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Rice blast disease in Malaysia: Options for its control

(Penyakit karah di Malaysia: Kaedah untuk pengawalan)

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Abstract

Rice blast disease is one of the major constraints responsible for considerable damage on rice production in Malaysia. Rice varieties resistant to blast disease have been developed since 1960 and it is the most economical control method to be used by farmers. However, evolution of the rice blast pathogen, *Pyricularia oryzae* Carava [teleomorph*: Magnaporthe grisea* (Herbert) Barr] resulted in the emergence of new virulent pathotypes, leading to breakdown of the resistant varieties after several seasons of planting. The use of chemical fungicides to control rice blast disease has long been viewed as the last resort. This article reviews the concept and applications of resistant varieties, chemical fungicides and cultural practices to control rice blast, focusing mainly on rice cultivation in Malaysia. To manage rice blast in an effective and sustainable way, all crop protection practices for future research should consider new approaches such as using silicon fertilizer as it is known to be capable of controlling diseases caused by fungi, breeding lines with resistant rice blast genes and biocontrol agents which are still not widely practiced in local rice cultivation.

Keywords: rice, rice blast, *Pyricularia oryzae*, control

Introduction

Rice is a staple food which plays an important part of food security concern by the government of Malaysia. Self-sufficiency level (SSL) is around 72% of the total requirement of of the Malaysian population. The total planted area in 2018 was 689,810 ha which produced 3,064,822 tonnes of rice grain and generated about 1,975,770 tonnes of white rice (DOA 2018). In addition, the average production in 2018 was 4,443 kg/ ha which was about 19% higher than the rice production in 2017. Even though rice production increased, the increase in the Malaysian population has not made any changes to the Malaysian SSL (Sharif 2013). According to Fatimah et al. (2011), the total consumption of rice increased from 2.5 million metric tonnes in 1985 to 4 million metric tonnes in 2009 because of the increase in the Malaysian population at a growth rate of 1.4%/year (Zainal 2015).

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Chamhuri et al. (2014) described that the national concept of SSL was not only the ability of a particular country to provide enough food in local production but also the ability and affordability to obtain enough nutritious food and sustain it without any obstacles. In addition, the rice industry in Malaysia ensures stability, social, political and economic importance. Moreover, there are 296,000 rice farmers totally dependent on growing rice for their household income (Zainal 2015).

However, one of the challenges in growing rice is pests and diseases which are capable of causing huge economic losses and reduction in the national SSL. In Malaysia, rice fields are infected by rice blast disease, bacterial leaf blight (BLB), brown planthopper (BPH) and tungro disease which could potentially decrease the yield by about 50%, 15%, 30% and 35%, respectively (Saad et al. 2004). According to Habibuddin (2012), blast disease caused by *Pyricularia oryzae* Carava [teleomorph: *Magnaporthe grisea* (Herbert) Barr] is considered as a major rice disease in Malaysia. The incidence of blast disease in Peninsular Malaysia was first observed in 1945. The national average yield loss was estimated at about 20% and plot yield loss was about 70% recorded on the susceptible variety of Jaya.

Types of rice blast disease and crop loss

There are two types of blast diseases commonly found in Malaysia, namely, foliar blast infecting the seedling stage and panicle blast infecting the panicle during the reproductive stage (Habibuddin 2012). This disease is weather driven and the pathogen is highly variable. Blast attack is on above ground parts as well as during all growth stages of the rice plant and it occurs through a special adhesive released from the tip of each spore when the fungal pathogen is attached to the leaves. The fungus has also been reported to infect plant roots (Pooja and Katoch 2014). Symptoms can be either lesions or spots and these symptoms may vary due to environmental conditions and varietal resistances. Leaf blast symptoms can be observed by lesions of white to grey-green with darker borders while older lesions are white grey surrounded by a red-brown margin and are diamond shaped (Hajano et al. 2011). Infection at foliar usually affects tillering of rice plants, hence producing a smaller number of panicles per hill. Meanwhile, symptoms of panicle blast appear at the base of the panicle causing ‘rotten neck’ or ‘neck rot’. Panicle blast affects the grain by either causing the grain to be partially unfilled or causing the breakage of the panicle, resulting in a complete yield loss (Chuwa et al. 2014).

