# PADDY SEED POSTHARVEST AND PROCESS ENGINEERING SYSTEM

Masniza Sairi*, Afiqah Aina Rahim, Asnawi Shahar, Mohamad Jani Saad, Saiful Azwan Azizan, Ishak Hashim, Wan Mohd Fariz Wan Azman, Badaruzzaman Mohamad Noh, Zainun Mohd Shafie, Hasmin Hakim Hasbullah, Sharifah Hafiza Mohd Ramli and Teoh Chin Chuang
*Engineering Research Centre*
*MARDI Headquarters, Persiaran MARDI-UPM*
*43400 Serdang, Selangor*
*Email: masniza@mardi.gov.my*; afiqah@mardi.gov.my; asnawi@mardi.gov.my; jani@mardi.gov.my; asazwan@mardi.gov.my; ishak@mardi.gov.my; wmfariz@mardi.gov.my; badar@mardi.gov.my; szainun@mardi.gov.my; hhhasbullah@mardi.gov.my; shhafiza@mardi.gov.my; cchin@mardi.gov.my*

Hairazi Rahim
*Socio Economy, Market Intelligence and Agribusiness Research Centre*
*MARDI Headquarters, Persiaran MARDI-UPM*
*43400 Serdang, Selangor*
*E-mail: hairazi@mardi.gov.my*

Azzami Adam Muhammad Mujab
*Technology and Business Commercialization Centre*
*MARDI Parit, Kg Padang Kangar*
*32800 Parit, Perak*
*E-mail: azzami@mardi.gov.my*

Mohd Hafiz Mohd Yusoff
*Director General Office*
*MARDI Parit, Kg Padang Kangar*
*32800 Parit, Perak*
*E-mail: mhmy@mardi.gov.my*

Nuraini Ahmad Ariff Shah
*Engineering Research Centre*
*MARDI Parit, Kg Padang Kangar*
*32800 Parit, Perak*
*E-mail: eniass@mardi.gov.my*

Amir Syariffuddeen Mhd Adnan
*Paddy and Rice Research Centre*
*MARDI Headquarters, Persiaran MARDI-UPM*
*43400 Serdang, Selangor*
*E-mail: asyariff@mardi.gov.my*

## ABSTRACT

*In this research, paddy seed postharvest and process engineering system was designed, developed and assessed its performance. The system comprises small-scale inclined bed dryer, optical color sorter, IoT-integrated cold storage room, and QR code-based paddy seed quality certification system. The system was implemented at National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak. The small-scale inclined bed dryer (maximum capacity of 6 tons/processing batch) is capable to dry paddy seed in 11.3 hours (approximate initial and final moisture content (m.c.) of 31.5 % and 12.2 %, respectively), and drying temperature of 42 □C to 45 □C. Installation of the optical color sorter in addition to the gravity separator and indented cylinder separator improved the capability to screen and isolate impurities (foreign matter, immature paddy, weedy paddy, and chalky paddy). On the other hand, the IoT-integrated cold storage room monitor temperature, T (15 □C to 20 □C), and relative humidity, RH (55 % to 60 %) inside the room. The application of cold room in storage of paddy seed demonstrated higher germination, and lower insect as compared to ambient room storage. The QR code-based paddy seed quality certification system contents are variety, batch number, packaging date, germination percentage, and purity percentage. The paddy seed postharvest and process engineering system implemented at MARDI Parit showed potential to increase foundation paddy seed productivity and quality.*

Keywords: inclined bed dryer, optical color sorter, cold storage room, quality certification.

## INTRODUCTION

Paddy or rough rice (*Oryza sativa L.*) seed is one of the important basic inputs in the rice cultivation industry, in addition to fertilizers, water, pesticide and others. In paddy seed postharvest handling and processing, the unit operations are pre-cleaning, drying, sorting, grading, packaging, storing and labeling. Efficient postharvest handling and processing is critical to obtain quality paddy (high germination rate, low pest and disease infestation etc.), hence increase paddy yield by as much as 20 – 30 % (Sinha *et al*., 2010). The postharvest handling and processing are important to ensure the paddy seed produced is in compliance with the

paddy seed quality control standard, MS 469:1993 by the Department of Agriculture, Malaysia (Department of Agriculture Malaysia, 2011).

