A Review for Rice Sheath Blight Disease

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ABSTRACT

Rice is an important food grain and is a staple food for majority of the world’s population. However, biotic stresses such as diseases have impeded rice cultivation both in the tropics and subtropics. Of them, Rice sheath blight (ShB), caused by Rhizoctonia solani, leads to severe yield losses in many rice production areas worldwide. Little progress has been made in rice breeding for sheath blight resistance. None of the commercially cultivated rice varieties have sufficient level of field resistance, and the disease is presently being managed by chemical pesticides. Within the strobilurins group, azoxystrobin fungicide is widely used as it works effectively against ShB pathogen infestation. The survival and inoculum potential of the R. solani is directly related with severity and incidence of disease. Wild relatives of cultivated rice are a potential source of novel genes for insect and disease resistance, as well as tolerance to several abiotic stresses and a source of yield and yield enhancing traits.

Keywords: Rice, Rhizoctonia Solani, Sheath Blight, Chemical Pesticides.

I. INTRODUCTION

R. solani can infect seed to fully mature plant, causing moderate to significant yield losses depending on the plant part affected. Visible plant disease symptoms include formation of lesions, plant lodging, and presence of empty grains. Large lesions formed on infected sheaths of lower rice leaves may lead to softness of the stem thereby initiating stem lodging (Wu et al., 2012). Rhizoctonia solani is a common soilborne pathogenic fungus that has worldwide implications on an extensive range of agricultural plants (Anderson, 1982). In rice, it is responsible for causing sheath blight disease, rendering significant declines in crop quality and yield (Su’udi et al., 2013). Wild relatives of cultivated rice are a potential source of novel genes for insect and disease resistance, as well as tolerance to several abiotic stresses and a source of yield and yield enhancing traits (Brar and Singh, 2011; Shakiba and Eizenga, 2014). It has been reported that polygalacturonase inhibiting proteins can inhibit the degradation of the plant cell wall by polygalacturonases from pathogens. Activity assay confirmed the inhibitory activity of OsPGIP1 against the PGase from Rhizoctonia solani. In addition, the location of OsPGIP1 was determined by subcellular localization (Rui et al., 2015). Damage increased substantially in major rice growing regions following introduction of high-yielding semi-dwarf rice cultivars, and the application of excessive nitrogen fertilizers to rice fields. Sheath blight management is difficult due to the low inherent level of resistance among cultivated or wild rice, and broad host range and high genetic diversity of the pathogen (Taheri et al., 2007). Owing to the limitations of conventional breeding and the use of environmentally hazardous chemical pesticides, alternative strategies are being tried globally to enhance protection of crops against invading pathogens (Maruthasalam et al., 2007). Genetic engineering may be proved as a promising alternative strategy for the management of economically important plant disease like rice sheath blight.
II. METHODS AND MATERIAL

A. Mode of Survival of Pathogen

The survival and inoculums potential of the R. solani is directly related with severity and incidence of disease. Sclerotia are the most important source of inoculums (Allison, 1951). Li Shi Dong (2004) reported that 60.9% sclerotia could survive after 265 days of being buried in natural sandy loam under field conditions in Beijing, while colonized rice straw debris (0.5-10 cm long) could not yield the fungus on medium plates after 88 days of being buried under same conditions. Singh and Singh (2008) reported that the infected leaf pieces incubated at 10 and 28°C also showed a steady reduction in fungus survival with an incubation period from an initial 100% to 53.3% and 63.3% respectively after a period of 5 months.

B. Host Range

Kozaka (1965), Tsai (1974) observed that rice fungus infected 20 species which are from 11 families and observed that the sclerotia from diseased tissue of weed hosts produced typical symptoms of sheath blight on paddy plants. Singh and Saksena (1980) found that aerial strain causing banded blight disease in bajra infected 22 plants species of both crop and wild plants belonging to 6 different families. Kannaiyan and Prasad (1980) have listed 30 monocot weed species as host of Thanatephorus cucumeris (Rhizoctonia solani). Goswami . (2010) reported that isolate SYL-13 possessed narrow host range and low avirulent while DIN-8 and GAZ-18 had wide host range and considered as virulent isolate of Rhizoctonia solani.

C. Chemical Control

Within the strobilurins group, azoxystrobin fungicide is widely used as it works effectively against ShB pathogen infestation (Groth and Bond, 2006). The fungicide is a derivative of β-methoxyacrylate and was the first registered fungicide from this class of chemistry (Anonymous, 1996). It is sold as Quadris 2.08 SC (Syngenta, Raleigh, NC). Azoxystrobin is considered one of the best fungicides in the U.S. for sheath blight control (Grichar et al., 2004). The mode of action of azoxystrobin is to inhibit electron transport and kill the fungal pathogen. Use of fungicide rate and composition is based on intensity of disease and the type of cultivars (susceptible/medium susceptible/moderately resistant) used. Benefits from fungicide control include lower disease incidence, likely reduction of inoculum, and improved grain and milling yields (Groth, 2008; Groth, 1996).