According to Supaad (1983), yield loss was about 30 to 40% on the susceptible varieties of Jaya and Sekencang. In addition, an outbreak of blast incidence in 1999 on the Setanjung rice variety caused losses of about RM66 million for that year (Habibuddin 2012). In 2015, a total of 4,033 ha was recorded to be infected by rice blast. Even though the area was less than 5% of the total planted area, it was estimated to be around 50% to 70% of yield losses caused by panicle blast (Latiffah and Norsuha 2018).

Data surveyed by Rosnani et al. (2015) on granary and non-granary areas showed that the highest percentage of rice plants were infected by rice blast (43%) compared to other diseases. The highest infected area was recorded at Kemubu Agriculture Development Authority (KADA) followed by Muda Agriculture Development Authority (MADA) and IADA Barat Laut Selangor. A total of 1,453 ha of rice fields were reported to be infected by leaf blast and 957 ha infected by panicle blast in 2017, and the most severe infection was recorded at Kodiang, Kedah (Norlida 2017). In addition, MADA recorded about 10,068 ha of rice fields infected by rice blast in 2017. Even though the infected rice fields were only 10% of the total 100,685 ha of the rice planted area in MADA, about 60,000 tonnes of the rice grain production was estimated to be infected. In such a case, the grain price could be cut by about 50% (Suzalina 2017).

Rice blast cycle

Pyricularia oryzae belonging to Ascomycetes has the characteristics of pyriform (oval shape), rounded base and narrowed towards the tip which is pointed or blunt, 2 – 3 septate, 2 – 4 celled and middle cells broader than others rarely 1 – 3 septate (Kulkarni and Peswe 2019; Kariaga et al. 2016). A complete cycle of blast disease starts when the spores infect and produce a symptom appearing as lesions or spots on the rice plant and later the fungi begin sporulation and deploy new spores through the air. In favourable humidity and temperature, *P. oryzae* manages to have many life cycles and produces higher number of spores. One cycle of blast disease can complete within a week and one lesion can generate more spores after twenty days (Sopialena and Palupi 2017). In addition, the pathogen survives under temperate climate as inoculum which is believed to have originated from infected rice seeds while according to Asibi et al. (2019), in the tropics, the pathogen survives as airborne conidia and is present throughout the year. Moreover, the rice blast pathogen can survive on rice residues in the field at least for two cropping seasons (Raveloson et al. 2018). According to Greer and Webster (2001), long periods of leaf wetness, high relative humidity and a temperature of 17 °C to 28 °C is favourable for rice blast development whereas, a relative humidity of ≥ 89%, an optimal temperature of 25°C to 28 °C and a minimum of 4 h of leaf wetness is favourable for *P. oryzae* sporulation. It was also stated that between 92% and 96% relative humidity and temperatures between 25 °C and 28 °C were the optimal conditions for *P. oryzae* conidial germination. However, infection of rice by *P. oryzae* usually occurs when the leaf wetness period is between 7 h and 14 h.

Conidia is transported by wind or water and infects the rice plants after landing on the plant surfaces. In rice growing areas, the spores are distributed by air currents but the maximum distance is still unknown. A number of studies have been carried out on the transmission from infected seeds to the seedling or vice versa under controlled glass house conditions. Studies have also been carried out on rice blast fungus transmission from artificially infested seeds to seedlings in the greenhouse (Manandhar et al. 1998). Seeds, crop residues and secondary hosts have been reported as possible sources of *P. oryzae* inoculum. Long et al. (2001) reported that *P. oryzae* can spread systemically within a seedling from an infested seed. They explained that *P. oryzae* may sporulate on the infested seeds on the soil surface under field conditions and the spread of conidia could occur through wind, rain or physical contact with healthy seedlings.

