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Comprehensive Review of Major Rice Diseases: Causal Agents, Symptomatology, and Integrated Management Strategies

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Abstract

Rice (*Oryza sativa* L.) is the staple food for more than 3.5 billion people worldwide, with annual global production exceeding 800 million tonnes. However, diseases remain a major constraint, causing average yield losses of 10–30%, and in severe outbreaks, such as rice blast epidemics in Asia, up to 50% loss has been recorded. Bacterial blight alone can result in 20–30% yield reductions, while sheath blight accounts for 15–25% under conducive conditions. This review provides a comprehensive overview of major rice diseases, focusing on their causal organisms, diagnostic symptoms, and modes of transmission. Recent advances in management are highlighted, including the deployment of over 100 resistant varieties, identification of more than 80 resistance genes and QTLs through molecular breeding, and transgenic approaches that have reduced disease severity by up to 40–60% in field evaluations. Cultural controls, such as crop rotation and optimized planting density, continue to play an essential role in integrated disease management. By compiling updated quantitative insights into disease impacts and control methods, this review aims to support researchers and farmers in early detection and effective management, thereby contributing to sustainable rice production.

Keywords: Rice diseases; Causal organisms; Diagnostic symptoms; Modes of transmission; Yield losses

Introduction

Rice (*Oryza sativa* L.) serves as a primary food source for more than half of the global population. However, its cultivation is continuously threatened by a range of biotic stresses, particularly diseases caused by viruses, fungi, and bacteria. These pathogens can lead to reduced yields, poor grain quality, and significant economic losses, particularly in regions where rice is the main agricultural commodity. On average, rice diseases are responsible for 15–20% yield loss annually, depending on the severity and geographical distribution of the outbreaks. For instance, in 2019, global rice yield losses due to major diseases were estimated at over 20 million tonnes, significantly impacting food security in Asia and Sub-Saharan Africa. Among these, rice blast, bacterial leaf blight, and tungro are among the top contributors to production decline. In severe outbreak years, localized yield losses can exceed 50%, particularly when resistant varieties break down or when favourable conditions for disease spread coincide with sensitive growth stages of the crop. The graphical representation related to yield loss is shown in Figure 1.

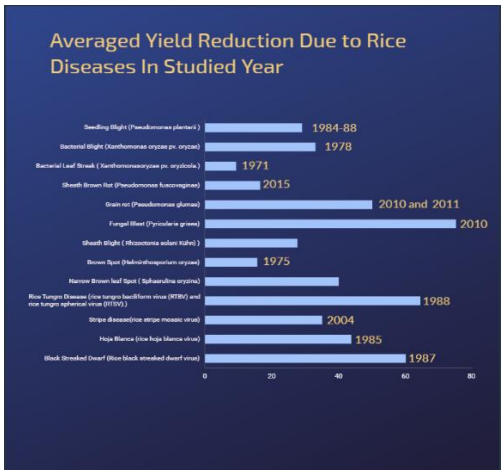
Viral diseases such as Rice Tungro Disease (RTD), Rice Grassy Stunt Virus (RGSV), Rice Stripe Virus (RSV), Rice Dwarf Virus (RDV), Rice Hoja Blanca Virus (RHBV), and Rice Black-Streaked Dwarf Virus (RBSDV) are transmitted by insect vectors like green leafhoppers and brown planthoppers. They cause symptoms such as plant stunting, yellowing, and sterility. Managing these diseases is

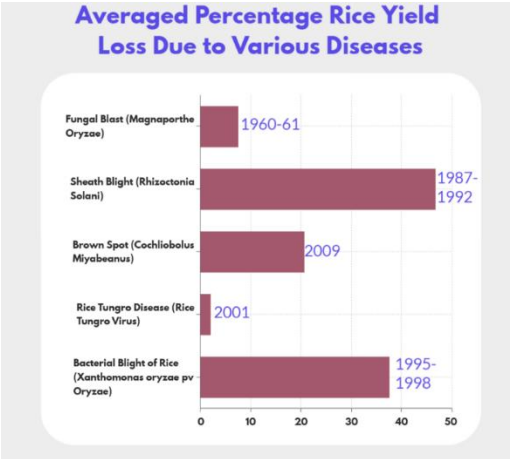
complicated due to the high mutation rates of viruses and the emergence of resistance-breaking strains.