In the tropical countries such as Malaysia, paddy seed at harvest generally has moisture contents (m.c.) between 20 – 28 % wet basis. Paddy seed should be dried the soonest after harvesting, preferably within 24 hours using proper drying method to reduce its m.c. to approximately 12 - 14 %. This is the safe m.c. to prevent paddy seed quantitative and qualitative losses during storage due to respiration, germination, growth of fungi (*Penicillium sp.* and *Aspergillus sp.*), and to prolong its shelf life (Sahari *et al*., 2018; Nguyen *et al*., 2019). Inclined bed dryer (IBD), fluidized bed dryer, and Louisiana State University (LSU) dryer are the most common paddy drying unit operations in the Asian countries (Sarker *et al*., 2013).

On the other hand, the sorting and grading processes are carried out implementing gravity separator, indented cylinder separator, and optical color sorter to obtain uniformity in the paddy seed morphological properties such as weight, size, and color, respectively. In addition, the sorting and grading processes screen and isolate impurities such as foreign matter, immature paddy, weedy paddy, and chalky paddy. Generally, storage conditions, packaging and treatment prior paddy seed storage are critical factors influencing paddy seed quality, and longer life-time (Gupta, 2010).

The distribution and sale of uncertified paddy seed in the market issues occured when irresponsible manufacturers use old paddy seed bags and/or quality certification labels to market uncertified paddy seed. Besides, paddy seed traceability information such as planting location, packaging date, seller profile, paddy seed variety, and fertilization are difficult to be accessed due to the limited information on current quality certification label.

In this research, it aims to design, develop and assessed the performance of paddy seed postharvest and process engineering system comprises small-scale inclined bed dryer, optical color sorter, IoT-integrated cold storage room, and QR code-based paddy seed quality certification system implemented at MARDI Parit, Perak.

## MATERIALS AND METHODS

The paddy seed postharvest and process engineering system integrates a small-scale inclined bed dryer, optical color sorter, IoT-integrated cold storage room, and QR code-based paddy seed quality certification system. The system was developed by Engineering Research Centre, MARDI, Selangor, and implemented at the National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak.

### *Small-scale inclined bed dryer*

The small-scale inclined bed dryer (IBD) consists of intake hopper, pre-cleaner, discharge car, drying chamber, diesel burner, blower and control panel with a maximum capacity of 6 tons paddy seed/processing batch (Figure 1). The drying study was conducted using MARDI Siraj (MR 297) paddy seed variety with initial wet weight of 5 tons. System performance evaluation was conducted based on drying rate and fuel consumption rate.

### *Optical color sorter*

The optical color sorter is Meyer Rice Color Sorter (Hefei Meyer Optoelectronic Technology Inc., China) with a capacity of 1 - 3 tons paddy seed/processing batch (Figure 2). The main components are intake hopper, inspection system, data processing system, ejection system, compressor, cyclone aspirator, bucket elevator and control panel. System performance evaluation was conducted based on paddy seed sorting efficiency in terms of impurities (foreign matter, immature paddy, weedy paddy, and chalky paddy). The evaluation was conducted by comparing three sets of paddy seed samples of MR 315 variety (T1: Raw; T2: No optical color sorter; T3: Optical color sorter). The paddy seed samples used in this study were from research plots that did not go through the roguing process in the field.

### *IoT-integrated cold storage room*

On the other hand, the IoT-integrated cold storage room monitor T and RH inside the room. The system comprises temperature and relative humidity sensor, gateway, server, software and dashboard (Figure 3). In addition, germination rate and insect count were also compared between paddy samples stored in cold room and ambient room up to 6 months of storage. The germination rate and insect count studies were conducted using MR 297, MR 315 and MRQ 76 paddy seed varieties. The insects studied were rust-red flour beetle (*Tribolium castaneum*, TC), Angoumois grain moth (*Sitatroga cerealella*, SC), rice weevil (*Sitophilos oryzae*, SO), and others.

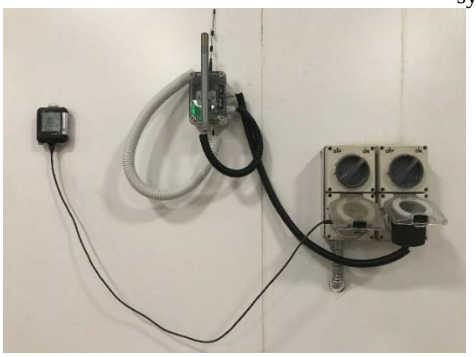
### *QR code-based paddy seed quality certification system*

The QR code-based paddy seed quality certification system developed comprises web-based application, computer, laser printer, water-proof certification paper. Figure 4 presents the certification label, and the process of sewing the certification label on the seed packaging bag. The time required for producing paddy seed quality certification label was compared between conventional label, QR code-based label (color), and QR code-based label (black and white) (n = 50).