Managing rice blast

There are several blast disease managements in the rice growing areas, namely, adaptation of resistant varieties, chemical controls and cultural practices. The use of resistant varieties is favourable to the farmers to control panicle blast. However, even though resistant variety is the most economical method to control blast, fungicides are still needed for immediate control, particularly in disease prone areas in dealing with epidemic situations (Saad and Supaad 1982).

Breeding rice for resistance

Development of Malaysian rice varieties was started since 1965 and the first few varieties were developed by the Department of Agriculture (DOA), Malaysia. These were done through selection of genotypes in farmers' fields and sent to India under the 'International Rice Commission' programme for crossing and breeding for F1 generation (Habibuddin 2012). Then, the evaluation of F2 to F7 generations was completely conducted in Malaysia. These were followed by the release of Malinja, Mahsuri and

Bahagia varieties. At that time screening was basically based on individual performances by natural infection. In 1969, the breeding works on rice were officially taken over by Malaysian Agriculture Research and Development Institute (MARDI). From 1970 to 1975, the popular varieties were Mahsuri, Malinja, Bahagia and Setanjung because of the increase of yield from 1.26 t/ha in 1965 to 2.66 t/ha in 1975 (Zainal Abidin 2015). However, Malinja and Mahsuri were found to be severely infected by panicle blast. Due to that, later screening was based on the ‘International Uniform Blast Nursery’ developed by the International Rice Research Institute (IRRI). This screening required the cultivar to be evaluated at 3rd week after seeds are sown at nursery evaluation.

In 1979, MR 7 (Sekencang) was released and it was one of the earliest varieties resistant to blast. MR 7 had a broad spectrum against *P. oryzae*. After that, all the released varieties such as MR 232, MR 253 and MR 263 had some degree of resistance to rice blast. In 1999, Setanjung was found prone to foliar blast, and the outbreaks caused an economic loss of about RM66 million (Habibuddin 2012).

MARDI emphasised on the high yielding varieties with blast and brown plant hopper (BPH) resistance characteristics by introducing genes resistant to BPH and blast through backcrossing for selected potential local varieties. According to Zainal Abidin (2015), MR 219 released in 2001 (resistant to foliar blast) and MR 220 released in 2003 (resistant to foliar blast) were the promising varieties at that time and these served the farmers for almost 15 to 18 seasons. This was valued at farm gate to be around RM2.0 billion per year (Habibuddin 2012). MR 219 and MR 220 had covered over 90% of the main production areas. However, the high incidence of panicle blast on MR 219 during the main season of 2008/2009 had caused the withdrawal of this variety (Zainal Abidin 2015).

Moderately resistant varieties to panicle blast, MR 253 and MR 263, released by MARDI in 2010, were recommended as alternatives to MR 219 and MR 220 (Sariam et al. 2012). These varieties were comparable with MR 219 and MR 220 in terms of yield. The use of these two alternative varieties helped to diversify plant genetics to prevent disease attack especially by rice blast. MR 232 was another alternative variety resistant to rice blast (Badrulhadza et al. 2013). However, Allicia and Kogeethavani (2015) found that MR 253 and MR 263 were moderately susceptible to panicle blast by screening. In 2016, MARDI released a new rice variety called MARDI Siraj 297 which was resistant to foliar and panicle blast. *Figure 1* shows the history of rice breeding for blast disease resistance in Malaysia.

Chemical control

Different fungicides have been evaluated for controlling blast disease under field conditions. Maisarah et al. (2014) recommended systemic chemical fungicides based on active ingredients of tricyclazole, isoprothiolane or azoxystrobin for Malaysian rice fields. Chemical fungicides should be sprayed as the lesions appeared on rice leaves followed by a second and third day spraying to control leaf blast. Meanwhile, chemical fungicides were sprayed before 25% panicle initiation stage to control panicle blast. In addition, for severe incidences, second spraying at three to seven days interval is needed using different active ingredients. This method was used if symptoms of dark grey-black lesions at panicle nodes or whiteheads occurred. According to Saad and Supaad (1982), tricyclazole was introduced into Malaysia as a new chemical used to control blast disease despite some other chemicals such as isoprothiolane and edifenpos which were widely known by farmers to control blast. However, tricyclazole was found to be more effective in controlling blast.

