THE EFFECT OF PACKAGING MATERIALS ON PADDY SEED QUALITY VARIETY TQR-2 UNDER DIFFERENT STORAGE CONDITIONS

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ABSTRACT

A study was conducted at the School of Sustainable Agriculture, Universiti Malaysia Sabah from September 2010 to February 2011 to investigate the effect of storage conditions and packaging materials on paddy seeds quality variety TQR-2. Paddy seeds variety TQR-2 collected were stored under 3 different conditions: ambient room condition (28-33 °C & RH 70-85%), air-conditioned room (25-27 °C & RH 68-81%) and freezer condition (5-15 °C & RH 12-40%). The seeds were packed in 4 different types of materials including Polypropylene bags, Jute bags, Flour bags and Polyethylene bags for a period of 5 months. The experiment was designed 3 X 4 Factorial in CRB (Complete Randomized Design) consisting of 2 factors: packaging materials and storage conditions. Germination test was carried out every two weeks interval. Seed quality parameters evaluated including seed germination percentage, percentage of normal seedlings, abnormal seedlings, dead seedlings, infested seedlings, seedlings with plumule, radicles, leaves and secondary roots, seedlings height and primary root length. Results were analyzed using two ways ANOVA repeated measures. At the end of 22 weeks, freezer condition (94.33%) and air-conditioned room (88.42%) maintained the highest percentage of germination rate compared to ambient room condition which varied from 97.25% to 40.67%. Both storage conditions also recorded with the highest percentage of normal seedlings, seedlings with plumules, radicles, leaves and secondary roots and the lowest percentage of dead seedlings and infested seedlings. In ambient room conditions, seeds packed in polyethylene bags (54.67%) showed higher germination rate if compared to the polypropylene bags (36.67%), jute bags (39.67%) and cloth bags (31.67%). Based on the findings of this study, paddy seed variety TQR-2 can be stored safely for more than 2 months in ambient room with lined polyethylene bags. The storability can be extended to more than 5 months in both freezer and air-conditioned room with any of the packaging materials used.

Pengaruh Bahan Bungkusan Terhadap Kualiti Biji Benih Padi Varietas TQR-2 di bawah Keadaan Simpanan yang Berbeza

ABSTRAK

Satu kajian telah dijalankan di Sekolah Pertanian Lestari, Universiti Malaysia Sabah dari September 2010 hingga Februari 2011 untuk menkaji pengaruh keadaan tempat simpanan dan jenis bahan bungkusan keatas kualiti biji benih padi varieti TQR-2. Biji benih padi varieti TQR-2 yang disimpan di bawah 3 keadaan yang berbeza: keadaan bilik persekitaran (ambient) (28-33 °C & RH 70-85%), keadaan bilik berhawa dingin (25-27 °C & RH 68-81%) dan peti sejuk (5-15 °C & RH 12-40%). Benih yang disimpan dalam 4 jenis kampit yang dibuat daripada Polipropilena, Jute, Kain dan Polietilena selama 5 bulan. Rekabentuk eksperimen adalah 3 X 4 Faktorial menggunakan susunan CRB (Complete Randomized Design) yang terdiri dari 2 faktor: bahan bungkusan dan keadaan simpanan. Uji percambahan dijalankan setiap dua minggu. Parameter yang dinilai termasuk peratusan percambahan biji benih padi, peratusan percambahan anak benih normal, anak benih tidak normal, anak benih mati, anak benih berpenyakit, anak benih dengan plumul, anak benih dengan radikal, anak benih dengan daun dan anak benih dengan akar sekunder, ketinggian anak benih dan panjang akar primer. Keputusan dianalisis dengan menggunakan ANAVA Dua Hala (repeated measures). Pada akhir minggu ke 22, peratus percambahan biji benih dalam peti sejuk (94.33%) dan bilik berhawa dingin (88.42%) mengekalkan peratusan percambahan yang tinggi berbanding dengan peratus biji benih yang disimpan dalam keadaan bilik persekitaran ambient yang berkurangan dari 97.25% kepada 40.67%. Kedua-dua keadaan penyimpanan mencatatkan peratusan yang tinggi dari segi pertumbuhan anak benih normal, anak benih dengan plumul, anak benih dengan radikle, anak benih dengan daun dan anak benih dengan akar sekunder tetapi peratusan benih mati dan benih berpenyakit adalah rendah. Peratus percambahan benih disimpan dalam keadaan bilik persekitaran ambient, biji benih yang dikampit dengan polietilena (54.67%) menunjukkan peratus percambahan yang tinggi jika dibandingkan dengan kampit polipropilena (36.67%), kampit jute (39.67%) dan kampit kain (31.67%). Berdasarkan penemuan kajian ini, biji benih padi varieti TQR-2 dapat disimpan dengan selamat melebihi 2 bulan dalam keadaan bilik persekitaran ambient yang dikampit dengan beg polietilena atau berlapisan polietilena. Tempoh simpanan sesuatu benih padi tersebut dapat diperpanjangkan lebih dari 5 bulan apabila disimpan dalam bilik simpanan yang suhu dan peratus kelembapan udaranya terkawal seperti peti sejuk (5-15 °C & RH 12-40%) dan bilik berhawa dingin (5-15 °C & RH 12-40%) dengan jenis bahan kampitan polipropilena dialas dengan polietilena.