Fungal diseases such as Rice Blast (*Magnaporthe oryzae*), Sheath Blight (*Rhizoctonia solani*), Brown Spot (*Bipolaris oryzae*), and Narrow Leaf Spot pose another serious threat, especially under favorable environmental conditions. These pathogens have high genetic variability, which often leads to the failure of host resistance, thus demanding constant genetic improvement and integrated management.

Bacterial diseases of rice are relatively less diverse and less damaging compared to viral and fungal infections. Furthermore, their impact has been mitigated effectively through breeding, agronomic practices, and chemical controls. Current management strategies have been largely successful, and most bacterial diseases do not pose as severe or persistent a threat under field conditions. "Unlike viral and fungal pathogens, bacterial diseases in rice are comparatively well-managed, and their impact on yield and quality is generally less severe due to the availability of effective management options and resistant cultivars." The detailed description of the diseases that affect rice is tabulated in Table 1.

Modern plant breeding approaches—including Marker-Assisted Selection (MAS), transgenic technology, and CRISPR-based gene editing—have been successfully used to develop rice varieties with enhanced resistance to all three categories of pathogens. This review presents a comprehensive overview of major rice diseases caused by viruses, fungi, and bacteria, and explores their symptomatology, transmission, and management, with a special focus on genetic resistance and biotechnological interventions.





a b

Fig. 1a. Yield reduction and **1b**. Loss percentage in rice across the study years

Viral Diseases

RTD

Rice tungro causes plant stunting, yellow to orangish leaves, panicle sterility, irregular specks, brown-colored leaves, and a reduced number of tillers (Bunawan et al., 2014). Rice tungro viruses (RTVs) are transmitted by the green leafhopper. Management of RTV can be achieved by planting varieties resistant to the green leafhopper (Azzam et al., 2002). Transgenic plants were developed in 1999 using a replicase-mediated resistance strategy to confer moderate to near-complete resistance against RTSV (Huet et al., 1999). Hybridization between IR64 and *O. rufipogon* led to the creation of the Matatag 9 rice cultivar, which displays reduced infection incidence against both RTSV and RTBV (Shibata et al., 2007).

Rice Grassy Stunt Disease

This viral disease, transmitted by the brown planthopper, causes rice plants to develop a mosaic of yellow and green shades along the leaf veins, and newly emerging leaves curl downward (Shiba et al., 2018). Management practices include planting brown planthopper-resistant cultivars and removing infected stubbles from the field (Rombach et al., 1994). Destruction of susceptible varieties and the adoption of resistant ones, such as IR28 (released by IRRI), which are resistant to the RGSV-1 strain, are effective. Research is ongoing to combat the resistance-breaking strain RGSV-2, with two accessions showing promising results (Cabunagan et al., 1998).

Rice Stripe Disease

Rice stripe disease is an economically important viral disease in Southeast Asian countries (Xu et al., 2021). Transplanting and seeding dates are key factors influencing the incidence and severity of the disease (Bae and Kim, 1994). Genetic engineering using the *cp* gene has successfully conferred resistance to RSV in rice (Hayakawa et al., 1992). Additionally, crossing susceptible *japonica* rice varieties with *indica* varieties carrying QTLs responsible for RSV resistance has resulted in resistant cultivars (Cho et al., 2013).