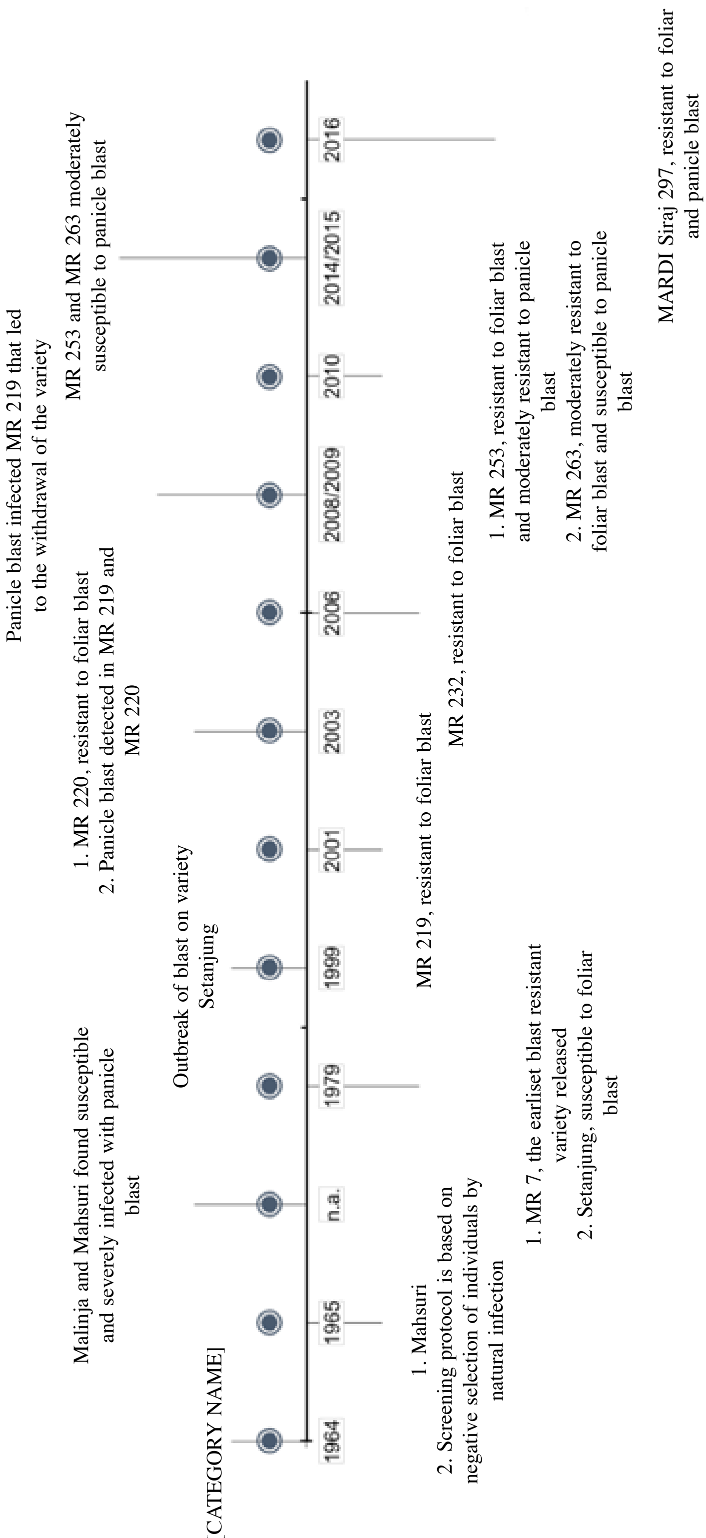

Figure 1. History of rice breeding for blast disease resistance in Malaysia

Rice blast can be prevented as early as possible at seed preparation and at young seedling stages. According to Yashoda et al. (2000), seeds treated with carbendazim (2 g/kg) and three sprayings of tricyclazole 0.06% (0.6 g/L each) at tillering stage, spraying 15 – 20 days after first application and thirdly at panicle initiation effectively controlled leaf blast disease. Meanwhile, Magar et al. (2015) reported that spraying tricyclazole (22%) mixed with hexaconazole [3% SC (0.2%)] thrice at weekly intervals starting at booting stage effectively controlled leaf blast. These combinations could reduce leaf blast by 87.08% and consequently the yield increased by 56.09% compared to the control. On the other hand, Ghazanfar et al. (2009) reported that the use of tetrachlorophthalide (3 g/L H_2O) significantly reduced leaf blast. Andi and Nur Amin (2013) reported that flusilazol (0.6 ml/L H_2O) was effective in controlling leaf blast up to 56 days after transplanting. Regardless of the chemical fungicides used in controlling rice blast, the timing of the application is crucial. According to Groth (2006), applications of azoxystrobin at a single application (0.11 kg a.i./ha) at heading stage can control blast and consequently improve rice grain. Meanwhile, applications at booting (0.11 kg a.i./ha) and heading stages (0.11 kg a.i./ha) were more effective. In addition, any delay in fungicide treatment would increase inoculum into the field and result in late-season infection. This is because plant tissues are most susceptible to blast infection at or just after head emergence. Therefore, application of fungicides after heading stage allowed more disease development and could possibly result in low grain yield because the rice plant will not be able to transport nutrients to the filling grain.

