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Evaluation on yield, yield component and physico-chemicals of advanced rice lines

(Penilaian hasil, komponen hasil dan fiziko-kimia ke atas titisan-titisan padi termaju)

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Abstract

Five new rice lines, namely, P589, P590, P591, P592 and P593 and three control varieties, MR253, MR263 and MR84 were evaluated in a preliminary yield trial for yield, yield components, physico-chemical properties as well as resistance to pests and diseases. Most of the new rice lines showed early maturation (102 – 120 days) and culm height ranged from 99.2 – 111.8 cm. Panicle length of advanced rice lines ranged from 24.3 – 26.6 cm. The percentage of filled spikelets/panicle of advanced rice lines ranged from 72.7 – 82.4%. Lines P590 and P593 significantly produced a heavier weight equivalent to a thousand grains as compared to all control varieties. Line P591 significantly produced a higher yield/ha as compared to all control varieties. The physical properties showed that all new rice lines produced >85% of head rice recovery and had long and slender grains. The chemical properties showed that P589 and P592 contained low amylose while P590, P591 and P593 contained intermediate amounts. They could be grouped into soft (P589), medium (P590, P591 and P592) and hard (P593) gel consistency. Alkali spreading values were low for P590, P591 and P593 and intermediate for P589 and P592. Evaluation for pests and diseases showed that lines P589, P590, P591 and P593 were resistant while P592 was moderately resistant to foliar blast disease. However, none of these rice lines showed resistance against sheath blight and bacterial leaf blight diseases. Screening for pests resistance showed that P589 and P592 were resistant to brown plant hopper while P590, P591 and P593 were moderately resistant to brown plant hopper. Meanwhile, P591 was resistant to Tungro disease while P589, P590, P592 and P593 were moderately resistant to the disease. Generally, P590, P591 and P593 have been found to be more promising lines due to their higher yield output with long and slender grain type and intermediate amylose content which met the Malaysian consumers’ preference.

Keywords: rice, yield, yield components, physico-chemical properties, pests and diseases

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Introduction

Over the past decades, MARDI has made a great contribution on the development of high-yielding rice varieties. The breeders have successfully developed and improved the rice morphology, shorten the maturation period and improved resistance to pests and dieases. This effort has contributed to the rice domestic scenario, especially in the farmers' cultural practice from manual transplanting to direct seeding, improved the rice plant morphology to semi-dwarf and photoperiod insensitive as well as cultivating rice for double cropping seasons (Othman et al. 1986). Since 1971, a total of 45 varieties have been released for farmers cultivation including three glutinous rice, one black glutinous (pulut hitam) and two imidazolinone resistant glutinous (MR220-CL1 and MR220-CL2), three fragrant rice (MRQ50, MRQ74 and MRQ76) and one coloured rice (YTM16). Some varieties have been more successful than others in terms of planted area such as MR84, MR219 and MR220. MR84 at one time was the most widely planted rice variety in irrigated areas under direct seeding conditions before it was devasted with bacterial leaf blight disease (Saad et al. 2012). Since 2001, MR219 and MR220 are MARDI's popular varieties which have been cultivated >90% in most granary areas over 20 seasons (Sariam et al. 2012). However, the demand and planted areas for MR219 and MR220 was slowly halted due to blast disease outbreak which caused high yield losses. Recently, three new rice varieties were released, namely, MR263, MR253 and MR269 as an alternative to MR219 for managing the blast disease outbreak. MR253 is moderately resistant to panicle blast disease and suitable to be planted in peat soil (Elixon et al. 2012). Meanwhile, MR263 is suitable to be planted in marginal soil especially in less fertile area (Sariam et al. 2012).

Generally, the rice breeding objectives are complimentary to the current rice industries needs. New varieties are introduced to suit the current agronomic practices, occurance of pest and diseases and farmers expectations for better rice yield. The demand for high quality rice has become important when consumers change their tastes and preferences as their purchasing ability and living standard increases (Othman et al. 1986).