Table 1. Summary of key Rice Diseases, Causal Agents, Symptoms and Management

Disease	Organism	About	Firstly appeared	Symptoms	Management
Seedling blight	*Pseudomonas plantarii*	Gram-negative, non-spore-forming, non-encapsulated rod, 0.7-1.0 x 1.4-1.9 µm, with one to three polar flagella (Azegami et al., 1987a)	Japan	Infected rice seedlings show yellowing (chlorosis) and drying of the second or third leaves. Later, they turn reddish brown and dry out, but do not become soft or rotten. In severe cases, root growth slows down, making the seedlings weak and prone to falling over. A compound called tropolone causes the yellowing of leaves and stunted root growth in these infected plants (Azegami et al., 1987b).	The application of iron compounds suppresses seedling blight (Saha, 2015)
Bacterial Brown Stripe	*Pseudomonas avenae* and *P. syringae pv. panici*	Gram-negative, seedborne, non-spore-forming, non-encapsulated rod. 0.92- 0.92-2.4x0.5-0.7 um, with one or two flagella. (Shakya et al.1985).	Upland and wetland nurseries	At the seedling stage, brown stripes appear between the veins, along the midrib, or at the leaf edges. Other symptoms include sheath bending and abnormal elongation of the mesocotyl (Kadota and Ohuchi, 1983).	Dry heat treatment at 65 °C for 6 days can eliminate the pathogen from seeds (Zeigler and Alvarez, 1988). In nursery boxes, the spraying of Kasugamycin can control the pathogen
Foliar diseases					
Bacterial blight	*Xanthomonas oryzae* pv. *oryzae*	Gram-negative, non-spore-forming rod. 0.55 x 3.5-2.17µm and mono-trichous flagellate. It is aerobic and grows best at a temperature of 25- 300 °C and pH 6.5-7.5 (Ou, 1985)	Japan	From the tillering stage onward, infected plants may show wilt (Kresek) and pale yellow or yellow leaves. Brownish-yellow stripes on the leaves increase in size, turning yellow and then white, and may merge to cover the entire leaf blade. In young lesions, small drops of bacterial exudate may be visible (Saha et al., 2015).	Use of host resistance, modification in cultural Practices, Biological control, Use of natural products or botanical extracts, and Use of conventional and non-conventional chemicals. (SAHA et al., 2015)
Bacterial Leaf Streak	*Xanthomonas oryzae* pv. *oryzi cola*	Gram-negative, seed-borne, non-spore forming rod, 1.2x0.3- 0.5 µm with a single polar flagellum (Saha et al., 2015)	Philippines (Fang et al., 1957)	The disease can affect rice at any growth stage. It first appears as small, water-soaked streaks between the veins. These streaks start as dark green, turn translucent, and then expand and merge, becoming light brown. Tiny yellow droplets of bacterial exudate often form on the lesion surface. As the disease progresses, the entire leaf turns brown, then greyish white, and eventually dies (Shekhawat and Srivastava, 1972).	overnight soaking of seeds in 0.025% Streptomycin solution and hot water treatment at 52°C for 30 minutes is effective in eradicating the seed infection. They have also reported that the sprays of Vitavax at 0.15-0.3% are effective in preventing