Generally, tricyclazole is the most common chemical reported worldwide to control rice blast. However, over dependence on only one method of control may not provide an effective way to suppress disease build in the field (Habibuddin 2012). Therefore, fungicides should be used alternately to suppress the disease and to prevent or at least slow down the pathogen from developing resistance against those fungicides. The benefit of fungicide application is to reduce disease development and reduce inoculum production in the rice field. *Table 1* shows the recommended chemicals for controlling blast disease in different countries.

Cultural practices

Use of certified seeds is crucial in rice cultivation. According to Wan Jusoh (2006), the use of certified seeds gives the promise of good quality seeds and could tackle the grassy weeds. Rosnani et al. (2018) reported that the use of uncertified MR CL2 seeds (Clearfiled® variety) may lead to several problems such as weedy rice recurs and increase of pest and diseases which meant lower yield and lower income. Manandhar et al. (1998) reported that seeds collected from plants infected by blast had a significantly higher infection than seeds from healthy plants. Guerber and TeBeest (2006) found that, blast disease cycle can be initiated from planting using naturally infected seeds. This indicated that the inoculum could be transferred either through the air or by systematic spread from plants infected by blast. Moreover, transmission through seeds is the best survival method by any pathogen as they can remain viable longer in seeds than in plant parts or in the soil. This is because rice seeds, especially the embryonal part, have a protein content that can be utilised by the pathogen as food. Therefore, using uncertified seeds by the farmers is risking the potential of spreading blast disease in rice growing areas. Once the area is infected by blast, the pathogen will remain in the soil or in host plants.

Weeds commonly found on bunds and channels should be eradicated to control blast disease (Maisarah et al. 2014). Rice plants are not the only host for *P. oryzae* pathogens to survive in the field. According to Lanoiselet and Cother (2005), *P. oryzae*

