AN ASSESSMENT OF RICE SEED QUALITY AT VARIOUS PHYSIOLOGICAL HARVEST MATURITY STAGES

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Abstract

The utilization of good quality seeds enhances crop yield. Present study aims to determine the effect of different physiological harvest maturity stages on seed quality of Indica rice cv. MR220. Rice seed (cv. MR 220) sample was collected from a paddy field in Bukit Lintang, Melaka, Malaysia and was harvested at three different stages of physiological maturity at 104, 111, and 118 days after sowing (DAS). The parameters studied were the initial seed moisture content (MC), electrical seed conductivity (EC), 1000 seeds fresh weight (SFW) and, germination capacity (GC). The seeds' MC at 104 DAS was 17.1%, 111 DAS was 14.33% and 118 DAS was 13.34%. Thousand SFW obtained the highest yield (32.72g) for the earliest harvest maturity (104 DAS) followed by 111 DAS (29.02g), and 118 DAS (27.42g). Seed leachate for the harvested seed at 104 DAS significantly recorded the highest by 0.033 µs $cm^{-1}g^{-1}$, as compared to only 0.012 µs $cm^{-1}g^{-1}$ for 111 and 118 DAS. Germination capacity (%) for both 118 and 114 DAS incurred more than 85% and a lower percentage (77%) was recorded from 104 DAS. In conclusion, loss of seed quality depends on physiological maturity whereas the sooner the harvest date, the lower the seed quality obtained. Therefore, farmers need to avoid early harvesting. The physiological maturity between 111 to 118 DAS is suggested to be an ideal range for farmers to produce better quality rice seeds of cv. MR220.

Keywords: Physiological Maturity, Harvest, Seed Quality, Indica Rice cv. MR220

Introduction

Physiological Maturity (PM) is important as it reflects seed quality. Physiological maturity is defined by Shaw and Loomis (1950) as the stage in seed development where the seed reaches its maximum dry seed weight and yield. For a successful crop production, the stage of maturity at harvest is the primary factor in the seed production chain that influences seed quality (Siddique & Wight, 2003; Finch-Savage & Bassel, 2015).

A key farm input for paddy field cultivation is its seeds. In Peninsular Malaysia, the popular local varieties include MR220 CL2, MR219, and MR263. Farmer use around 140kg/Ha of those seeds which cost about RM270/Ha with yield production between 2,000 – 8,000 MT/Ha (Serena et al., 2019). However, rice yield production depends on several interrelated factors such as environmental factors, field management and maintenance as well as seed variety and quality. Harvesting paddy plant earlier may result in low quality such as decrease in longevity, low vigour, and poor establishment in field. A good quality seeds can increase yield production by 5-20% (IRRI, 2020). High quality seeds enable farmers to attain a higher percentage of seed germination, vigorous seedling establishment, faster growth rate and uniformity in ripening and maturity development.

The main criteria for describing seed quality includes their genetic, seed lot characteristics, and initial seed viability. For rice seeds, loss of seed viability and vigor depends on the harvest date as reported by Bakhtiar et al. (2013). A similar report was found by Abdul Rahman and Ellis (2019) who proved that harvesting process at different phases during seed development showed low in rice seed quality (cv. Aeron1 and Glevar). Agronomically, the duration of filling and ripening is from the date of heading to the time when the maximum grain weight is attained and grain weight when harvested too early (Krishnan et al., 2011). In addition, seeds are vulnerable to deteriorate rapidly in storage if harvesting process was conducted while seed moisture content is sstill high (early stage during physiological maturity). Generally, seed deteriorate in storage even under optimal storage condition. The development stage of seeds at harvest is vital for storage longevity (Ellis et al., 1993; Sanhewe & Ellis, 1996). However, longevity depends on plant species and external factors such as moisture content, temperature and the composition of atmosphere gaseous during storage (Chin & Robert, 1980).

In general, paddy in southern-west Malaysia (the state of Melaka) is cultivated twice a year, between May and July and end of December to March. During these growing seasons, it is free from climatic disaster such as flood and drought. Therefore, to produce a high quality of rice seeds, it is important to cultivate paddy in a suitable season.

Producing a high quality of rice is a priority for most farmers in order to get high profitability. Thus, avoiding crop losses from their farm is vital. Farmers usually harvest their paddy plant by observing ripened grain emergence and its colour characteristic. The ripened grain needs to emerge 80% from its panicle with yellowish-brown in colour. This practice is still accepted by local farmers in many places to determine the maturity level of the paddy plant in field. According to IRRI (2020), the ideal harvesting time placed between 130 and 136 days after sowing for late, 113 and 125 for medium, and 110 days for early-maturing varieties. Therefore, the correct timing offset estimated during physiological maturity will greatly improve crop grain quality.