D. Biological Control

Secondary metabolites of rice sheath blight pathogen

A series of metabolites from several types of R. solani have been identified. They included fatty acids (i.e., 9-(Z)-octadecenoic acid and 9,12-octadecadienoic acid) (Aliferis and Jabaji, 2010a), steroids (i.e., ergosterol) (Ma et al., 2004; Aliferis and Jabaji, 2010a), phenolics (i.e., m-hydroxyphenylacetic acid, m-methoxyphenylacetic acid, p-hydroxybenzoic acid, methyl p-hydroxybenzoate) (Mandavaetal, 1980; Adachi and Inagaki, 1988), alkaloids (i.e., Nb-acyetyltryptamine) (Pedrasetal, 2005), cyclopeptides (i.e., cyclo (S-Pro-S-Leu), cyclo (S-Pro-S-Ile), cyclo (S-Pro-S-Val)) (Pedra et al., 2005), saccharides (i.e., RS-toxin) (Vidhyasekaran et al., 1997; Sriram et al., 2000), and glycoprotein (Velazhahan and Vidhyasekaran, 2000). Some PGPR are used commercially to enhance plant growth and health. Seed treatment of rice with PGPR resulted in increased root and shoot length of seedlings (Kumar et al., 2009).
E. Role of OsWRKY Transcription Factors in Rice Disease Resistance

WRKY transcription factors in plants regulate diverse biological functions including abiotic and biotic stress responses, growth and development, embryogenesis and many other physiological processes. Indica and japonica genotypes of rice were identified to have 111 and 113 WRKY genes respectively in their genomes. Reports on the involvement of some of the WRKY genes in rice disease resistance covering the major diseases like blast and bacterial blight indicate the possibilities of further exploring these genes for the production of disease resistant varieties (John et al., 2015).

F. PR Genes Enhance Resistance Against Sheath Blight

Several groups have reported that the introduction of single PR genes such as PR-3 chitinase (Datta et al., 2000, 2001; Lin et al. 1995), PR-5(thaumatin-like protein) (Datta et al., 1999) provides resistance against rice sheath blight pathogen. The expression of different PR genes in combination such as rice chitinase (CHI11) and tobaccob-1,3-glucanase (gluc) (Sridive et al., 2008), CHI11 and thaumatin-like protein (Kalpana et al., 2006), maize ribosome inactivating gene MOD1 and rice basic chitinase gene RCH10 (Kim et al., 2003a) and barley chitinase, and barley b-1,3-glucanase genes (Jach et al., 1995) that are driven by different constitutive promoters, conferred a higher level of sheath blight resistance than any single PR gene. Moreover, constitutive expression of these genes may provide a metabolic burden and increased energy cost to the plants. Therefore, combined tissue-specific overexpression of PR genes in rice may deliver a novel strategy to control yield losses caused by sheath blight pathogen.

G. OsPGIP1 in rice Sheath Blight Resistance

Cell wall is the first shield for the defense of plant cells against the attack of pathogens (De Lorenzo et al., 2001). During the early stage of pathogen invasion, phytopathogenic fungi produce a series of hydrolytic enzymes to degrade the plant cell wall, such as polygalacturonases (PGases), xylanases and galucanases (Alghisi and Favaron, 1995). In order to resist the invasion of pathogens, the plant also secretes some enzymes such as chitinases and polygalacturonase inhibiting proteins (PGIPs) to prevent the degradation of the plant cell wall by pathogens (Shanmugam, 2005; Vorwerk et al., 2004). PGIP can also maintain the elicitation activity of oligosaccharides for a longer time, prolonging the defense response of the plant (Mishra et al., 2012).

H. Predicting Potential Epidemics of Rice Sheath Blight Using a Rice Disease Epidemiology Model, EPIRICE

EPIRICE is a generic epidemiological model that can be parameterized to address any specific rice disease (Savary et al., 2012). It was recently developed as a general model framework for fungal, viral, and bacterial diseases at different levels of hierarchy in a crop canopy (leaves, sheaths, entire plants) depending on the nature of the disease. Thus, its structure was designed to be as simple as possible, involving a few state variables and a limited number of core parameters and weather variables. Savary et al. (2012) developed EPIRICE to evaluate the potential importance of plant diseases in rice and their intensity and distribution at a global scale, at which very limited actual field data on disease epidemics exist across different locations and years.

III. REFERENCES


[29] Mandava NB, Orellana RG, Warthen JD, Worley JF, Dutky SR, Finegold H, Weathington BC.


[38] Singh SB and Saksena HK. 1980. A new sheath and leaf blight of bajra.Indian Phytopath.33:127-129