Creating variability and rice progeny selection are two important processes in rice breeding. Emasculation technique is mostly used in MARDI's breeding programmes to create variability. Other methods including mutation, anther culture and hybrid rice technology have also been used. After variability is generated, the progeny will be selected through several generations starting from bulk to pedigree selection until the populations are uniform. The selected rice progenies will then be evaluated for yield potential in preliminarly, advanced and regional trials prior to release.

Yield potential is one of the important traits to be considered in MARDI rice breeding programmes towards increasing rice productivity. Yield is related to the function of total dry matter and harvest index. Yield is normally determined by several agronomic traits such as heading days, number of productive tillers, grain weight, total spikelets per panicle, grain filling and panicle length (Othman et al. 1986; Halil and Necmi 2003; Chandra et al. 2009). Modern high-yielding varieties normally produce about 18 – 19 tonnes/ha of biomass and harvest index is around 0.45 – 0.50 (Virk et al. 2004).

As far as the breeders are concerned, the physical and chemical properties towards developing new varieties should have medium or long and slender grains, high percent of head rice recovery, intermediate amylose, gelatinatisation temperature and soft gel consistency to constitute with MARDI's breeding programmes. These criteria are important as it affects the consumers acceptibility to rice products upon selling to the market. Grain appearance is determined by the grain shape (length, width and dimension ratio) and the endorsperm translucency affecting the milling and cooking properties (Gholam et al. 2004). The amylose content affects the tenderness and texture of the grains when cooked (Ong and Blanshard 1995; Champagne et al. 2004). Gel consistency is important as it determines the firmness of the cooked rice grains (Kohlwey 1994). Meanwhile, alkali spreading (indexed from gelatinisation temperature) is an indicator for cooking duration requirement of rice grains (Cuevas et al. 2010).

Besides yield and physico-chemical properties, varieties with better resistance against major pests and diseases is a priority. Varieties with durable and broad-spectrum resistance to major pests and diseases are important as an economical way to minimise yield losses. In Malaysia, blast disease in particular is one of the major diseases that could normally cause yield losses up to 50%. Introgression of blast resistant genes into elite varieties is therefore important towards resistance against this disease. Other important pests and diseases that cause high yield loses are bacterial leaf blight, sheath blight, brown planthopper and tungro.

Therefore, the objective of the study was to evaluate the yield potential, yield components, grain physical and chemical properties as well as the resistance to major pests and diseases (blast, brown plant hopper, sheath blight and bacterial leaf blight) of selected advanced rice lines in preliminarly yield trial stage (PYT). This evaluation is important towards selection of desirable rice lines for further evaluation in advanced yield trials (AYT) prior to selection in regional trials.

Materials and methods

Five new rice lines coded as P589, P590, P591, P592 and P593 including control varieties MR253, MR263 and MR84 were evaluated on yield and yield components in PYT stage. These advanced lines were evaluated for two seasons (off-season 2012 and main-season 2012/2013) in PYT plot at MARDI Seberang Perai, Penang, Malaysia. The 20 – 25 days old seedlings were transplanted as single seedling per hill with 25 x 25 cm of planting distance. The crops were fertilised with 100:75:103 kg/ha of N, P_2O_5, K_2O. Data was collected for yield (kg/ha), maturation (days), culm height (cm), number of panicles/plant, panicle length (cm), filled grains/panicle (%), total spikelets/panicle and 1,000 grains weight (g). Data on milling, physical and chemical properties were recorded for grain length (mm), grain width (mm), 500 grain weight (g), head rice (%), milling recovery (%), milled grain length (mm), milled grain width (mm), length to width ratio (mm), amylose content (%), gel consistency and alkali spreading. Pests and diseases screening were done based on IRRI standard evaluation system (1996) that was adopted in MARDI breeding and screening programme.