Germination is one of the characteristics to determine seed physiological quality. As seed quality is poor, it might produce low seed germination percentage thus it is not preferred for farmers to use low-quality seeds for the next planting season. Poor seed quality will produce low seed vigour such as producing non-uniform seedling and reducing in yield production. In addition, to produce a maximum yield, minimum loses and high quality of harvest product, it is important to select a good seed quality as a planting material, combined with good management practice.

Materials and Methods

Seed sample of *Oryza sativa* cv. MR220 was harvested from a paddy field in Bukit Lintang, Melaka, Malaysia (2°11' latitude and 102°19' longitude) at different stages of physiological maturity on 10^{th}, 17^{th} and 24^{th} of April 2018 at 104, 112, and 118 DAS, respectively. Panicles were gently threshed by hand to obtain filled seeds, while and empty seeds were removed. About 0.5-1.0 kg of trashed seeds were brought out to Plant Science laboratory in Universiti Teknologi MARA (UiTM), Jasin Campus, for seed analysis.

1000 Seed Fresh Weight

Seed counter was used to calculate 1000 of seeds and weighted at each of the different seed samples using the analytical balance (Electronic Balance, Adam PW-214) at 3 decimal points.

Fresh Seed Moisture Content (at harvest)
A weighed sample of 0.5-1.0 g seeds with three replications was dried in the constant temperature oven at 130 for 1 hour. Moisture content on a wet-weight basis was determined as:-

$$MC\ (\%) = \frac{\text{(Original weight (wt.) of seed - dried wt. of seed)}}{\text{Original wt. of seed}} \times 100$$

Electrical Conductivity Test
Seed electrical conductivity was tested as recommended by the International Seed Testing Association (ISTA) procedure. Leachate was measured on 25 seeds collected from each of three (3) different physiological maturity stages with three replications. Seed was weighed using electronic balance soaked in 100ml deionized water (25℃). After 16 hours, seed was removed from water and leachate was recorded using EC meter (Model Milwaukee pH/EC/TDS Combo Meter), whereas beaker without seed represented as a control (without leachate). The electrode was cleaned before the measurement was taken and wiped before being reused for another replication. The formulation of EC is as shown below and expressed as $\mu s\ cm^{-1}\ g^{-1}$.

$$\text{Electrical Conductivity } (\mu s\ cm^{-1} g^{-1}) = \frac{\text{(Solution Conductivity-Controlled Conductivity)}}{\text{(Weight of replicate (g))}}$$

(ISTA, 1995)

Germination Capacity (%)
Before conducting the germination test, seed was maintained in a range of 10-14% moisture content. Only seed harvested at 104 DAS had to dry in room temperature and was managed by reweighing the samples regularly for one week until the estimated range level was obtained (ISTA, 2010). Meanwhile, the other seed sample (111 and 118 DAS) had reached the recommended seed moisture content while seed was harvested (10-14%).
Samples of seeds (three replicates of 50) were tested for ability to germinate. Seed was rolled in paper towel and kept in an incubator, set up at 34/11°C (16h/8h) for 21 days (Ellis et al., 1983). After 14 days incubated; seed sample was observed on its ability to germinate normally. Seed considered as germinated when radicle protrusion reached more than one-half of the seed's length. Numbers of normal seedlings were counted and calculated for their germination capacity (%). Those firm seeds (not germinated after 21 days) were pricked to promote germination and test was extended to 28 days if necessary.

Results and Discussion

Table 1 shows the results, the effects of harvesting process at three (3) different stages during physiological maturity on seed quality parameters; 1000 seed fresh weight (SFW), seed moisture content (MC) at harvest, electrical conductivity (EC) and germination capacity (GC).

Table 1 Parameters of seed quality of Indica rice cv. MR220 freshly harvested at different stages of physiological maturity, 104, 111 and 118 DAS from plant grown at a paddy field

DAS	1000 seed fresh weight (mg)	Seed moisture content (%)	Electrical conductivity (µs.cm-1g-1)	Germination capacity (%)
104	32.72b	17.1b	0.03b	77.0b

111	29.02a	14.3a	0.01a	85.5a
118	27.41a	13.3a	0.01a	86.5a
	*	*	**	*

*significant difference < 0.05; **significant difference at <0.01; DAS (day after sowing)