					infection and lesion development. Sankel, Captain and Fytolan were also effective to some extent. Banerjee et al. (1984)
Halo blight	*Pseudomonas syringae* pv. *oryzae*	Circular, pale green to yellowish brown lesions, 2-10 µm in diameter on leaf blades (Kuwata, 1985)	Japan	The lesions have a dark brown center—either a spot or stripe—and are surrounded by a clear halo. As the disease progresses, the lesions may merge to form large blotches (Kuwata, 1985)	
Sheath Brown Rot	*Pseudomonas fuscovaginae*	Gram-negative, non-spore forming rod, 0.5-0.8x2.0 x 3.5 µm with one to four polar flagella (Tanii et al., 1976)	Asia, Latin America, South America, Central Africa and Madagascar	In seedlings, the disease causes systemic discoloration of the leaf sheath, which may spread to the midrib and leaf veins. In mature plants, symptoms usually appear on the flag leaf sheath between the booting and heading stages. The sheath dries, and the panicle withers. Glumes of panicles emerging from infected sheaths develop water-soaked lesions that later turn light brown. The grains from these panicles may be discolored, deformed, or even empty (Zeigler and Alvarez, 1987, 1990).	Use of clean seed or seed treated with dry heat at 64 °C for 6 days (Saha et al., 2015)
Grain rot	*Pseudomonas glumae*	Gram-negative rod 0.5-0.7x1.5-2.5 µm with one to three polar flagella	Japan, Korea, and Taiwan (Chien et al., 1983)	The disease causes a brown, water-soaked soft rot of the leaf sheaths, often accompanied by wilting or soft rot of the leaves. Affected panicle grains appear shrunken and pale green, later turning dirty yellow to brown and dry (Zeigler and Alvarez, 1990).	The pathogen can be eliminated from small seed samples by dry heat treatment at 65 °C for 6 days. Pre-treating rice seeds with a high concentration (10^{10} cfu/ml) of an avirulent strain of *P. glumae* is also highly effective in reducing disease incidence
Bacterial Palea Browning	*Erwnia herbicola*	Gram-negative, and fermentative, with peritrichous flagella	Japan (Azegami et al., 1983)	Light brown, water-soaked lesions appear on the lemma or palea, later turning dark brown. Discoloration is most commonly seen on the palea. Infected panicles produce more immature and lighter grains at harvest, and the affected grains turn brown after milling (Saha et al., 2015)	No management for the disease is available
Bacterial Foot Rot	*Erwinia chrysanthemi*	Gram-negative rod with four to six peritrichous flagella.	Japan, India, Bangladesh, Korea, and the Philippines (Goto, 1979 a,b)	In infected plants, the leaf sheaths show dark brown decay, and the attached leaves turn yellow and wilt. The infection often starts at the ligules. The nodes, culms, and crown become rotted, and infected tillers can be easily pulled from the crown. Culms and internodes may	No management for the disease is available. (Saha et al., 2015)

				turn black, and roots near infected nodes decay and fall off. Bacterial ooze is sometimes found inside the culms, and affected plants often have a foul odor. In some cases, even without visible sheath browning, young leaves may wilt due to systemic infection of the crown alone (Saha et al., 2015).	
Fungi					
Blast	*Pyricularia oryzae* Sasaki (1922, 1923).	Filamentous ascomycete fungus *Magnaporthe oryzae*	China (Couch et al., 2005; Mew, 2018)	Mature conidia are three-celled, pear-shaped (pyriform), and septate. They have a basal appendage at the point where they attach to the conidiophore, known as the hilum (Howard and Valent, 1996)	The blast nursery method enables rapid evaluation of the resistance of many rice varieties to various pathogen races present in a region (Saha et al., 2015)
Sheath Blight	*Corticium sasakii* Matsumoto or *Rhizoctonia sozani* Kuhn (Ou, 1972)		Asia, Brazil, Surinam, Venezuela, and Madagascar (Ou, 1972)	Seedling-stage inoculation, detached flag-leaf inoculation, leaf-sheath inoculation, and adult-plant inoculation	
Brown Spot	*Cochliobolus miyabeanus* (Padmanabhan, 1973)	The physiological disorder, chronic disease (MK Barnwal, 2013)	Krishna-Godavari delta, India (MK Barnwal, 2013)	The *aikiochi* disorder occurs mainly on peat, or on sandy or muck soils. (Saha et al., 2015)	
Narrow Brown Leaf Spot	*Cercospora oryzae*	The translocation of nutrients that have been divided, because nutrients are prioritized for the panicle formation	Asia, Africa, North America, Central America, and Australia (Saha et al., 2015)	emergence of narrow and elongated patches with a position parallel to the bone leaf (Simanjuntak et al., 2020)	
Virus					
Tungro	*Nephotettix virescens* (Hibino, 1983; Siwi et al., 1987)	The Rice Tungro Bacilliform Virus (RTBV) and the Rice Tungro Spherical Virus (RTSV).	South and South East Asian countries (Andi Nasruddin, 2016)	Infected plants show stunted growth and yellow to orange discoloration of the leaves	Tungro may be detected by the iodine/starch test or by using insect transmission tests to assay plants

Rice Dwarf Disease

This viral disease causes plant stunting and the appearance of tiny white chlorotic spots on rice leaves (Iida et al., 1972). A gene silencing approach targeting quantitative resistance genes has successfully led to the development of transgenic rice plants with strong resistance to RDD (Shimizu et al., 2009). As no R genes against RDV have been reported, QTL-conferred qualitative resistance plays a valuable role in managing this disease (Shoufa et al., 2010; Pan et al., 2009; Kou et al., 2012).