Figure 1: Small-scale inclined bed dryer (IBD)

Figure 2: Optical color sorter

Figure 3: Cold storage room real-time data monitoring system (a) Temperature and relative humidity sensors (b) IoT system display



(a)


(b)

Figure 4: QR code-based paddy seed quality certification system (a) Process of sewing the certification label onto the seed packaging bag (b) White certification label for foundation paddy seed

(a)


(b)

## RESULTS AND DISCUSSION

### *Small-scale inclined bed dryer*

The small-scale inclined bed dryer development at the National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak aims to enable efficient drying process at a smaller paddy seed harvest capacity. The existing large-scale inclined bed dryer has a processing capacity of 10 tons/processing batch.

The system is capable to dry paddy seed in 11.3 hours with initial and final m.c. of 31.5 % and 12.2 %, respectively. The drying temperature was set at 42 °C to 45 °C and paddy seed thickness of 80 cm to 102 cm. The drying rate was recorded 1.9 % m.c./hour. On the other hand, the fuel consumption rate for the drying process was 12.5 L/hour. Previous studies on paddy drying using industrial-scale IBD with a capacity of 15 tons/processing batch reported average initial m.c., final m.c., drying time, and drying temperature of 23.6 %, 13.1 %, 15.7 hours, and 42 °C, respectively (Sahari *et al.*, 2015). Due to its miniaturized-scale, the system allows drying on a smaller volume of paddy seed which prevents the issue of heat loss and floating paddy seed on bed surface.

### *Optical color sorter*

The optical color sorter development in addition to the gravity separator and indented cylinder at the National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak improved the capability to screen and isolate impurities (foreign matter, immature paddy, weedy paddy, and chalky paddy). The results demonstrated significant reduction in immature paddy, weedy paddy and chalky paddy with the application of colour sorter. However, the reduction is insignificant for foreign matter. The optical color sorter is able to reduce the amounts of impurities in MR 315 paddy seed samples from 24.0 % to 1.2 % where it complies with the paddy seed quality control standard, MS 469:1993 by the Department of Agriculture, Malaysia (Department of Agriculture Malaysia, 2011). This standard sets the maximum limit of the impurities quantity in paddy seed samples must not exceed 2.0 % for foundation, registered and legal seeds production (Shahar, 2023).

### *IoT-integrated cold storage room*

The development of the IoT system aims for real-time monitoring of temperature, T (15 °C to 20 °C), and relative humidity, RH (55 % to 60 %) inside the cold storage room at the National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak. The application of the IoT system facilitate plant operators to monitor the cold storage room conditions in real-time. In the case of system non-compliance, plant operators will be notified via a message/SMS.

The application of cold room in the storage of paddy seed demonstrated higher germination rate as compared to ambient room storage. At Month 6 of storage, all the paddy varieties' germination rate was higher than ambient room storage samples (Figure 5). This is in agreement with previous study in which paddy seed maintain germination above the minimum standard (80 %) up to 60 months when stored under low T (15 °C) and low RH (30 %), as compared to 24 months under ambient storage (Gupta, 2010). In addition, germination rate showed a gradual reduction due to storage duration for both storage conditions (Figure 5).

In the present study, the application of cold room in the storage of paddy seed samples also exhibited lower pest as compared to ambient room storage (Figure 6). At Month 6 of storage, no insects were detected in the cold room samples. However, 683 insects (various species) were detected in the ambient room samples (various paddy varieties); alive and dead.