Moisture content is associated with all aspects of physiological seed quality. Present study showed that seed MC for earlier harvesting (104 DAS) has a significant difference within both harvest maturity stages (111 and 118 DAS). The highest seed MC was obtained at 104 DAS (17.10%) followed by 111 DAS (14.33%), and 118 DAS (13.34%). As expected, the earlier harvesting maturity stage (104 DAS) pertaining more water content in seed. This indicates that, late harvest for 14 days resulted 22% losses of seeds water content. Keeping moisture content at the correct range is very important, not only for seed viability but also storage purposes. Even though 13-17% seed MC is a recommended range during harvesting paddy in field, rice seeds are proven to increase their longevity when kept in storage in the range of 10-14% seed MC (Ellis, 1992). Seed desiccation tolerance is defined as the ability of seeds to survive drying to a low moisture content and germinate upon rehydration. IRRI (2020) mentioned that generally, paddy plant reaches its physiological harvest maturity when the seed moisture content is less than 30%. A study conducted by Ilieva et al. (2014) reported that, late harvest for about 3 weeks indicated seeds water loss to 28.5%. A similar study was conducted by Sürek and Beşer (1998) proved that seed moisture content would decrease if harvesting time was delayed. Ellis (1992) addressed that seed quality may decrease due to seed degradation process which is influenced by initial seed moisture content and temperature of storage room. Therefore, it is important for seed producers to keep their seeds stored in a suitable range of moisture content in order to prolong seed longevity prior to being released to farmers for planting.

In **Table 1**, different stages during harvesting maturity show a significant effect on EC value with p= 0.00, whereas the significance different recorded with 111 DAS and both late harvest maturity stages (114 and 118 DAS). Lowest EC (0.01µs $cm^{-1}g^{-1}$) was recorded from seed harvested at 111 and 118 DAS, while the highest was at 104 DAS with 0.03 µs $cm^{-1}g^{-1}$. For rice, the concentration of leachate is related to the total soluble sugar present in seeds. This present study indicates that seeds harvested during late stages of physiological maturity showed a good quality seed of production due to less leachate leakage. This was due to the strength of seed membrane integrity as it enables to hold leaching of sugar (in seed) from leakage. In addition, a higher of seed leachate concentration leads to rapid seed deterioration thus causes poor in seed quality (Teixeira et al., 2011).

Table 1 shows that the highest 1000 seed fresh weight (SFW) was obtained during 104 DAS with 32.72g, 111 DAS with 29.02g and 118 DAS with 27.41g. There was no significant difference occurred between 111 and 118 DAS. However, both physiological maturity stages have significant difference with 104 DAS with p= 0.04. Kim et al. (2016) reported that the changes of 1000 SFW showed a steady increase on three different varieties of rice after 20 days after heading (DAH) until 45 DAH ranged from 16g and 20g to 22g and 24g respectively. Baktiar et al. (2015) also reported that the amount of 1000 SFW increased with day after flowering (DAF) from 15 DAF to 35 DAF. However, according to Yoshida and Harai (1977), daily mean temperature influences 1000 seed grain weight, whereas the grain weight will be decreased as temperature increases. The higher result of 1000 SFW might be due to a high water content in seed and this was proven in the present study where the highest seed moisture content was recorded at 104 DAS (early stage during physiological maturity). The seed moisture content is relatively associated with seed fresh weight where more water content on seed was recorded.

Seed germination is defined as the ability of seeds to produce normal seedlings under optimum conditions. This study strongly suggests that seed viability (germination capacity) increased as leakage decreased. Highest germination percentage (GP) was obtained for seed harvested at 118 DAS (86.5%), followed by 111 DAS (85.5%) and 104 DAS (77%.) Similar reports by Siti and Ellis (2019) and Bakhtiar et al. (2013) highlighted that early harvest reduces ability for seeds to germinate normally and increases seed dormancy (Ellis et al., 1993). In contrast, Siti and Ellis (2019) found in their study that EC was not affected by environmental stress for Japonica rice cv. Gleva. However, this present study proved that EC showed a significant difference when harvested at different stages of physiological maturity. Feyem et al. (2016) found that there was a significant difference between harvesting time and germination. Six different harvesting date at 20, 25, 30, 35, 40, and 45 days after 50% heading have obtained different germination rate with 59.8%, 75.7%, 98.9%, 99.4%, 99.8% and 97% respectively. According to Paderes et al. (1996), a lower germination percentage was obtained when the rice seed was stored at high value of moisture content. Our present finding is proven to be similar with a study by Paderes et al. (1996) whereby an early harvesting (104 DAS) showed lower seed quality (germination capacity) with only 77% less; as compared to 11% from a late harvest maturity.

Conclusion

A low seed water content and nutrient leakage at harvest obtained the highest percentage of germination, whereas a high germination capacity of seed hysiological characteristic indicates a good quality of rice seeds. As a conclusion, present study suggests that both late harvesting during physiological maturity (114 and 118 DAS) provided a good seed quality of Indica rice cv. MR220. Identifying the suitable stages of physiological maturity for harvesting is a good management practice to be applied by farmers to maximize seed yield production and quality.

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Conflict of interests

The authors declare that there are no conflicts of interests concerning the publication of this paper.

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