Grain length and width as well as milled rice length and width were measured by randomly picking 15 grains from each sample and measuring with a digital calipers. Length was classified as extra long = >7.5 mm, long = 6.6 – 7.5 mm, medium = 5.51 – 6.6 mm and short = <5.5 mm. Length and width ratio was calculated by milled grain length/milled grain width (L/W dimension) and classified as slender = >3.0, medium = 2.1 – 3.0, bold = 1.1 – 2.0 and round = 1.0 or less. The 1,000 grain weight was based on counting 1,000 milled grains and weighing using an analytical sensitive balance. The gelatinisation temperature was corresponding to alkali spreading (Little et al. 1958). A total of 10 intact milled grains of each sample was placed onto a petri dish which contained 15 ml of 1.7% KOH solution for 23 h at room temperature to allow spreading of the soaked grains. Alkali spreading scale was classified based on gelatinisation value (Jennings et al. 1979; Juliano and Pascual 1980; Waters et al. 2006). Alkali spreading categories were considered as low (scale 6 – 7 with temperatures ranging from 55 – 69 °C), intermediate (scale 4 – 5 with temperatures ranging from 70 – 74 °C) and high (scale 2 – 3 with temperatures ranging from 75 – 79 °C). Amylose contents were determined based on Juliano (1971). Amylose content was classified as high (>25%), intermediate (20 – 25%), low (10 – 19%), very low (3 – 9%), or waxy (0 – 2%) based on Kumar and Khush (1987). Gel consistency was measured according to length of cold gel in vial tubes horizontally placed for 60 min after wetting the powder with 0.2 ml of 95% ethanol containing 0.025% thymol blue and 2.0 ml of 0.2N KOH (Cagampang et al. 1973). Samples were grouped based on the length of the gel as hard (<40 mm), medium (41 – 60 mm) and soft (>61 mm) (Graham 2002).

The experiments were laid out using Randomised Complete Block Design (RCBD), replicated three times with 2 x 3 m plot size. A combined analysis of variance (ANOVA) was done according to Kempthorne (1979) and mean seperation was performed using Duncan Multiple Range Test (DMRT). Statistical analysis was done using the SAS programme version 9.1.

Results and dicussion

Mean square showed culm height, number of panicle produced per plant, panicle length, 1,000 grains weight and yield were highly significant at $p < 0.05$ (*Table 1*). There is no interaction observed between seasons and rice lines. This indicated that, there is no variability between seasons and rice varieties and all rice lines could be cultivated at any crop seasons. *Table 1* shows the maturation of rice lines ranging from 102 – 122 days. Line P593 significantly showed earlier maturation (102 days) compared to control MR84 (122 days) while other rice lines were not significantly different compared to MR84. Based on IRRI SES (1996) classification, rice maturation could be classified into very early (<105 days), early (105 – 120), medium (121 – 135 days), late (136 – 160 days) and very late (>160 days). Results from this study showed that P589, P590 and P592 were classified as early maturation whereas P591 showed medium maturation. Only line P593 was categorised as very early maturation. Varieties with medium maturation within 120 – 125 days could also cope to be planted for both main and off cropping seasons. In Malaysia, cultivation period of less than 160 days excluding fallow period provides longer intersession transition period and could help to keep the seasons in phase if there is prolonged drought or delay planting because of water shortage or labour problem (Othman et al. 1986). Short maturation traits could also be used by breeders as donors in breeding for earliness.

Culm height of advanced rice lines ranged from 99.2 – 111.8 cm. Line P589 significantly had the tallest culm height (111.8 cm) than the other rice lines as well as the control varieties MR253, MR263 and MR84 (97.1 cm, 105.0 cm and 105.5 cm respectively). P591 had shorter culm height (99.2 cm) compared to MR84 (105.5 cm) and MR263 (105.0 cm). Plant height is one of the important traits that contribute to resistance against lodging. According to IRRI SES (1996), plant height is classified into semi-dwarf (<110 cm), intermediate (110 – 130 cm) and tall (>130 cm). Based on total length of culm height and panicle length, P589 was classified as tall (plant height >130 cm) while P590, P591, P592 and P593 were intermediate in plant height (110 – 130 cm). None of these rice lines could be classified as dwarfs. Rice lines with shorter culm height have a potential to avoid lodging problem. In rice production, lodging will reduce yield because it can disturb ripening process, decrease crop yield, have poor grain quality and insufficient for mechanisation operation during harvesting.