Rice Hoja Blanca

Rice Hoja Blanca causes devastating damage, especially in the western hemisphere. QTLs responsible for resistance against Hoja Blanca have been identified; these act either against the virus or its vector (Romero et al., 2014). RNA-mediated resistance in transgenic *Indica* rice has been successfully demonstrated. Transformation using the RHBV nucleocapsid (N) gene resulted in a range of outcomes, from susceptibility to complete immunity (Lentini et al., 2003).

Rice Black-Streaked Dwarf Virus (RBSDV)

Rice plants infected with RBSDV exhibit stunting, dark leaves, and small enations on the stems and undersides of the leaves (Zhou et al., 2008). The *Indica* rice cultivar 'Tetep' has been identified as resistant to RBSDV and is considered a valuable source of resistance for breeding programs (Zhou et al., 2015). Additionally, genome editing approaches have potential for developing transgenic rice plants resistant to RBSDV (Wang et al., 2021).

Table 2. Summary of other important diseases and their symptoms

Disease	Organism	About	Firstly appeared	Symptoms
Grassy Stunt Disease	*Nilaparvata lugens* in 1964 (Rivera et al., 1966).	Mycoplasma Agati et al. (1941)	Philippines Eishiro Shikata,1980	Stunted and develops excess tillering that produces a bushy appearance
Stripe Disease	*Laodelphax striatellus*	Affect dicotyledonous Arabidopsis thaliana and Nicotiana benthamiana (Annu. Rev.2021)	Japan (Shinkai, 1962).	
Dwarf Disease	*Nephotettix* cincficeps *Recilia dorsalis*	70nm in diameter, the diameter of the long axis is 75nm, and the short axis 66nm	Japan	Yellowish white specks along the veins of unfolded leaves (Fukushi, 1934)
Hoja Blanca	*Sogatodes olyzicola* (Muir) and *Sogarodes cubanus* (Crawf)	8-10nm diameter (Shikata, 1969)	Colombia, as early as 1935 (Galvez, 1969)	One or more white stripes on the leaf blade or whole leaf blade are white or mottled in a typical mosaic pattern
Black streaked dwarf	Small brown plant hopper (Kuribayashi, 1952)	Spherical, Polyhedral, 60nm diameter (Shikata, 1969b)	Japan (Shinkai, 1962)	Gall appears as a waxy, irregularly elongated protuberance extended along major veins of the lower surface of the leaf blade on the outer surface of the leaf sheath

Fungal Diseases

Rice Blast

Conventional breeding efforts by IRRI have produced cultivars carrying multiple genes for disease resistance (Miah et al., 2013). Resistance to rice blast is governed by both major genes and quantitative trait loci (QTLs) (McCouch et al., 1994). MARKER-ASSISTED SELECTION (MAS) is a powerful tool for breeding against rice blast because resistant phenotypes are often controlled by one or a few genes (Young, 1996; Srivastava et al., 2017), such as *Pik* (Zhai et al., 2011), *Pi54* and its alleles (Vasudevan et al., 2015), *Pi36(t)* (Liu et al., 2005), *Pik-h* (Zhai et al., 2014), and *Pi50(t)* along with the *Pi2/Pi9* gene family (Zhu et al., 2012). However, MAS has been used to a limited extent due to its high cost. Transgenic approaches have also been explored to develop rice cultivars resistant to blast. Several resistance genes and closely linked molecular markers have been identified (Srivastava et al., 2017).

Rice Sheath Blight (RSB)

No rice cultivars with complete resistance to sheath blight have been identified to date (Li et al., 2019; Shi et al., 2020; Molla et al., 2020), limiting the efficacy of conventional breeding methods (Li et al., 2021). However, molecular marker approaches have led to the identification of sheath blight resistance-associated genes, including *Rsb1* (Che et al., 2003). Although no single major resistance gene has been confirmed, multiple QTLs associated with RSB resistance have been reported. Research has also focused on genes encoding chitinase and β-1,3-glucanase, which can suppress pathogen growth. Notably, homozygous *OsPGIP1* transgenic lines exhibited significantly enhanced resistance to RSB in field tests (Mao et al., 2014).