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%	Percentage
ANOVA	Analysis of variance
cm	Centimeter
DAS	Days after sowing
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
IRRI	International Rice Research Institute
ISTA	International Seed Testing Association
MARDI	Malaysia Agriculture Research and Development Institute
MC	Moisture content
RH	Relative humidity
SIRIM	Standards and Industrial Research Institute of Malaysia
SPSS	Statistical Package for Social Science
SSA	School of Sustainable Agriculture
SST	School of Science and Technology
UMS	Universiti Malaysia Sabah

CHAPTER 1

INTRODUCTION

1.1 Introduction

Paddy (*Oryza sativa L.*) is the most important cereal crop cultivated in the world, which feeds more than half of the world's population (Alam *et al.*, 2009). In Malaysia, there is approximately 670,524 hectares (ha) of land cultivated with paddy producing 1,535,000 tonnes (t) of rice annually (Jamaludin, 2009). The present rice production is not enough for the increasing population of the country where there is only 73% of self sufficiency level. The average yield of paddy in our country is only 3.6 t ha^{-1}, which was low compared to Australia (9.53 t ha^{-1}), Spain (7.84 t ha^{-1}), Japan (6.67 t ha^{-1}), China (6.35 t ha^{-1}) and Philippines (3.20 t ha^{-1}) (FAO, 2001; Masiur Rahman, 2004). Thus, it is important to increase the paddy production in the country to feed the rising of human population in the future.

Good quality seed is vital to farmers since it is the main factor that will influence the germination, establishment of paddy seedlings and final yield of paddy. Thus, farmers are encouraged to plant certified seeds to ensure high purity, germination rate, viability and vigorousity which in turns producing high yielding paddy plants. It is fact that quality seed can increase yield by 15-20% (Fakir, 2004; Alam *et al.*, 2009). Experimental evidences reveal that seed quality can be improved to almost its genetic potential by manipulation of growing environment of the seed crop and by preserving suitable storage environmental up to the next planting season (Alam *et al.*, 2009).

However, some farmers prefer to retain the seeds produced from previous crop as the planting material for the next growing season. This is a way to reduce the planting cost due to the purchase of the expensive and uncertainly of getting good or certified seeds. Nevertheless, paddy seeds if not handled and stored under proper

condition and management will cause tremendous loss in seed quality. In most cases farmers' saved seeds are badly infested with stored grain pests and moulds with very poor germination (Masiur Rahman, 2004; Haque *et al.*, 2007). A good quality seed can be seriously deteriorated if stored under sub optimal condition, particularly high air temperature and relative humidity. Thus, farmers will use very high seed rate than the actual requirement to compensate the ungeminated seeds (Hossain *et al.*, 2002). This may cause wastage of seeds.