Results in *Table 1* showed that P589 produced significantly higher number of panicles/plant (19) as compared to control MR263 (17). P590 and P593 produced significantly lesser number of panicles/ plant (16) compared to controls MR84 and MR253 (20 and 18 respectively).

Panicle length of advanced rice lines ranged from 24.3 – 26.6 cm. Lines P593, P589 and P590 have significantly longer panicle lengths (26.6, 26.5 and 26.0 cm respectively) as compared to control varieties MR263 (24.1 cm) and MR84 (23.5 cm).

The percentage of filled spikelets/panicle of advanced rice lines ranged from 72.7 – 82.4% (*Table 1*). Line P592 produced significantly higher percentage of filled spikelets/panicle (82.4%) compared to control varieties MR253 and MR263 (69.3 and 71.0% respectively). Line P589 produced significantly higher number of total spikelets/panicle (193 spikelets/panicle) compared to control MR84 (152 spikelets/panicle) but not significantly different compared to controls MR263 and MR253 (175 and 188 spikelets/panicle respectively).

The 1,000 grains weight of rice lines ranged from 25.1 – 30.6 g. Lines P590 and P593 produced significantly heavier thousand grains weight (30.6 and 30.3 g respectively) compared to all control varieties of MR84, MR263 and MR253 (27.2, 27.9 and 28.3 g respectively). Meanwhile, P589 showed significantly lighter 1,000 grains weight (25.1 g) than other rice lines as well as the control varieties.

The panicle traits (number of panicles per plant, panicle weight, panicle length and number of grains per panicle) that attribute to yield could affect the rice yield potential as a guide to assess the performance of a particular rice cultivar (Oko et al. 2012). In the tropics, grain yield is closely correlated with solar radiation during ripening. The longer availability of the solar energy which leads to higher grain-filling capacity could increase the grain yield (Tanaka et al. 1966; Fujita et al. 1984).

The yield potential of advanced rice lines ranged from 5,205 – 6,750 kg/ha (*Table 1*). P591 significantly produced higher yield (6,750 kg/ha) compared to control varieties MR263, MR84 and MR253 (5,884, 5,787 and 5,151 kg/ha respectively). P590 also significantly produced higher yield (6,453 kg/ha) compared to MR84 and MR253 (5,787 and 5,151 kg/ha respectively) except for MR263 (5,884 kg/ha). Meanwhile, P593 showed comparable yield (6,322 kg/ha) to control varieties but only significantly different to MR253 (5,151 kg/ha). These three rice lines seem to be promising and could be further evaluated in advanced yield trial stage. The rice breeders are interested to develop a variety with improved yield and other agronomic traits by selecting the desirable traits from early to advance generation until progenies are homozygous. In early stages of selection, yield is difficult to estimate and yield components are more helpful if they are highly heritable, genetically independent and positively correlated (Halil and Necmi 2003).

Increasing rice yield has been associated with plant ideotype such as erect leaves with relatively small leaf dimension, relatively short plant with sturdy culm to reduce lodging, high tillering ability and absence of interplant competition to allow closer planting distance (Othman et al. 1986). IRRI has proposed two approaches to increase yield potential: i) development of rice variety with new plant type (NPT) morphology derived from tropical japonica germplasm and ii) development of indica hybrid for tropical environment as an effective way to break the ceiling yield (Peng et al. 1999). Improvement in plant type design base on NPT has been achieved in China on their super hybrid rice which emphasised more on the traits of the top three leaves and the panicle position within the canopy, focusing on large panicle size, large source-sink relationship, improved photosynthesis and delayed leaf senescence of the top three leaves during the ripening phase (Peng et al. 2004).