Table 1. Chemicals used in several countries to control blast disease

Chemical	Target	Country	Source
Tricylazole 0.05%	leaf blast & panicle blast	Malaysia	Saad and Supaad (1982)
Carbendazim + Tricylazole (0.06%)	leaf blast & neck blast	India	Yashoda et al. (2000)
Tetrachlorophthalide Tebuconazole + Trifloxystobin Difenoconazole 25%	leaf blast & neck blast	Pakistan	Ghazanfar et al. (2009)
Tricylazole 0.06% Kitazine 0.1% Ediphenphos 0.1%	leaf blast	India	Ganesh et al. (2012)
Flusilazol Difenoconazole Difenokonazole + Propikonazole (64%) Carbendazim (6.2%) + Mancozeb (73.8%)	leaf blast & neck blast	Indonesia	Andi and Nur Amin (2013)
Tricyclazole 28% + Hexaconazole 3%	leaf blast & neck blast	Nepal	Magar et al. (2015)
Pyraclostrobin 100 g/l CS	leaf blast	India	Pramesh et al. (2016)

can survive on several weed species found in the fields and one of the common weeds is *Echinochloa crus-galli*. A study by Hakim et al. (2010) found that *E. crus-galli* (L) was one of the most abundant weed species in rice growing areas. In the Muda rice granary area, *E. crus-galli* was one of the dominant weeds based on percentage of area infested (Azmi and Baki 2007). Therefore, weed control could possibly reduce the potential host for *P. oryzae*.

Majority of rice farmers in Malaysia practice direct seeding to reduce the labour cost and the rice fields need to be drained off during the first 10 days of rice cultivation (Yahaya et al. 2017). According to Greer and Webster (2001), this may provide favourable conditions for *P. oryzae* transmission from seeds to seedlings. Long et al. (2001) reported that *P. oryzae* sporulation can be detected for almost two to three weeks after the infested grain touched onto the soil surface. This is because shallow water favours the disease more than deep water and low water supplies increases the spore mobility in the rice fields while continuous flooding could limit the blast development. This indicated that naturally infested seeds lying on the soil surface could be potential source for inoculum transmission from seeds to the emerging seedlings. Therefore, field preparation for any rice growing area previously infected by rice blast should be done accordingly to avoid rice blast incidence, such as a good soil preparation, uniformity in planting and practice of recommended plant-spacing could limit the spore infections.

Nutrient management

Several studies have shown that excessive nitrogen increased the susceptibility of the rice plants to rice blast. Currently, rice farmers are recommended not to apply more than 120 kg/ha of nitrogen. According to Long et al. (2000), a single application of nitrogen significantly increased disease incidence compared to split-N application. The incidence and severity of leaf blast was lower when nitrogen fertilizer was applied as splits. Therefore, for local conditions, nitrogen should be applied in four split-N applications with less than 120 kg/ha.

Gaps in knowledge

Despite the importance of the rice industry in Malaysia and the serious threats to rice cultivation by blast disease, several gaps in knowledge could be addressed by research to control the rice blast disease.

Growing mixed rice varieties could offer better protection against rice blast. Han et al. (2016) reported that the combinations of commercial rice varieties (mixed-planting) significantly reduced the occurrence of rice blast disease compared to monoculture (single variety). The average of rice blast incidence was less than 10% in mixed-planting compared to single planting which was about 20% for two years under field planting conditions. According to Gallet et al. (2014), the use of different rice varieties through the combination of several rice varieties creates a different pool of genes in the rice fields. Thus, any mixture between two varieties creates an unstable adaptive for the rice blast pathogen in the rice fields. Therefore, variety mixtures, especially the use of any resistance varieties, could control the rice blast. In addition, this could benefit the rice plants as it could hinder or at least delay the blast pathogen before the rice plants breakdown after planting for several seasons. This is because the fungal pathogen is able to develop resistance to the genetics of the rice varieties and also resistance to chemical fungicides. This is well described by Daniel (2000) who explained that the resistant variety breakdown is related to genotype by environment (GxE) interactions and more specifically, signal transduction pathway by environment (STPxE) interactions. A particular blast pathogen with the ability to evade the initiation of signal transduction pathway by a rice plant and the rice plant genotype in addition to G/STPxE interaction has successfully infected the rice plant. The pathogen is capable of overcoming G/STPxE over time as the blast pathogen can adapt to create new pathotypes. One way to reduce natural adaption of new blast pathotypes is by introducing new genotypes of rice plants or mixture of different varieties. The advantage of using a resistant rice variety or a mixture of rice varieties is to reduce the number of potential hosts (rice plant) for a particular blast pathotype to infect the rice plant. Hence, each blast pathotype can only infect rice plants of a particular resistance and susceptibility. In addition, it helps to reduce the use of chemicals and prevents long-term negative impact on people. This is because agricultural products contain high chemical residues, adversely affect the environment and increase the level of tolerance of pathogens to chemicals (Allicia and Koogeethavani 2015).