The problem in paddy seed storage is most farmers store the seeds traditionally at ambient room condition for both short term and long term storage period. The scenario is more prevalent in developing countries as the farmer lack of a seed storage centre to handle the seed in a proper technique and controlled environment conditions. Moreover, in a hot and humid climate as in the tropics, maintaining good quality of paddy seed during long term storage is not an easy task. If it is not properly managed, even for a short period of storage, it will give rise to undesirable moisture migration and accumulations of hot spots in specific areas within the paddy seeds followed by mould growth and insect infestation (Rukunudin, 2009).

Mettananda (2005b) indicates that storage condition and packing method are important factors in maintaining seed viability. Jute bags commonly used for paddy seed storage have been gradually replaced by polyethylene and polypropylene bags. Paddy seeds packed in polyethylene bags could maintain germination rate above 85% up to seven to eight months storage period (Mettananda, 2005b).Therefore it is important to investigate the effect of packaging material on seed quality during storage. There are considerable amount of work done on storage of rice seeds in relation to various storage conditions in different countries of the world (Masiur Rahman, 2004; Kawamura *et al.*, 2004; Mettananda, 2005; Hohenheim, 2005 and Alam *et al.*, 2009). However, research works done locally on the effect of storage conditions on the paddy seed quality are limited.

1.2 Justification

Most farmers in Sarawak are producing their own paddy seeds as planting material to reduce cost of production. However, most of the local variety planted such as Biris, Bario and Saratani are cultivated for only one season in a year as the maturation period of these variety are longer than 5 months. Hence, the harvested paddy seeds are stored for more than half years in the paddy granary or warehouse. The seeds are stored in

the traditional storage (paddy granary) at tropical condition for few months before sowing. According to Kawamura (2004), the germination rate of rice subjected to room temperature storage decreased to about 50%, indicating that the rice seeds had lost their viability during room temperature storage. The declining in seed quality will affect the paddy field performance, resulting in low germination rate, low growth rate, low pest and disease resistance, low competitive ability and most important of all decreased in yield. Therefore, this study is therefore undertaken to compare the performance of different storage conditions and packaging materials on paddy seed quality TQR-2 and to find out the most suitable storage combination. Any improvement in the system would not only improve storage capacity but also contribute to safe guarding national food security and safety. Successful seed storage is the key to farmers' seed security and enables communities to generate income through collecting, storing and selling of seeds.

1.3 Objectives

I. To determine the effect of different storage conditions on paddy seed quality variety TQR-2 evaluated by seed germination rate, normal seedlings, abnormal seedlings, infested seedlings, dead seeds, seedlings with plumule, seedlings with radicle, seedlings with leaves, seedlings with secondary roots, seedlings height and seedlings' primary root length.

II. To determine the effect of different packaging materials in packing and maintaining paddy seed quality variety TQR-2 evaluated by seed germination rate, normal seedlings, abnormal seedlings, infested seedlings, dead seeds, seedlings with plumule, seedlings with radicle, seedlings with leaves, seedlings with secondary roots, seedlings height and seedlings' primary root length.

1.4 Hypothesis

H0 : There are no significant effects between storage conditions and packaging materials on paddy seed quality variety TQR-2 .

Ha : There are significant effects of storage conditions and packaging materials on paddy seed quality variety TQR-2.

CHAPTER 2

LITERATURE REVIEW

2.1 Paddy (*Oryza sativa L.)*

Paddy has been and is still the number one staple food of the country since its formation in 1963. It is of great significance especially due to its role in being the food security of the country. It is from genus *Oryza* where there are seven to twenty species of grasses native to tropical and subtropical regions of Asia and Africa. The selected species suitable for consumption as rice are *Oryza glaberrima* and *Oryza sativa*. However, *Oryza sativa* provides twenty percent of global grain and is a food crop of major global importance. It contains two major subspecies which are the *japonica* or *sindica* variety and *indica* variety.