The results of correlation analysis as shown by their coefficients of correlation (*Table 2*) showed that yield/hectare was highly significant and positive correlation with 1,000 grains weight (r = 0.445**). Yield also positively correlated with panicle length (r = 0.022) and percent of

Table 1. Mean comparison of yield and yield components of advanced rice lines

Entries	Mat (days)	CH (cm)	NP	PL (cm)	FS (%)	TS	TWG (g)	YLD (kg/ha)
Variety								
P589	117^{ab}	111.8^{a}	19^{ab}	26.5^{a}	77.3^{ab}	193^{a}	25.1^{d}	$5,205^{de}$
P590	119^{ab}	102.9^{bc}	16^{d}	26.0^{a}	72.7^{ab}	186^{ab}	30.6^{a}	$6,453^{ab}$
P591	122^{a}	99.2^{de}	18^{bc}	24.3^{cd}	79.3^{ab}	151^{b}	29.9^{ab}	$6,750^{a}$
P592	120^{ab}	104.2^{bc}	17^{cd}	25.1^{bc}	82.4^{a}	157^{ab}	28.3^{bc}	$5,751^{cd}$
P593	102^{b}	101.4^{cd}	16^{d}	26.6^{a}	75.0^{ab}	175^{ab}	30.3^{a}	$6,322^{abc}$
MR84	122^{a}	105.5^{b}	20^{a}	23.5^{d}	73.4^{ab}	152^{b}	27.2^{c}	$5,787^{cd}$
MR253	114^{ab}	97.1^{e}	18^{bc}	25.7^{ab}	69.3^{b}	188^{ab}	28.3^{bc}	$5,151^{e}$
MR263	117^{ab}	105.0^{b}	17^{cd}	24.1^{cd}	71.0^{b}	175^{ab}	27.9^{c}	$5,884^{bc}$
Season								
OS 2012	117^{a}	106.6^{a}	19^{a}	26.0^{a}	70.6^{b}	172.8^{a}	27.2^{b}	$6,006^{a}$
MS2012/2013	116^{a}	100.2^{b}	17^{b}	24.5^{b}	79.5^{a}	171.0^{a}	29.7^{a}	$5,819^{a}$
Lines x Season	225.2^{ns}	12.1^{ns}	0.2^{ns}	1.5^{ns}	54.2^{ns}	938.3^{ns}	1.5^{ns}	400575.3^{ns}
CV (%)	12.4	2.3	9.0	4.7	10.4	17.2	4.5	7.2

Note: Means same superscripts are not statistically different based on Duncan Multiple Range Test (DMRT) at $p \leq 0.05$

ns = not significant

Mat = Maturation (days), CH = Culm height, NP = Number of panicles/plant, PL = Panicles length, FS = Filled spikelets/panicle, TS = Total spikelets/panicle, TWG = Thousand grains weight, YLD = Yield, OS = Off season and, MS = Main season

Table 2. Phenotypic correlations among the traits

	Mat (days)	CH (cm)	NP	PL (cm)	FS (%)	TS	TWG (g)	YLD (kg/ha)
Mat (days)	1.000	0.163	0.096	–0.12	0.125	–0.361*	–0.149	–0.023
CH (cm)		1.000	0.190	0.319*	–0.193	0.047	–0.555**	–0.022
NP			1.000	0.013	–0.105	0.013	–0.468**	–0.045
PL (cm)				1.000	0.003	0.293*	–0.160	0.022
FS (%)					1.000	–0.186	0.241	0.021
TS						1.000	–0.195	–0.223
TWG (g)							1.000	0.445**
YLD (kg/ha)								1.000

*Significant at $p < 0.05$, **significant at $p < 0.01$

Mat = Maturation (days), CH = Culm height, NP = Number of panicles/plant, PL = Panicle length, FS = Filled spikelets/panicle, TS = Total spikelets/panicle, TWG = 1,000 grains weight and YLD = Yield

filled spikelets per panicle (r = 0.021). Total spikelets per panicle significantly and positively correlated with panicle length (r = 0.293). However, yield showed negative correlation with culm height (r = 0.022). Meanwhile, 1,000 grains weight significantly showed negative correlation with culm height (r = –0.555) and number of panicles/plant (r = –0.468). Other researchers also noted that yield is correlated with effective tillers, number of grains per panicle and grain weight (Ashraf et al. 1999; Ramakrishman et al. 2006; Ali et al. 2007; Mohammed et al. 2007). Meanwhile, Zahid et al. (2005) reported that yield had negative correlation with plant height on 14 genotypes of basmati rice.