Silicon fertilizers (Si) are capable of controlling diseases caused by both fungi and bacteria in different plant species. Silicon fertilizers increased rice resistance to leaf and neck blast, sheath blight, brown spot, leaf scald and stem rot (Datnoff et al. 1997). In rice plants, more than 90% of total Si in the shoot is present in the form of silica gel (Ma et al. 2001). Silicon is deposited as a 2.5 μm layer below the thin cuticle layer, forming a cuticle-Si double layer in leaf blades of rice (Yoshida 1981). These depositions of Si protect plants from multiple abiotic and biotic stresses. The physical barrier was the first mechanism proposed to explain how silicon increased rice resistance to blast caused by *P. oryzae*. The great number of silicified bulliform cells in the epidermis of rice leaves is believed to act as a physical barrier that efficiently impeded or slowed penetration by *P. oryzae* (Rodrigues et al. 2015). Silicon is deposited beneath the cuticle to form a cuticle-Si double layer. This layer can mechanically hinder penetration by fungi and, thereby, interrupt the infection process (Ma and Yamaji 2006). In addition, this cuticle-silicon double layer was linked with a decrease in the number of blast lesions seen on the leaf blades and with a decrease in the number of infection pegs created by the appressoria that pierced the underlying cell wall, allowing fungal access into the epidermal cell. Ma and Takashi (2002) estimated that rice straws applied to the field as compost was equivalent to an addition between 300 and 1,000 kg/ha/year SiO_2 and, consequently, helped to maintain silicon from depletion in paddy soil. Farnaz et al. (2012) reported that granular silica gel (95% SiO2) or liquid sodium silicate (12% SiO2) tested on MR 219 showed significantly lower disease severity and incidence compared to non-treated plants regardless of silicon type used. However, granular silica gel was found to be more effective in controlling leaf blast compared to liquid Si. Silicon content in the rice leaves and for shoot and root dry weights were much higher with the application of granular than liquid form of silica.

In Malaysia, rice blast disease can be controlled by introducing resistance genes into local rice varieties using conventional and molecular breeding programmes. According to Ariya-anadech et al. (2018), the presence of the rice blast resistance gene, *Pik*, has been shown to have a broad-spectrum resistance against rice blast populations and this gene has been famously used as a resistant donor to incorporate the *Pik* resistance into desired rice varieties. However, some of the blast resistance genes are only resistant to specific pathotypes and due to high blast disease pathogenic variability, the rice varieties tend to breakdown (Tanweer et al. 2015). Moreover, most of the blast genes identified provide resistant to leaf blast disease. Therefore, rice breeders need to find the various gene sources to strengthen the genetic diversity in the Malaysian rice gene pool.