Rice Brown Spot Disease (RBSD)

Application of silicon (Si) has been shown to significantly reduce RBSD severity (Silva et al., 2012; Van Bockhaven et al., 2015; Dallagnol et al., 2011) and improve yield (Dallagnol et al., 2014). Red light-induced resistance to RBSD has also been reported (Parada et al., 2015). Several QTLs—*BSq4.1*, *BSq11.1* (Katara et al., 2010), *qBSR2-kc*, *qBSR7-kc*, *qBSR9-kc*, and *qBSR11-kc* (Matsumoto et al., 2017)—have been identified as potential candidates for breeding RBSD-resistant cultivars. Marker-assisted selection has led to the development of the world's first rice variety with practical resistance to RBSD (Matsumoto et al., 2021).

Narrow Leaf Spot (RNLS)

Screening efforts have identified rice lines with resistance to narrow leaf spot (RNLS) (Russell et al., 2013), including cultivars such as Rexoro, Fortuna, Asahi, and Kamrose. While rice cultivars display varying levels of susceptibility, plant resistance alone is considered unreliable due to the continuous emergence of new fungal strains capable of overcoming host resistance. Although RNLS is currently a minor rice disease, IRRI continues to screen breeding lines and eliminate susceptible genotypes from its programs.

References

Azzam O and Chancellor TC (2002) The biology, epidemiology, and management of rice tungro disease in Asia. Plant Dis 86:88–100.

Bae SD and Kim DK (1994) Occurrence of small brown planthopper (*Laodelphax striatellus* Fallen) and incidence of rice virus disease by different seeding date in dry seeded rice. Korean J Appl Entomol 33:173–177.

Bunawan N, Hamidun AR, Dusik L, Noraini SNB and Mat Amin N (2014) Rice tungro disease: From identification to disease control. World Appl Sci J 31(6):1221–1226.

Cabunagan RC, Azzam O and Coloquio E (1998) Potential sources of resistance against RGSV 2 in wild rice germplasm. Int Rice Res Notes 23(3):1–1.

Che K, Zhan Q, Xing Q, Wang Z, Jin D, He D and Wang BL (2003) Tagging and mapping of rice sheath blight resistant gene. Theor Appl Genet 106(2):293–297.

Cho WK, Lian S, Kim SM, Park SH and Kim KH (2013) Current insights into research on *Rice stripe virus*. Plant Pathol J 29(3):223–233. https://doi.org/10.5423/PPJ.RW.10.2012.0158

Dallagnol LJ, Rodrigues FA, da Matta FM, Mielli MVB and Pereira SC (2011) Deficiency in silicon uptake affects cytological, physiological, and biochemical events in the rice–*Bipolaris oryzae* interaction. Phytopathology 101:92–104.

Dallagnol LJ, Rodrigues FA, Mielli MVB and Ma JF (2014) Rice grain resistance to brown spot and yield are increased by silicon. Trop Plant Pathol 39:56–63.

Hayakawa T, Zhu Y, Itoh K, Kimura Y, Izawa T, Shimamoto K and Toriyama S (1992) Genetically engineered rice resistant to *Rice stripe virus*, an insect transmitted virus. Proc Natl Acad Sci USA 89(20):9865–9869.

Huet H, Mahendra S, Wang J, Sivamani E, Ong CA, Chen L, De Kochko A, Beachy RN and Fauquet C (1999) Near immunity to *Rice tungro spherical virus* achieved in rice by a replicase-mediated resistance strategy. Phytopathology 89(11):1022–1027.

Iida TT, Shinkai A and Kimura I (1972) Rice dwarf virus. CMI/AAB Descr Plant Viruses No. 102.

Katara JL, Sonah H, Deshmukh RK, Chaurasia R and Kotasthane AS (2010) Molecular analysis of QTLs associated with resistance to brown spot in rice (*Oryza sativa* L.). Indian J Genet 70(1):17–21.