Results in *Table 3* showed that P589 significantly produced lowest percentage of white rice (52.5%). There was no significant difference among the rice lines and control varieties on percentage of head rice recovery. The percentage of head rice recovery ranged from 85.8 – 91.7%. The percentage of broken rice among the advanced rice lines ranged from 8.3 – 12.2%. The percentage of broken rice was not significant among the rice lines tested as well as the control varieties. Results of this study showed that most of the advanced rice lines produced >65% milling recovery except for P589 (52.5%). Under controlled environment, the maximum milling recovery is 69 – 70% depending on rice variety. Under controlled conditions, head rice recovery can be as high as 84% of the total milled rice or 58% of the paddy weight. However, commercial millers normally considered 65% milling recovery as reasonably good after considering other factors such as imperfection or unfilled grains during processing (IRRI 2013). Results of this study showed that percentage of head rice recovery was above 85% and meets above reguirement. Based on the Malaysian Standards, all advanced rice lines can be graded as Super grade (<15% broken rice).

Table 3. Evaluation on physical properties of promising MARDI rice lines

Entry	WR (%)	HR (%)	ML (mm)	MLC	MLW (mm)	Grain length to width ratio (mm)	Grain dimension
P589	52.5[c]	87.8[a]	6.38[de]	M	1.83[c]	3.49[a]	S
P590	65.6[ab]	89.8[a]	7.04[a]	L	1.97[b]	3.58[a]	S
P591	73.6[a]	89.4[a]	6.68[bc]	L	2.05[ab]	3.26[b]	S
P592	70.8[ab]	90.0[a]	6.65[bc]	L	2.02[ab]	3.30[b]	S
P593	65.6[b]	90.6[a]	6.89[ab]	L	2.08[a]	3.31[b]	S
MR84	64.9[ab]	85.8[a]	6.20[e]	M	2.09[a]	2.97[c]	M
MR253	65.1[ab]	91.7[a]	6.55[dc]	M	2.01[ab]	3.25[b]	S
MR263	64.7[ab]	87.4[a]	6.68[bc]	L	2.00[ab]	3.34[b]	S
CV (%)	7.6	3.4	2.2	-	2.7	2.6	–

Note: Means with same superscripts are not statistically different based on Duncan Multiple Range Test (DMRT) at $p \leq 0.05$
WR = White rice, HR = Head rice, ML = Milled grain length, MLC = Milled grain length category, MLW = Milled grain width, M = Medium, L = Long and S = Slender

The milled grain length of new rice lines showed that P590 significantly has longer grain (7.04 mm) compared to MR84, MR253 and MR263 (6.20, 6.55 and 6.68 mm respectively). Meanwhile, P589 significantly showed shorter grain (1.83 mm) compared to controls MR84, MR253 and MR263 (2.09, 2.01, and 2.00 mm respectively). According to length, rice can be classified into extra long (>7.5 mm), long (6.6 – 7.5 mm), medium (5.51 – 6.6 mm) and short (<5.5 mm) (IRRI SES 1996) while grain dimension (grain length/width) can be classified as slender (>3.0 mm), medium (2.1 – 3.0 mm), bold (1.1 – 2.0 mm) and round (<1.1 mm). Based on that clasification, all new rice lines have long grain except for P589. However, all new rice lines still can be categorised as slender grain as they have more than 3.0 mm of grain length to width ratio. This criteria is important to meet the local consumer preference. According to Ahmad Hanis et al. (2012), Malaysian consumers preferred a rice variety with long and slender characters compared to short grain. Rosniyana et al. (2006) also reported that long grain fetched better market price compared to medium or shorter grain.

