel ujian-t. Keputusan statistik menunjukkan terdapat perbezaan antara benih padi dijangkiti penyakit hawar daun dan benih padi yang sihat bagi G, B, S, GRVI dan VARI. Teknik ini boleh digunakan untuk mengesan benih padi dijangkiti penyakit hawar daun dengan kadar kejayaan masing-masing 88.33%, 100.00%, 95.55% dan 96.33% bagi 20% BLB, 40% BLB, 60 % BLB dan 100% BLB. Min nilai piksel daripada 12 ciri-ciri warna dan dua ciri-ciri fizikal (luas dan panjang paksi utama) telah digunakan untuk mengesan padi angin. Keputusan statistik menunjukkan perbezaan dipercayai antara padi angin dan benih padi bagi luas, panjang paksi utama, GLI dan RGRI. Model klasifikasi telah dibangunkan berdasarkan analisis data dan keputusan menunjukkan purata pengesanan kejayaan adalah 99.25 %. Kesimpulannya, teknik pemprosesan imej boleh digunakan untuk mengesan bendasing benih padi yang disebabkan oleh sekam (menggunakan pengimejan haba), mengesan benih padi yang dijangkiti penyakit hawar daun (menggunakan pengimejan tampak) dan menegsan padi angin (menggunakan pengimejan tampak dan sifat-sifat fizikal). Pendekatan pemprosesan imej yang dicadangkan adalah lebih praktikal dan kurang memakan masa berbanding amalan pengesanan semasa.

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**APPROVAL SHEETS**

I certify that a Thesis Examination Committee has met on 27 July 2016 to conduct the final examination of Norazlida binti Jamil on her thesis entitled "Husk, Bacterial Leaf Blight, and Weedy Rice Classification in Paddy Seeds Using Imaging Techniques" 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 students be awarded the Master of Science.

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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 Master of Science. The members of the Supervisory Committee are as follows:

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## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| BLB | Bacterial Leaf Blight |
| WR | Weedy Rice |
| SOP | Standard of Procedure |
| PSA | Peptone Sucrose Agar |
| TH | Threshold |
| *Xoo* | *Xanthomonas Oryzae pv. oryzae* |
| V1 | Variant 1 |
| V2 | Variant 2 |
| V3 | Variant 3 |
| MARDI | Malaysia Agriculture Research and Development Institute |
| FOASTAT | Food and Agriculture Organization Corporate Statistical Database |
| FAO | Food and Agriculture Organization of the United Nations |
| IRRI | International Rice Research Institute |
| IBD | Inclined Bed Dryer |
| CL | Clearfield |
| FBS | Flatbed Scanning |
| VIS | Visible |
| UV | Ultraviolet |
| NIR | Near-infrared |
| µm | Micrometre |
| kernel/min | Kernel per minute |
| LDA | Linear Discriminant Analysis |
| QDA | Quadratic Discriminant Analysis |
| ANN | Artificial Neural Network |
| S | second |
| Min | minute |
| spp. | Species |
| °C | Degree Celcius |
| Nm | Nanometre |
| R | Mean Value of Red |
| G | Mean Value of Green |
| B | Mean Value of Blue |
| H | Mean Value of Hue |
| S | Mean Value of Saturation |
| V | Mean Value of Value |
| I | Mean Value of Intensity |
| RGB | Red Green Blue |
| HSV | Hue Saturation Value |
| CWAD | Canada Western Amber Drum |
| CWRS | Canada Western Red Spring |
| VF | Vegetation Fraction |
| VARI | Visible Atmospherically Resistant Index |
| $I_{KAW}$ | Kawashima Index |
| GLI | Green Leaf Index |
| RGRI | Red Green Ratio Index |
| GRVI | Green-Red Vegetation Index |
| $I_{PCA}$ | Principal Component Analysis index |
| $m^2$ | Square metre |

| | |
|---|---|
| PCA | Principal Component Analysis |
| N | Nitrogen |
| UAV | Unmanned Aerial Vehicle |
| DAP | Day of Planting |
| R | Regression |
| P | Probability |
| >= | greater than |
| < = | less than |
| VF | Vegetable Fraction |
| Volt | Voltage |
| Watt | Watt |
| ROI | Region of Interest |
| DOA | Department of Agriculture |
| PSA | Peptone Sucrose Agar |
| g | gram |
| ml | mililitre |
| PC | Personal Computer |
| i.e | example |

# CHAPTER 1

# INTRODUCTION

## 1.1 General Overview

Certified paddy seeds normally contain impurities and contaminations after being harvested from fields. Currently, the demand of good quality certified paddy seeds arise because of farmers' demand and expectation. High quality paddy seeds show characteristics such as containing minimum impurity, free from seed-borne diseases, free from weedy rice (WR), insect-free, and other matters as shown in Figure 1.1 (IRRI, 2015). Purity normally refers to the genetic purity or physical purity. Normally, physical purity for paddy seeds indicate that it is free from defective seeds and other impurities while genetic purity refers to the trueness to the type or the absence of seeds of other varieties of the same crop species.