Kou Y and Wang S (2012) Toward an understanding of the molecular basis of quantitative disease resistance in rice. J Biotechnol 159(4):283–290.

Lentini Z, Lozano I, Tabares E, et al. (2003) Expression and inheritance of hypersensitive resistance to rice hoja blanca virus mediated by the viral nucleocapsid protein gene in transgenic rice. Theor Appl Genet 106:1018–1026.

Li MY, Wang JN, Wang GD, Feng ZM, Ye YH, Jiang W, Zuo T, Zhang YF, Chen XJ, Pan XB, Ma YY, Chen ZX and Zuo SM (2019) Improvement of japonica rice resistance to sheath blight disease by incorporating quantitative resistance genes qSB11HJX and qSB9TQ. J Yangzhou Univ 40:1–7.

Li D, Li S, Wei S and Sun W (2021) Strategies to manage rice sheath blight: Lessons from interactions between rice and *Rhizoctonia solani*. Rice 14(1):1–15.

Liu XQ, Wang L, Chen S, Lin F and Pan QH (2005) Genetic and physical mapping of Pi36(t), a novel rice blast resistance gene located on rice chromosome 8. Mol Genet Genomics 274(4):394–401.

Mao B, Liu X, Hu D and Li D (2014) Co-expression of RCH10 and AGLU1 confers rice resistance to fungal sheath blight *Rhizoctonia solani* and blast *Magnaporthe oryzae* and reveals impact on seed germination. World J Microbiol Biotechnol 30:1229–1238.

Matsumoto K, Ota Y, Seta S, Nakayama Y, Ohno T, Mizobuchi R and Sato H (2017) Identification of QTLs for rice brown spot resistance in backcross inbred lines derived from a cross between Koshihikari and CH45. Breed Sci 67(5):540–543.

Matsumoto K, Ota Y, Yamakawa T, Ohno T, Seta S, Honda Y, Mizobuchi R and Sato H (2021) Breeding and characterization of the world's first practical rice variety with resistance to brown spot (*Bipolaris oryzae*) bred using marker assisted selection. Breed Sci 71:23–30.

McCouch SR, Nelson RJ, Tohme J and Zeigler RS (1994) Mapping of blast resistance genes in rice. In: Zeigler RS, Leong SA and Teng PS (eds) *Rice Blast Disease*. IRRI & CAB International, pp.167–186.

Miah G, Rafii MY, Ismail MR, Puteh AB, Rahim HA, Asfaliza R and Latif MA (2013) Blast resistance in rice: A review of conventional breeding to molecular approaches. Mol Biol Rep 40(3):2369–2388.

Molla KA, Karmakar S, Molla J, Bajaj P, Varshney RK, Datta SK and Datta K (2020) Understanding sheath blight resistance in rice: The road behind and the road ahead. Plant Biotechnol J 18:895–915.

Pan C, Li A, Chen Z, Wu L, Zhang H, Huang N, Chen X and Zhang Y (2009) Detection of QTL for resistance to rice black streaked dwarf viral disease. Acta Agron Sin 35(12):2213–2217.

Parada RY, Monnai W, Ueno M, Kihara J and Arase S (2015) Red light induced resistance to brown spot disease caused by *Bipolaris oryzae* in rice. J Phytopathol 163(2):116–123.

Rombach MC and Gallagher KD (1994) The brown planthopper: Promises, problems and prospects. In: Singh HF (ed) *Biology and Management of Rice Insects*. Wiley Eastern Ltd.

Romero LE, Lozano I, Garavito A, Carabali SJ, Triana M, Villareal N, Reyes L, et al. (2014) Major QTLs control resistance to rice hoja blanca virus and its vector *Tagosodes orizicolus*. G3 Genes Genomes Genet 4(1):133–142.

Russell GE (2013) *Progress in Plant Breeding—1*. Elsevier.

Shi W, Zhao SL, Liu K, Sun YB, Ni ZB, Zhang GY, Tang HS, Zhu JW, Wan BJ, Sun HQ, Dai JY, Sun MF and Yan GH (2020) Comparison of leaf transcriptome in response to *Rhizoctonia solani* infection between resistant and susceptible rice cultivars. BMC Genomics 21:245.