The chemical properties (*Table 4*) showed that P589 and P592 contained 13.3 and 19.5% of amylose and categorised as low amylose, while P590, P591 and P593 contained intermediate amylose (22.2, 24.5 and 24.1% respectively). Meanwhile, the control variety MR84 contained high amylose (30.2%) and both MR253 and MR263 had intermediate amylose (23.6 and 24.1% respectively). Consumers preference based on amylose content varies across countries. The Philippines consumers prefer low amylose, while Malaysian and Indonesian consumers prefer rice with intermediate amylose and Thailand consumers pay a premium for low to intermediate amylose (Unnevehr et al. 1992). Other factors reported to affect amylose content are temperature during grain filling, nitrogen fertilisation and degree of milling (Aslam Sagar et al. 1988).

Results in *Table 4* also showed that P589 had 82.7 mm of gel consistency (GC) elongation and was categorised as soft in a similar category with MR84 (67.3 mm). Gel consistency of P590, P591 and P592 was categorised as medium (43.3, 53.9 and 44.7 mm respectively), while GC for P593 was 32.7 mm (hard). Gel consistency is responsible for softness of cooked rice (Sabouri 2009). Rice with soft GC showed the tendency of cooked rice to be soft upon cooling. Gel consistency also varies from country to country. Based on a report by Unnevehr et al. (1992), gel consistency for rice grain was medium to hard in the Philippines and Indonesia but medium to soft in Bangladesh.

P590, P591 and P593 were categorised as low alkali spreading value (ASV) (scale 7) in a similar category with all control varieties. Both P589 and P592 fell under intermediate ASV category (scale 4 and 5 respectively). The alkali spreading value (ASV) was classified as low to intermediate categories among the advanced rice lines tested. This indicated that the temperature required for normal cooking is <70 °C for rice with low ASV (P590, P591 and P593) while rice lines with intermediate ASV (P589 and P592) required a temperature ranging from 70 – 74 °C.

Results from nursery blast screening (Main season 2012/2013) (*Table 5*) showed that P589, P590, P591 and P593 showed resistance to foliar blast disease, while P592 showed moderate resistance. Panicle blast screening with dominant pathotype 7.0 and virulent pathotype 7.6 showed that P590 was resistant to pathotype 7.0 while rice lines P589, P591, P592 and P593 were moderately resistant to pathotype 7.0. Rice line P592 was resistant to pathotype 7.6 while P590 and P593 were moderately resistant to this pathotype. None of these lines showed resistance against sheath blight and bactrial leaf blight diseases. Screening for pest resistance showed that P589 and P592 were resistant to brown plant hopper while P590, P591 and P593 showed moderate resistance. Meanwhile, P591 was resistant to tungro disease while P589 and P592 were moderately resistant to the disease. P590 and P593 were found to be moderately susceptible to tungro. For future rice breeding programmes, rice lines that showed better resistance especially against blast disease and brown planthopper pest maybe useful in managing pest and disease outbreaks.

Table 4. Evaluation on chemical properties of promising MARDI rice lines

Entries	Amylose (%)	Amylose category	Gel consistency (mm)	Gel consistency group	Alkali spreading value (scale)	Alkali spreading category
P589	13.3	L	82.7	S	4	Int
P590	22.2	Int	43.3	M	7	L
P591	24.5	Int	53.9	M	7	L
P592	19.5	L	44.7	M	5	Int
P593	24.1	Int	32.7	HD	7	L
MR84	30.2	HI	67.3	S	7	L
MR253	23.6	Int	48.0	M	7	L
MR263	24.1	Int	52.0	M	7	L