An alternative approach to sustainably manage rice blast disease should include the use of biocontrols. Chou et al. (2019) reported that *Trichoderma harzianum* reduced neck blast and leaf blast incidences in susceptible varieties although not consistent because of environmental factors such as high humidity, high nitrogen concentration in the soil, short sunshine hours and cold weather. Besides that, more virulent rice blast pathotypes may hinder the effectiveness of *Trichoderma*. Afroz et al. (2018) reported that *Bacillus* spp. could lower the disease severity of up to 40% and is statistically at par with rice plants treated with fungicide and the strains showed consistency in reducing rice blast incidences for at least two consecutive years under field conditions. The rice plants treated with *Bacillus* spp. increased activity of antioxidant enzymes such as superoxide dismutase, peroxidase, polyphenol oxidase and phenylalanine ammonia-lyase which are known to be associated with induced resistance against inoculation of *P. oryzae*. Shan et al. (2013) reported that *Bacillus methylotrophicus* BC79 strain could be a potential biocontrol of rice blast. The strain caused morphological changes in *P. oryzae* by enlarging hypae, abnormal shape, vessicle distortion or empty devoid of cytoplasm in the mycelium. Thus, the mycelium growth limited and even caused cell death. Kunyosying et al. (2018) reported that certain yeast strains (CMY045 and CMY018) significantly reduced rice blast disease and could be potential biocontrol agents against *P. oryzae*. These yeast strains showed lowest disease incidences of about 18% under field conditions compared to the control (30%) at 55 days after treatment. This could be due to the modes of action by the microbial antagonists utilizing nutrients more rapidly than pathogens, thus, inhibiting spore germination of the pathogens in the field.

Conclusion

Rice blast is an economically important disease in Malaysia. There are many management methods recommended in the rice fields to control rice blast disease. Planting resistant varieties and using chemical controls can be effective for management of the rice blast disease while cultural practices such as mixed varieties planting and nutrient management must be integrated to encourage a sustainable rice cultivation. However, rice blast disease has become more difficult to control because the pathogens have the ability to adapt and later emerge into new and more virulent pathotypes. Thus, management and control of rice blast becomes more challenging. Some actions should always remain the main priorities such as development of new resistant varieties using either the conventional or molecular methods. Looking for resistant genes may require lots of human resource, funding and ample time. Due to the possibility of resistance varieties breakdown by new virulent pathotypes, new plant breeding methods must consider combining different race-specific resistance genes in a single genotype to make rice plants more durable. One of the main issues of biocontrol agents is that they appear to work in lab scale experiments but might not be effective in controlling rice blast disease under field conditions as they are affected by organic matter, pH, nutrient levels and soil properties which vary at different locations. Thus, environmental conditions should be taken into consideration when selecting the biocontrols. Little effort has been given to the idea of using silicon fertilizers as a tool in Integrated Disease Management even though this element has been demonstrated to control several important plant diseases as effectively as chemical fungicides. There is limited information on the impact of silicon on growth of local rice varieties in Malaysia, particularly to control rice blast disease. More scientific evidence to support the beneficial use of silica as a fertilizer in rice cultivation is necessary to determine how blast disease can be reduced or controlled and later could be integrated in rice cultivation in Malaysia.

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Abstrak
Penyakit karah padi adalah salah satu kekangan utama yang bertanggungjawab terhadap kerosakan pengeluaran padi di Malaysia. Varieti padi tahan penyakit karah telah dibangunkan sejak tahun 1960 merupakan kaedah kawalan yang paling ekonomi untuk digunakan oleh petani. Walau bagaimanapun, evolusi patogen karah padi, *Pyricularia oryzae* Carava (teleomorph: *Magnaporthe grisea* (Herbert). Barr) menyebabkan kemunculan pathotip baru lebih berbahaya yang membawa kepada kerentanan varieti padi selepas beberapa musim menanam. Penggunaan racun kulat kimia untuk mengawal penyakit karah padi telah lama dilihat sebagai usaha terakhir. Artikel ini mengulas konsep dan penggunaan varieti rintang penyakit karah, racun kulat dan kaedah amalan kultur untuk mengawal penyakit karah padi, yang memberi tumpuan terutamanya kepada penanaman padi di Malaysia. Untuk memastikan pengurusan penyakit karah padi berkesan dan mampan, semua amalan perlindungan tanaman pada masa hadapan dan kajian penyelidikan perlu mempertimbangkan pendekatan baharu seperti penggunaan baja silicon kerana ia diketahui mampu mengawal penyakit yang disebabkan oleh kulat. Pembaikbakaan baka pokok padi dengan mempunyai gen rintang karah padi dan penggunaan agen kawalan biologi masih tidak diamalkan dalam penanaman padi tempatan.