(a) (b)

**Figure 1.1: Paddy seeds (a) Good quality paddy seeds (b) Poor quality paddy seeds**

This study focuses on husk and Bacterial Leaf Blight Disease (BLB) for physical purity. Distributing certified paddy seeds containing fungi and bacteria will cause severe yield and economic losses in paddy seed production. On the other hand, for genetic impurities, this study focuses on WR, which has become a major factor that reduces the production of certifed paddy seeds. Thus, cleaning is needed to remove impurities and contaminants. Conventional method of paddy cleaning used air blow where lighter materials such as straw, chaff, and husk are blown away by air. Later, machines that perform tasks such as cleaning, separating, and grading seeds based on paddy thickness, aerodynamic behaviour, length, and other characteristics were introduced.

## 1.2 Problem Statement and Motivation

In Malaysia, paddy seed distributors need to be certified under the Rice Seeds Certification Scheme supervised by the Department of Agriculture (DoA). This scheme has set the standard of good qualitypaddy seeds in the genetic aspect, the purity of nature, physical purity, germination, and percentage of moisture content level (Ahmad Termizi Ismail and Abd Razak Said, 2012). In this scheme, various types of machines were used to separate impurities. Fine cleaner and grain separator were used to remove physical purities such as husk, chaff, straw, and other light materials, while indented cylinder was used to remove broken or mechanically damaged paddy seeds and WR that have shorter length than paddy seeds.

The scheme is conducted to identify diseases, which is carried out by planting paddy seeds at nurseries to monitor the condition of the seeds. Any symptoms of diseases will be detected. Inspection is based on symptoms that appear on leaves and roots during vegetative of paddy crop. This process may take from seven days up to 30 days and agriculture experts are required to check on the symptoms and analyse the problems. In conclusion, the end-to-end process of Rice Seeds Certification Scheme requires various types of machine, is time consuming and subject to human error.

This motivated a need to develop a new approach by using only a single machine. ToThe imaging technique approach may be a potential solution since it provides consistent results, fast analysis, and is non-destructive (Brosnan and Sun, 2004). Application of imaging techniques has been proven to be an effective tool for analysis in various fields and applications such as automatic inspection of postharvest quality, sorting, grading, and others (Vibhute and Bodhe, 2012). Therefore, this study focuses on the possibility of using image processing technique to extract useful information that can be used to classify husk, BLB, and also WR. Thermal imaging technique was used for husk detection because there is a difference in properties between husks and paddy seeds when heating and cooling treatment applied. Besides, it is difficult to distinguish between husk and paddy seed by using colour imaging because both have same colour properties. Colour imaging techniques was used for BLB and WR classification because there are differences in physical and colour properties between paddy seeds, BLB-infected seeds, and WR.

## 1.3 Objectives

The aim of this study was to develop a new method to determine the classification of paddy seeds by using imaging techniques. The specific objectives were as follows:

i. To detect the impurities of paddy seeds caused by paddy husks using thermal imaging technique.
ii. To detect the occurrence of bacterial leaf blight diseases in paddy seeds using colour imaging technique.
iii. To detect WR seeds using colour imaging technique.

## 1.4 Scope and Limitation of The Study

This study focuses on paddy varieties MR219 and MR220 because these are the common varieties of paddy planted in Malaysia. Paddy husk was used as a sample of impurity since it has similarity in terms of shape and size with paddy seed compared with other types of impurities such as soil and straw, which are much easier to be identified. Moreover, this study also focused on one type of pathogen, which is *Xoo* that causes BLB disease and three variance of WR, which are V1, V2, and V3. The study was setup such as the seeds were experimentally arranged (in array) in the laboratory environment. It was based on normal practice being done for image analysis.

## 1.5 Thesis Outline

This thesis consists of five chapters. Chapter 1 presented the introduction, problem statements, and the objectives of this research and also scope and limitation. In Chapter 2, literature review about paddy in Malaysia, paddy seed classification i.e. husk, BLB, and WR are described. Moreover, literature review on imaging techniques for paddy seeds classification is also discussed. Chapter 3 describes the proposed method for paddy seed classification. The image pre-processing techniques used are also described in this chapter. Chapter 4 presents results of the experiments and the comparison of the overall performance of the proposed method. Finally, in Chapter 5, the conclusions are summarised and some suggestions on future works are also discussed.

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# LIST OF PUBLICATION

**Publications:**

Jamil, N. and Khairunniza-Bejo, S. (2014). Husk Detection Using Thermal Imaging Technology. Agriculture and Agricultural Science Procedia 2 (2014): 128 – 135.

Khairunniza-Bejo, S. and Jamil, N. (2013). Preliminary Study on Detection of Fungal Infection in Stored Paddy Using Thermal Image. International Proceedings of Chemical, Biological and Environmental Engineering, 60(2013):19-23. (Cited in Scopus.)

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