L = Low, Int = Intermedediate, S = Soft, HI = High, HD = Hard and M = Medium

Table 5. Pest and disease resistance of advanced rice lines

Entries	Foliar blast	Panicle blast		Sheath blight	Bacteria leaf blight	Brown plant hopper	Tungro
		Pathotype 7.0	Pathotype 7.6				
P589	R	MR	MS	S	MS	R	MR
P590	R	R	MR	HS	MS	MR	MS
P591	R	MR	MS	MS	MS	MR	R
P592	MR	MR	R	S	MS	R	MR
P593	R	MR	MR	S	MS	MR	MS
MR253 (control)	R	MR	MS	MS	MS	R	MR
MR263 (control)	R	S	HS	S	MR	R	S
MR211 (control)	S	HS	HS	S	MS	R	–
MR84 (control)	R	R	MR	MS	MS	MR	MS
TNI (control)	–	–	–	–	–	HS	S
R.Heenathi (control)	–	–	–	–	–	R	–
Y1286 (control)	–	–	–	–	–	–	MR

R = Resistant, MR = Moderately resistant, MS = Moderately susceptible, S = Susceptible, HS = Highly susceptible

Conclusion

Rice lines P590, P591 and P593 are shown to be promising due to their better characteristics in terms of yield, morphology, physico-chemical properties and resistance. Results indicated that P591 has more yield output compared to the controls. These new lines could be classified as having early-medium maturation periods and intermediate plant height. They also have long and slender grains, produce good head rice recovery and contain intermediate amylose content. These lines also have better resistance against foliar blast disease and moderately resistant to brown planthopper pest. However, these lines showed moderate to susceptible resistance against sheath blight and bacterial leaf blight disease. Thus, these new rice lines could be further evaluated in Advance Yield Trial.

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Abstrak

Lima titisan padi baru P589, P590, P591, P592 dan P593 termasuk tiga varieti kawalan MR253, MR263 dan MR84 telah dinilai di peringkat percubaan hasil awal. Titisan tersebut telah dinilai keatas hasil, hasil komponen, kimia-fiziko dan kerintangan kepada perosak dan penyakit. Didapati kesemua titisan padi tersebut dalam kategori sebagai matang awal (sekitar 102 – 120 hari) dan panjang batang sekitar 99.2 – 111.8 cm. Panjang tangkai titisan padi yang dinilai ialah sekitar 24.3 – 26.6 cm. Peratus biji bernas/tangkai kesemua titisan padi yang dinilai ialah sekitar 72.7 – 82.4%. P590 and P593 adalah signifikan dan mempunyai biji yang berat berbanding dengan kesemua varieti kawalan. P591 adalah signifikan dan menunjukkan hasil tuaian yang tinggi berbanding dengan kesemua varieti kawalan. Ciri fizikal menunjukkan kesemua titisan padi baru tersebut menghasilkan >85% kepala beras dan mempunyai beras yang panjang dan tirus. Manakala, kandungan kimia pula menunjukkan titisan padi P589 dan P592 mengandungi kandungan amilosa yang rendah sementara titisan P590, P591 dan P593 adalah sederhana. Konsistensi gel bagi titisan padi tersebut boleh dikelaskan kepada lembut (P589), sederhana (P590, P591 dan P592) dan keras (P593). Nilai pecahan alkali adalah rendah bagi P590, P591 dan P593 dan sederhana bagi P589 dan P592. Penilaian terhadap penyakit dan perosak menunjukkan titisan P589, P590, P591 dan P593 adalah rintang dan P592 sederhana rintang kepada penyakit karah daun. Namun, kesemua titisan padi tersebut adalah rentang kepada penyakit hawar daun bakteria dan hawar seludang. Saringan kepada serangga perosak menunjukkan P589 dan P592 adalah rintang, manakala P590, P591 dan P593 sederhana rintang kepada benah perang. Manakala, P591 adalah rintang dan P589, P590, P592 dan P593 sederhana rintang kepada penyakit merah virus. Secara amnya, P590, P591 dan P593 lebih berpotensi untuk diketengahkan kerana hasil tuaian tinggi, ciri beras yang panjang dan tirus serta sederhana kandungan amilosa yang mana ciri-ciri ini memenuhi citarasa pengguna tempatan.