Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Juniper Publishers
key to the Researchers

Mini Review
Volume 24 Issue 5 - July 2020
DOI: 10.19080/ARTOAJ.2020.24.556282

Agri Res & Tech: Open Access J

Broad Spectrum Resistance: An Important Guarantee of Grain Yield

Yuchen Liu and Weitao Li*

State Key Laboratory of Crop Gene Exploration and Utilisation in Southwest China, Rice Research Institute, Sichuan Agricultural University, China

Submission: July 23, 2020; **Published:** July 27, 2020

***Corresponding author:** Weitao Li, State Key Laboratory of Crop Gene Exploration and Utilisation in Southwest China, Rice Research Institute, Sichuan Agricultural University, China

Abstract

Crop diseases bring great pressure to food security. Among methods of reducing grain loss caused by pathogens, breeding varieties with broad spectrum resistance (BSR) is commonly known as the most economical and effective approach. Recently, many progresses have been obtained on BSR studies, such as developing BSR genes and revealing their molecular mechanisms. In this review, we summarized the advances, opportunities, and challenges of crop BSR studies. Additionally, we made perspectives of studying crop BSR in the future.

Keywords: Broad spectrum resistance; Innate immune; Crop disease; Food security; Grain yield

Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimates that loss of grain caused by crop diseases amounts to 10% every year. However, the continuous growth of world population will result into food crisis in 2050 [1]. To guarantee food security, breeding broad spectrum resistant (BSR) varieties is the most effective way to defend against fungi, bacteria, and viruses. Therefore, it is necessary to enhance BSR of crop. Developing the *BSR* genes is the basis of breeding BSR varieties.

The plant innate immune system has two layers, pathogen-associated molecular patterns (PAMPs)-triggered immunity (PTI) and effector-triggered immunity (ETI) [2]. Factors in PTI mainly include PAMPs and their receptors, while factors in ETI mainly include effectors and nucleotide-binding domain and leucine-rich repeat receptors (NLRs) [3]. However, lots of factors, such as some transcription factors and non-coding RNAs, are not clearly divided into the two layers [4, 5]. Previous studies often indicated that there is clear border between PTI and ETI, and PTI usually confer durable and broad-spectrum resistance (BSR), whereas ETI confer strong but race specific resistance (RSR). However, recent studies showed that the signaling crosstalk between PTI and ETI is present, and some NLRs in ETI can also trigger BSR [6]. It shows the difficulty and complexity of studying plant immunity, especially BSR, but it also provides us with opportunities to recognize BSR.

The resistance conferred by RSR genes often breaks down within 3-5 years due to the high variability and fast evolving populations of the fungus [7]. It further highlights the importance of developing *BSR* genes. Currently, some BSR genes are developed from crops, such as *Xa21, Pi-d2* and *Ptr* in rice [6, 8], *Yr36, Pm21* and *Fhb7* in wheat [9-11], *Rp1-D, Rxo1*, *ZmFBL41*$^{Chang7\text{-}2}$ in maize [12-14]. Additionally, some susceptibility genes in plant can confer BSR when losing their functions [6, 15]. However, application of BSR genes in breeding crop is inadequate because of an acute shortage of developing BSR genes and elucidating their resistant mechanisms.

Rice blast and bacterial blight of rice are devastating diseases of rice. Li et al. has reported recent advances in BSR to the rice blast disease, which included the identified *BSR* genes and their mechanisms [6]. Among the *BSR* genes conferring resistance to *Xanthomonas oryzae pv. oryzae (Xoo), Xa21* is the first cloned and the most important BSR genes. It encodes a transmembrane receptor-like kinase, which can recognize *RaXX* of *Xoo* to confer BSR resistance [16]. In wheat, four genes including *Lr34/Yr18/Pm38/Sr57, Lr27/Yr30/Sr2, Lr46/Yr29/Pm39/Sr58 and Lr67/Yr46/Pm46/Sr55* confer resistance to wheat rust and powdery mildew [17]. In maize, ZmCCoAOMT2 encoding a caffeoyl-CoA O-methyltransferase confers quantitative resistance to three important foliar maize diseases, such as southern leaf blight, gray leaf spot and northern leaf blight [18]. Among these *BSR* genes, just several genes are applied in breeding crop, such as rice *pi21* [19] and *Pigm* [20], barley *Mlo* [21]. Wheat *Fhb7* and rice *bsr-d1* have also great potential of application in breeding because *Fhb7* and *bsr-d1* confer broad resistance to *Fusarium* and *Magnaporthe oryzae* species, respectively, without yield penalty [4, 11].

Biological technologies have advanced at a breathless pace, which provide great opportunities for researchers to study resistance mechanisms, such as reconstitution and structure of the Resistosome using the cryoelectron microscopy [22], elucidating resistant mechanism of tomato using multi-omic [23], editing genes using TALEN or CRISPR/CAS9 technology [24]. Prospects for the development of plant immunity have improved markedly.

Previous studies have established a framework for the plant BSR system. However, to ensure grain yield and food security, some important studies are still needed to keep going forward.

1. Screening BSR materials that provide new *BSR* genes.
2. Using computational biology to develop the *BSR* genes.
3. Identifying elite *BSR* genes without negative effects for plant growth and development.
4. Developing and promoting new technologies to refine the results.
5. Keeping crop yield and quality while enhancing disease resistance.