2.1.1 Paddy variety TQR-2

Paddy variety TQR-2 is a new variety being released by Agriculture Research Centre, Tuaran under Department of Agriculture after six year of research and studies. It is a promising variety due to the good eating quality and high yield potential of more than 7 t ha^{-1}. It is derived from hybridization between B6555B-199-40 with Baruman, carried out in Balai Penelitian Tanaman Padi (BPTP), Sukmandi, Indonesia. The detail characteristics of paddy variety TQR-2 can be found in Appendix A.

2.2 Seed certification process

Seed certification is a program that maintains and make available to the public high quality seed and propagating materials which posses three major concepts: superior purity, genetic purity and high seed quality standards. In the certified seed production system, it can be restricted into four generation as the following (Copeland and McDonald, 2001);

a) Breeder seeds

Breeder seed is produced under the direct supervision or authorization by the plant breeder and represents the true pedigree of the variety.

b) Foundation seeds

It is the first generation seed from breeder seed that produced under contract by a foundation seed organization as authorized by plant breeder. It is labeled with white tags.

c) Registered seeds

This class of seeds is for the purpose of increasing seed before the production of certified seeds. It is not intended to be commercial class of seed. It is designated with red seed tags.

d) Certified seeds

This is the final produce of seed certification program developed from foundation or registered seeds. It is labeled with blue tags and distributed to the farmers for sowing. This class of seeds is produced under supervision of Standard Department of Agriculture, Malaysia SJPM 1/2001 following the steps stated in Paddy Seed Certifying Scheme.

2.2.1 Seed Certification Stages

Growing and producing certified paddy seeds involve many processes and each stage in the production of certified seed is supervised by the inspector to make sure that contamination is minimal and that varietal purity is maintained (Oren and Bass, 1978). There are three major stages of certification where certain requirements have to be fulfilled from the aspects of breeders, farm and seeds. Moreover, agronomic principles should be considered as well prior to planting (Schwass and Allo, 1973).

The variety of paddy to be grown for seed production must have a suitable agro-climate adapted to the photoperiodic and temperature conditions prevailing in that location. The history of the field where the seed is sown should be checked. Many certification regulations include a requirement which forbids the production of certified seed from a field which has been previously planted in the same crop variety within a specific period of time. Moreover, the seed source should be proven of variety purity in

certain certification class. There are five desirable characteristics for land selected for paddy seed production such as the following (Schwass and Allo, 1973);

a) The plot should have light and well drained soil texture and fertility characteristics as required by the crops.
b) The plot should equip with good drainage and irrigation properties.
c) The plot should be free from volunteer plants and seeds of weeds and other crop plants
d) The soil of the selected plot should be comparatively free from soil borne disease and pests
e) The same crop or variety should not have been cultivated during the previous paddy season or else all the seeds should be destroyed to prevent Rice Tungro disease
f) Only the best seed growers with the right combination of experience, land, facilities and ability are accepted as seed growers

First certification stage is carried out one or two days before transplanting. Isolation distances may be required between crops of the same cross-pollinated species, regardless of whether the crop is pollinated by wind or insects. A distance of 2 meters (m) as barrier is required for two different types of variety planting closed together. All the plants that are grown out of the sowing line will be discarded.

Second certification is done before heading or flowering. Inspections of the growing crops in the field are carried out to make sure that the crop is true to variety and to determine the frequency of any off-type plants growing within it. Off-types must be rouged to meet the minimum standard, but if there are more than a permissible maximum number of undesirable plants, this particular plot will be rejected from certification. The farmers participated in the production of quality paddy seeds must strictly followed the standard requirement of SIRIM accordingly.

Last certification is carried out before harvesting. It is to ensure that rouging for off-types and inspection of pest, disease and weeds are done prior to harvesting. Paddy seeds suspected with seed borne disease exceeding the acceptable level will be rejected. Moreover, seeds with significant trait of lodging will not be accepted as well.