Figure 5: Comparison of germination rate between paddy seed samples stored in cold room and ambient room

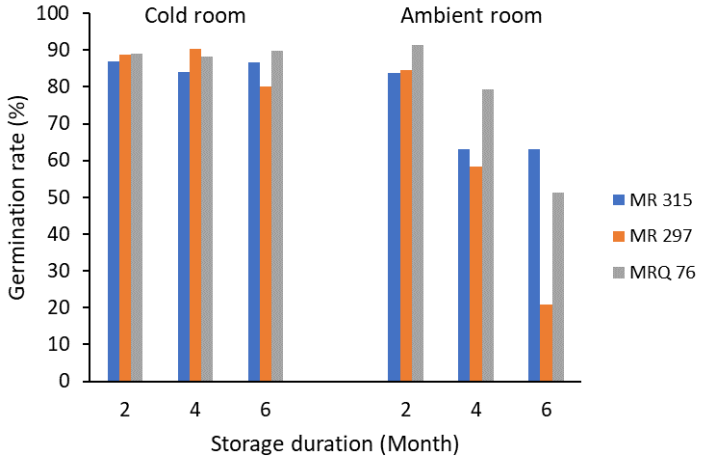
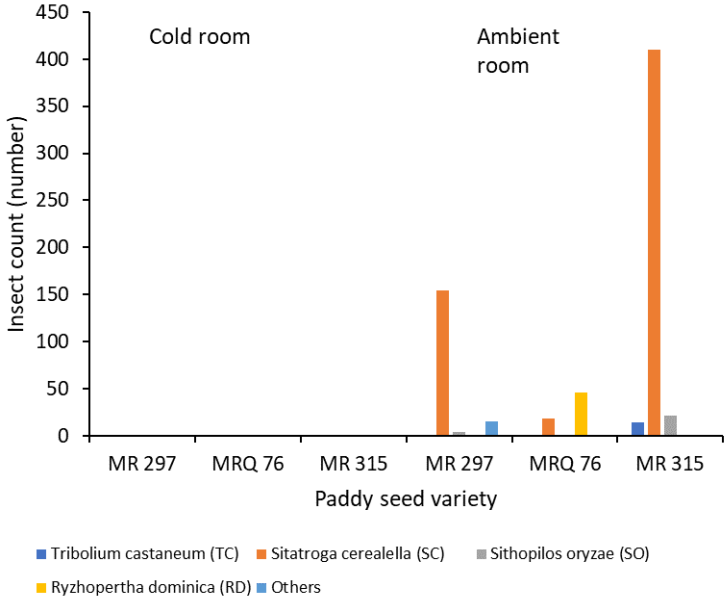



Figure 6: Comparison of the insect count between paddy seed samples stored in cold room and ambient room at Month 6 of storage



***QR code-based paddy seed quality certification system***

The development of the QR code-based paddy seed quality certification system at the National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak aims to improve the existing labeling system that was carried out conventionally. The application of the system started with inserting required information such as variety, batch number, packaging date, germination percentage, and purity percentage into the system. Then, the QR code-based label was printed, and stitched onto the 20 kg paddy seed packaging bag. Users can verify the quality certificate by scanning the QR code on the certification label hence prevent the risk of procuring uncertified paddy seed. The foundation paddy seed uses white label card.

The QR code-based certification labels (black and white, and color) have the same design. The QR code-based label (black and white) exhibited the shortest production time as compared to QR code-based label (colour) and conventional label (Table 1). The production time of QR code-based label (black and white) was reduced 4.5 times as compared to the conventional method in which operator needs to key in the information manually. The production time of QR code-based label (black and white) is reduced by 2.0 times compared to QR code-based label (color).

Table 1: Comparison of the time required for producing paddy seed quality certification label

| Method | Conventional label | QR code-based label (color) | QR code-based label (black and white) |
|---|---|---|---|
| Time (s) | 1,633 ± 45 | 819 ± 10 | 408 ± 7.2 |

## CONCLUSION

The research focuses on the development and performance evaluation of the paddy seed postharvest and process engineering system at the National Foundation Paddy Seed Processing Plant, MARDI Parit, Perak. The small-scale inclined bed dryer demonstrated good performance; dried paddy seed in 11.3 hours at temperature of 42 °C to 45 °C (final m.c. of approximately 12.2 %). The fabrication of an IoT-integrated paddy seed drying system is under way to replace the manual m.c. measurements. The introduction of optical colour sorter in paddy seed processing line improved the capability to screen and isolate impurities hence produced quality paddy seed. On the other hand, the IoT-integrated cold storage room allows real-time monitoring of T and RH. The application of cold room in storage of paddy seed demonstrated higher germination, and lower insect as compared to ambient room storage. The QR code-based paddy seed quality certification system allows in situ verification of the certificate. The QR code-based label exhibited shorter production time as compared to conventional label. The paddy seed postharvest and process engineering system implemented in MARDI Parit showed potential to increase foundation paddy seed productivity and quality.

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