Shiba T, Hirae M, Hayano-Saito Y, Ohto Y, Uematsu H, Sugiyama A and Okuda M (2018) Spread and yield loss mechanisms of rice stripe disease in rice paddies. Field Crops Res 217:211–217.

Shibata Y, Cabunagan RC, Cabauatan PQ and Choi IR (2007) Characterization of *Oryza rufipogon*–derived resistance to tungro disease in rice. Plant Dis 91(11):1386–1391.

Shimizu T, Yoshii M, Wei T, Hirochika H and Omura T (2009) Silencing by RNAi of the gene for Pns12, a viroplasm matrix protein of rice dwarf virus, results in strong resistance of transgenic rice plants to the virus. Plant Biotechnol J 7(1):24–32.

Shoufa Z (2010) Occurrence and damage analysis of a new rice dwarf disease caused by Southern rice black streaked dwarf virus. Plant Prot 36:45–50.

Silva MRJ, Pereira SC, Rodrigues FA, Antônio L Jr, Fontes LF and Oliveira MGA (2012) Silicon and manganese on the activity of enzymes involved in rice resistance against brown spot. Trop Plant Pathol 37:339–345.

Srivastava D, Shamim MD, Kumar M, Mishra A, Pandey P, Kumar D, Yadav P, Siddiqui MH and Singh KN (2017) Current status of conventional and molecular interventions for blast resistance in rice. Rice Sci 24(6):299–311.

Van Bockhaven J, Spíchal L, Novák O, Strnad M, Asano T, Kikuchi S, Höfte M and De Vleesschauwer D (2015) Silicon induces resistance to the brown spot fungus *Cochliobolus miyabeanus* by preventing the pathogen from hijacking the rice ethylene pathway. New Phytol 206(2):761–773.

Vasudevan K, Gruissem W and Bhullar NK (2015) Identification of novel alleles of the rice blast resistance gene *Pi54*. Sci Rep 5:15667.

Wang W, Ma S, Hu P, Ji Y and Sun F (2021) Genome editing of rice eIF4G loci confers partial resistance to rice black streaked dwarf virus. Viruses 13(10):2100.

Xu Y, Fu S, Tao X and Zhou X (2021) Rice stripe virus: Exploring molecular weapons in the arsenal of a negative sense RNA virus. Annu Rev Phytopathol 59:351–372.

Xue B, Pan C, Chen CH, Zuo SM, Zhang YF, Xu WJ, Ma N, Jiang QX, Qin JH and Zhou CH (2009) A new rice cultivar Wulingjing 1 resistant to *Rice stripe virus* developed by marker assisted selection. Acta Agron Sin 35(10):1851–1858.

Young ND (1996) QTL mapping and quantitative disease resistance in plants. Annu Rev Phytopathol 34:479–501.

Zhai C, Lin F, Dong Z, He X, Yuan B, Zeng X and Pan QH (2011) The isolation and characterization of Pik, a rice blast resistance gene which emerged after rice domestication. New Phytol 189(1):321–334.

Zhai C, Zhang Y, Yao N, Lin F, Liu Z, Dong Z, Wang L and Pan Q (2014) Function and interaction of the coupled genes responsible for Pik-h–encoded rice blast resistance. PLoS One 9(6):e98067.

Zhou G, Wen J, Cai D, et al. (2008) Southern rice black streaked dwarf virus: A new proposed *Fijivirus* species in the family *Reoviridae*. Chin Sci Bull 53:3677–3685.

Zhou T, et al. (2015) Genetic analysis and molecular mapping of QTLs for resistance to rice black streaked dwarf disease in rice. Sci Rep 5:10509. https://doi.org/10.1038/srep10509

Zhu X, Chen S, Yang J, Zhou S, Zeng L, Han J, Su J, Wang L and Pan Q (2012) The identification of Pi50(t), a new member of the rice blast resistance Pi2/Pi9 multigene family. Theor Appl Genet 124(7):1295–1304.

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