2.2.2 Seed Harvesting

All the equipments and machines used in harvesting should be cleaned thoroughly to prevent variety mixing. During harvesting, the official inspectors are responsible for ensuring that the total amount of seeds supposedly harvested from a particular field is, in fact, seed harvested from that crop. For this purpose, the inspectors will brand and seal all the bags as soon as they have been filled with seed at harvesting. The mature paddy seed crop is harvested at physiological maturity (PM) of 18% - 24% MC. The seed should be hard but should not exceed 25% MC as seed harvested with excessive MC will damage during harvesting and not able to maintain its quality during storage. On the other hand, excessively dry seed is more susceptible to mechanical injury during harvesting (Copeland and McDonald, 2001).

2.2.3 Seed Conditioning

All seeds must be cleaned thoroughly to remove other crop and weed seed, chaff, straw and other inert matter to meet the purity standards for certification. Each of the classes of seeds should fulfill the official standard for seed certification under Malaysia Seed Certification Agency as shown in Appendix B. The processes involved in seed conditioning are pre-cleaning, drying, tempering, indented cylinder grinding, fine grading, gravity separator grading, seed treatment and finally bagging or packaging of certified seeds. The function of each seed conditioning stages is as the following;

a) Pre-cleaning

Screen pre-cleaner is used to rough clean various kinds of trash such as chaff, stems and other lighter contamination.

b) Drying and tempering

Seeds pass through the drying silo in order to lower the MC to acceptable level of 12%. Tempering process is to prevent the seeds from heat injury after exposed to temperature as high as 40 ^{0}C.

c) Indented cylinder

This machine is specially designated to separate seeds differing in length.

d) Fine grading

This step separates seeds in term of width and thickness.

e) Gravity separator

This step separates seeds in term of weight or density. It is used to separate undesired contaminants which are similar in size, shape and seed coat characteristics.

f) Seed treatment

Paddy seed treatment with 0.2% Thiram applied via slurry method will prevent fungal infection during storage for 120 days.

2.2.4 Seed Storage

Sealing and tagging of seeds will be carried out prior to storing. The tag or label will carry information on the date of test, the crop species, the variety and certification class, plus a reference to the purity and germination certificate for the line of seed. The germination and purity requirement for registered seeds can be found in Appendix B. Seeds will be stored in cold room with controlled relative humidity and temperature to preserve the viability and vigorousity of seeds.