Acknowledgement

The project is supported by the Outstanding Young Scientific and Technological Talents Project in Sichuan Province (2019JDJQ0045) and Tianfu Ten-thousand Talents Program (Tianfu science and technology elite project).

References

1. Bailey-serres J, Parker JE, Ainsworth EA et al. (2019) Genetic strategies for improving crop yields. Nature 575: 109-118.
2. Wood EJ (2004) Cellular and molecular immunology (5th ed.): Abbas AK, Lichtman AH. Biochem Mol Biol Edu 32(1): 65-66.
3. Jones JD, Dangl JL (2006) The plant immune system. Nature 444: 323-329.
4. Li W, Zhu Z, Chern M et al. (2017) A natural allele of a transcription factor in rice confers broad-spectrum blast resistance. Cell 170(1): 114-126.e15.
5. Yang L, Huang H (2014) Roles of small RNAs in plant disease resistance. J Integr Plant Biol 56(10): 962-970.
6. Li W, Chern M, Yin J et al. (2019) Recent advances in broad-spectrum resistance to the rice blast disease. Curr Opin Plant Biol 50: 114-120.
7. Dean RA, Talbot NJ, Ebbole DJ et al. (2005) The genome sequence of the rice blast fungus Magnaporthe grisea. Nature 434(7036): 980-986.
8. Ke Y, Deng H, Wang S (2017) Advances in understanding broad-spectrum resistance to pathogens in rice. Plant J 90(4): 738-748.
9. Fu D, Uauy C, Distelfeld A et al. (2009) A kinase-START gene confers temperature-dependent resistance to wheat stripe rust. Science 323(5919): 1357-1360.
10. He H, Zhu S, Zhao R et al. (2018) Pm21, encoding a typical CC-NBS-LRR protein, confers broad-spectrum resistance to wheat powdery mildew disease. Mol Plant 11(6): 879-882.
11. Wang H, Sun S, Ge W et al. (2020) Horizontal gene transfer of Fhb7 from fungus underlies Fusarium head blight resistance in wheat. Science 368(6493): eaba5435.
12. Collins N, Drake J, Ayliffe M et al. (1999) Molecular characterization of the maize Rp1-D rust resistance haplotype and its mutants. Plant Cell 11(7): 1365-1376.
13. Zhao B, Lin X, Poland J et al. (2005) A maize resistance gene functions against bacterial streak disease in rice. Proc Natl Acad Sci USA 102(43): 15383-15388.
14. Li N, Lin B, Wang H et al. (2019) Natural variation in ZmFBL41 confers banded leaf and sheath blight resistance in maize. Nat Genet 51(10): 1540-1548.
15. Zaidi SS-E-A, Mukhtar MS, Mansoor S (2018) Genome editing: targeting susceptibility genes for plant disease resistance. Trends Biotechnol 36(9): 898-906.
16. Pruitt RN, Schwessinger B, Joe A et al. (2015) The rice immune receptor XA21 recognizes a tyrosine-sulfated protein from a gram-negative bacterium. Sci Adv 1(6): e1500245.
17. Li W, Song GQ, LI JH et al. (2020) Melecular detection of four pleiotropic disease resistance genes in wheat. J Triticeae Crops 40(4): 395-400.
18. Yang Q, He Y, Kabahuma M et al. (2017) A gene encoding maize caffeoyl-CoA O-methyltransferase confers quantitative resistance to multiple pathogens. Nat Genet 49(9): 1364-1372.
19. Fukuoka S, Saka N, Koga H et al. (2009) Loss of function of a proline-containing protein confers durable disease resistance in rice. Science 325(5943): 998-1001.
20. Deng Y, Zhai K, Xie Z et al. (2017) Epigenetic regulation of antagonistic receptors confers rice blast resistance with yield balance. Science 355(6328): 962-965.
21. Wolter M, Hollricher K, Salamini F et al. (1993) The mlo resistance alleles to powdery mildew infection in barley trigger a developmentally controlled defence mimic phenotype. Mol Gen Genet 239(1-2): 122-128.
22. Wang J, Hu M, Wang J et al. (2019) Reconstitution and structure of a plant NLR resistosome conferring immunity. Science 364(6435): eaav5870.
23. Jeon JE, Kim JG, Fischer CR et al. (2020) A pathogen-responsive gene cluster for highly modified fatty acids in yomato. Cell 180(1): 176-187.e19.
24. Wang Y, Cheng X, Shan Q et al. (2014) Simultaneous editing of three homoeoalleles in hexaploid bread wheat confers heritable resistance to powdery mildew. Nat Biotechnol 32(9): 947-951.

How to cite this article: Yuchen L, Weitao L. Broad Spectrum Resistance: An Important Guarantee of Grain Yield. Agri Res & Tech: Open Access J. 2020; 24(5): 556282. DOI: 10.19080/ARTOAJ.2020.24.556282

 How to cite this article: Yuchen L, Weitao L. Broad Spectrum Resistance: An Important Guarantee of Grain Yield. Agri Res & Tech: Open Access J. 2020; 24(5): 556282. DOI: 10.19080/ARTOAJ.2020.24.556282