2.3 Paddy seed structure or morphology

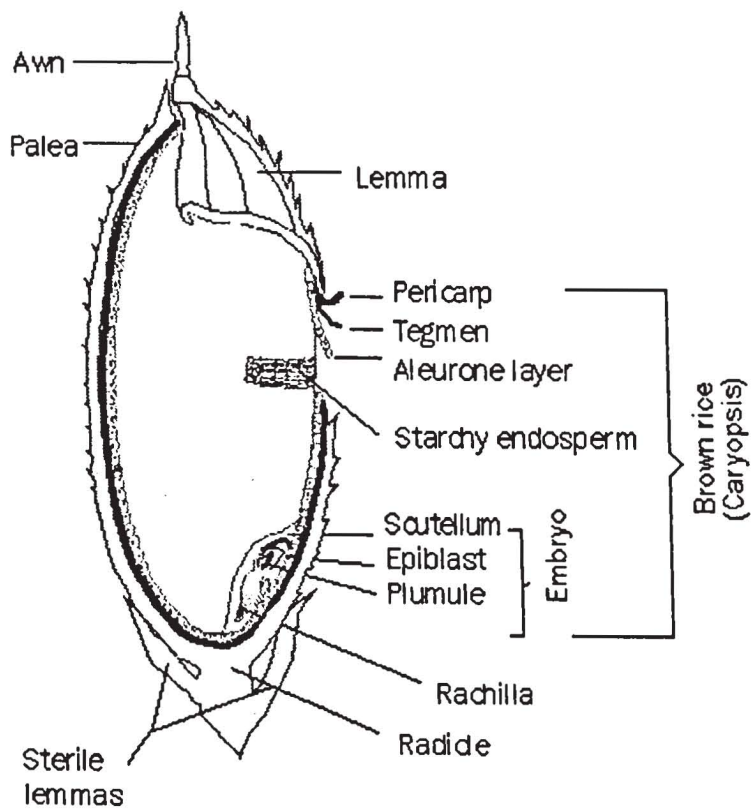


Figure 2.1 The structure of a paddy kernel
Source: Vergara, 1992

The paddy grain, commonly called as seed, consists of the true fruit or brown rice (caryopsis) and the hull. It consists mainly of the embryo and endosperm. The surface contains several thin layers of differentiated tissues that enclose the embryo and endosperm such as tegmen layer, aleurone layers and pericarp layers. The hull is composed of palea, lemmas and rachilla as shown in Figure 2.1.

The morphology of a paddy plant seedling has a root system, stem, leaf and reproductive system composed of panicle and spikelets. The paddy plant is an annual grass with round, hallow, jointed culms, rather flat leaves and a terminal panicle. It has fibrous roots system which consists of rootlets and root hairs.

2.4 Growth phase

Paddy variety TQR-2 is considered as the early maturity period cultivars of 120 days to 125 days. The growth phases can be divided into different stages which are the vegetative phase, reproductive phase and ripening phase. The vegetative phase begins with germination and ends at panicle initiation. On the other hand, the reproductive phase starts with panicle formation within the leaf sheath and undergoes anthesis. The ripening phase begins after anthesis and ends at grain maturation.

The duration of the vegetative phase of paddy variety TQR-2 is around 65 days. It begins with seed germination and proceeds with a repetitive production of shoot units until panicle initiation. Each shoot unit produces a leaf, tiller, and root primordial. Many environmental factors influence the rate of development such as temperature, day length, nutrition, planting density and humidity (Nemoto *et al.*, 1995).

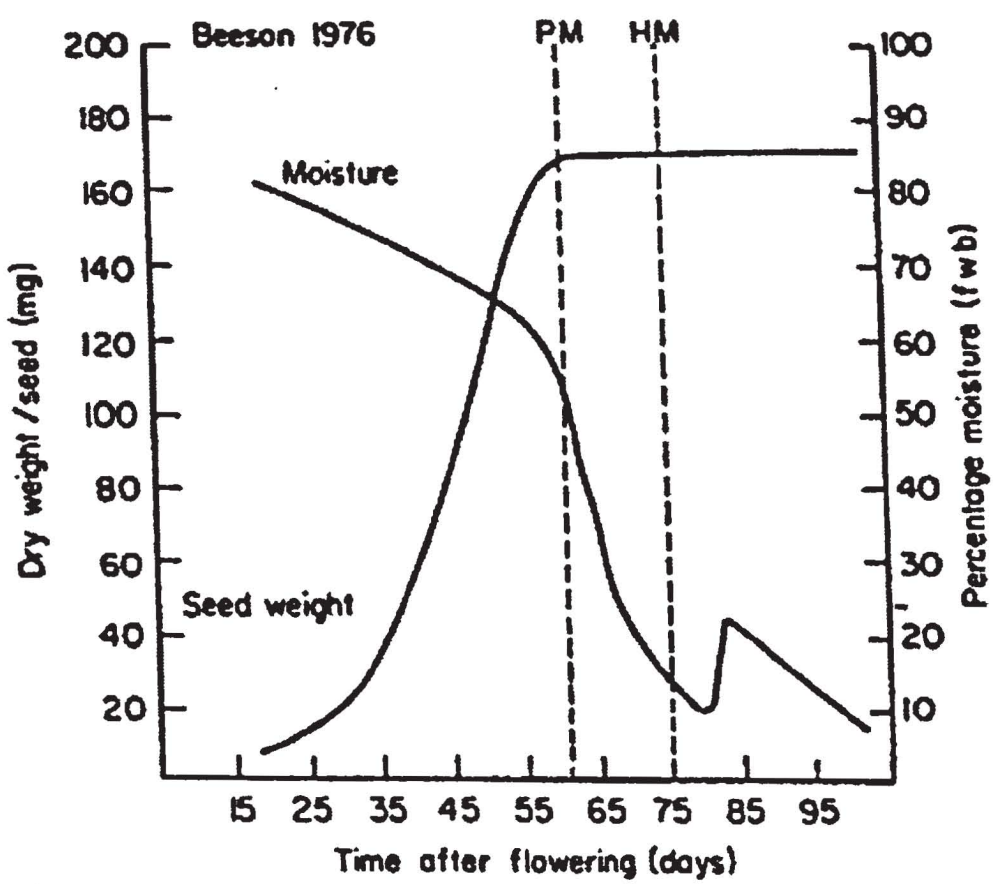
The reproductive phase is characterized by changes in vegetative growth characteristics and formation of the panicle. Internode elongation results in increased plant height, with a concomitant reduction in tillering and root growth. Leaf architecture during the reproductive phase is critical to optimizing yields and reducing lodging. Environmental conditions and crop management directly influence the number of spikelets formed and pollen fertility.

The last phase is the grain ripening stage which last for 30 days. It is divided into milk stage, soft dough stage, hard dough stage and mature grain. During ripening, grain growth is characterized by increase in size and weight of kernel due to translocation of starch and sugar from culms and leaves. Grain dry weight increases

despite fresh weight decreases due to water loss from 58% - 20% (Yoshida, 1981). Cool temperature can extend the ripening periods.

2.5 Physiological maturity

The development of seed from fertilization to accumulation of nutrients, to seed dry down and to dormancy represents a change in morphological and physiological ontogeny that can alter seed performance potential. PM is a point which the seed achieves its maximum dry weight. It has the greatest potential for maximum germination and vigor (Delouche, 1974; Basra, 2006). However, seeds at PM have high moisture levels which are unsafe for storage. Seeds are typically not harvested until it attains harvest maturity where the moisture content is low enough for safe storage. During the period of physiological maturity and harvesting maturity, the seeds may be exposed to severe environment conditions that adversely affect the quality (Copeland and McDonald, 2001).



PM = Physiological maturity
HM = Harvesting maturity

Figure 2.2 The changes of seed dry weight and moisture content during growth development and maturation

Source: Copeland and McDonald, 2001

2.6 Chemical constituents of paddy seeds

Seeds are composed largely of metabolically inactive food reserves that are stored for usage during germination process. It is mainly consists of carbohydrate, protein, lipid and other chemical compounds. Carbohydrates are the major storage substances in paddy seeds where fats and proteins contents are low. Moreover, carbohydrate can be stored in different forms such as starch, hemicelluloses, pectin and mucilage. Mucilage, pectin and cellulose located in the cell wall of various seeds increase imbibitions of water during seed germination. In contrast, starch molecules have little impact on seed imbibitions due to its uncharged structure with only attracts water at very acid pH or after high temperature treatment (Copeland and McDonald, 2001).

The major storage protein in rice which accounts for about 70-80% of total proteins is glutelins. The loss in seed viability and protein content are due to the fact that cellular membranes are composed primarily of proteins and lipids. During the seed deterioration process, disorganization of proteins and lipid phase transitions influence the membrane structure and integrity, consequently seed viability (Das *et al.*, 2010).

Other chemical compounds that can be found in paddy seeds are as the following;

a) Phytin

In rice seeds phytin accumulates in the aleurone and scutellum cells but not in the starchy endosperm cells (Tanaka *et al.*, 1973). During germination, phytin is digested and released phosphate, cations and inositol that are utilized by the seedlings (Yoshida *et al.*, 1999).

b) Tannins

Tannins also occur in seeds particularly in the seed coat structures. The presence of tannins and lipids in the seed coat contribute to hard seed coat dormancy which prevent water entry through the natural openings. The open, porous structure results in a more rapid hydration of the embryo that moves from the radicle to the coleptile end (McDonald *et al.*, 1994).

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