Current Trends in Biomedical Engineering & Biosciences
ISSN: 2572-1151

Juniper Publishers
key to the Researchers

Mini Review
Volume 4 Issue 3 - May 2017
DOI: 10.19080/CTBEB.2017.04.555638

Curr Trends Biomedical Eng & Biosci


# Exploring the Role of Wall Associated Receptor like Kinases (Waks) During Plant-Fungal Mutual Interaction

**Nivedita and Malik Z Abdin***

*Department of Biotechnology, Jamia Hamdard, India*

**Submission:** April 04, 2017; **Published:** May 24, 2017

*Corresponding author: Malik Z Abdin, Department of Biotechnology, Jamia Hamdard, New Delhi, India, Tel: +91-9818462060; Email: mzabdin@rediffmail.com

**Abstract**

Plants possesses the capability to perceive effector molecules released from microbes which is recognize by receptors which in turn triggers the defense system. Wall-associated receptor-like kinase (WAKs) belong to plant receptor-like protein kinases (RLKs) family which regulate the signaling cascades encompassing plant immune system and development by forming protein complexes with cell wall components and receptors. In this review, we provide the perspective that WAKs might play critical role in signaling event involving endophytic colonization in host plant.

**Keywords:** Wall-associated receptor-like kinase; *Piriformospora indica*; Basal defense

## Mini Review

Plants respond to a large number of external and endogenous stimuli, which are translated into cellular responses that enable their adaptation to changing environmental conditions. Most of the land plants including crop plants are involved in beneficial symbiotic or parasitic interactions with a range of micro-organisms, which has a strong impact on agriculture and forestry. Fungi interact with plants as pathogens or benefactors. The cellular and molecular responses of plants to microbe interaction have been studied extensively [1-3].

Receptor protein kinases (RPKs) are key molecules in animal cell interactions and signal recognition. Many plant receptor-like protein kinases (RLKs) have been identified by both molecular and genetic approaches. In contrast to animals, where most RPKs are tyrosine kinases, plants RLKs are ser–thr kinases. Wall-associated receptor-like kinase (WAKs) are reported to have important roles in cell expansion, heavy-metal stress tolerance and pathogenic bacteria resistance in the plants [4-7]. This is also documented that protein kinases involved in maintaining plant-specific cytoskeleton- cell wall continuum [8], osmotic stress signaling [9], integrating environmental stimuli into a cellular response mediated by $H_2O_2$ to effect stomatal closure [10]. These evidence suggests that these WAK protein kinase might play a role in fungal invasion inside the root cortex by regulating cell wall-cytoskeleton interface, priming defense/immune system of plant thereby conferring resistance against pathogen and abiotic stresses and affecting plant growth and development.

The WAKs family is represented by 26 members in Arabidopsis and 125 members in rice [11]. WAKs can be structurally categorized into three parts:

i. an extracellular N-terminal ligand-binding domain followed by

ii. a hydrophobic transmembrane (TM)-spanning helix, region and

iii. a cytoplasmic kinase region which is sandwiched between transmembrane and kinase domain [12].

The members of this family are known to be involved in disease resistance, hormone signaling, legume-rhizobium symbiosis, pollen development, senescence, abiotic and in wounding stress responses [13,14]. The maintenance of continuity between cell wall-plasma membrane (CW–PM) is a crucial factor that governs plants' response to various stimuli and is crucial for resistance against pathogens [15].

An endophytic fungus Piriformospora indica, of the Sebacinaceae family, colonizes the roots of a wide variety of plant species and promotes their growth, in a manner similar to mycorrhizal fungi. Its hosts include the cereal crops rice, wheat, and barley as well as many Dicotyledoneae, including Arabidopsis [16]. The establishment of a transformation system and the full genome sequence of the fungus [17,18] will likely stimulate great progress towards further functional analysis. The positive effects of fungus have been observed for several plant species implicated a biotrophic interaction between the fungus and its host [19]. The coincidence of host cell death with the fungal proliferation increases upon tissue maturation and accompanied by host cell death. This incidence suggests a new type of mutualistic interaction attributed to *P. indica* [20]. Many studies have been performed to identify genes involved in successful colonization and defense system induced as a result of *P. indica* infestation [21,22]. There were many genes RLKs have been identified such as LysM receptor-like kinases, CERK1, BAK1 etc that participates in chitin recognition and MAMP-triggered immunity (MTI) or other defense responses [21,23,24]. It remains to be investigated the exact role of LysM receptor-like kinases during establishment of the fungal symbiosis. Several mutant analyses of WAK genes provided evidence for their involvement in disease resistance [4,25,26]. This establishes the fact that WAKs are important components of basal defense.

Studies revealed the involvement of WAK/WAKL members in plant functions but the nature of their ligand binding and the mechanism of their intracellular signal transduction is still lacking. However, it have been shown that the extracellular domain of WAK1 binds to cell wall carbohydrate components such as pectins [27,28] and cell wall proteins such as the Gly-rich protein, AtGRP-3 [29].

An extracellular EGF (Epidermal Growth Factor) domain in WAK known to bind small peptides in animals [30] and form homo and heterodimers with receptors [31]. In plant, pattern-recognition receptors (PRR) proteins recognize pathogen derived Pathogen Associated Molecular Patterns (PAMPs) and Damage Associated Molecular Patterns (DAMPs) that produce from the damages caused by pathogen invasion. This perception of pathogen through PRRs induces PAMP triggered immunity (PTI) or basal defense [32]. There is evidence that PRR/DAMP protein complex interact with Arabidopsis Wall-Associated Kinase 1 (AtWAK1) and oligogalacturonides (OGs) [25], a derivatives of pectin which is component of the plant cell-wall [33].

Fungal cell wall are mainly composed of polysaccharides (chitin, glucan) and proteins [34]. It is suspected that the *P. indica* CWE (cell wall extract) might contain an active proteinaceous factor instead of chitin [35]. It is demonstrated that the early transcriptional regulation of the rice OsWAK genes is triggered by chitin and is partially under the control of the chitin receptor CEBiP [36]. In our previous study, a rice WAK gene was found to be highly upregulated in response to *P. indica* invasion [37]. WAKs have been known to regulate various gene involved in disease resistance against fungal pathogen but their possible involvement in plant-fungal mutual interaction is yet to be established. However, it is possible that WAKs genes might play a crucial role in endophytic development in host plant and the resulting induction of basal defense against pathogen in similar or different fashion.

We hope that this insight into the role of WAKs in plant-fungal association will stimulate the important area of research that will provide the ways to develop new strategies for crop protection and sustainable agriculture.

## References


1. Smith SE, Read DJ (1997) Mycorrhizal symbiosis. San Diego: Academic Press.
2. Strack D, Fester T, Hause B, Schliemann W, Walter MH (2003) Arbuscular mycorrhiza: Biological, chemical and molecular aspects. J Chem Ecol 9: 1955-1979.
3. Peskan-Berghofer T, Markert C, Varma A, Oelmuller R (2004) Association of Piriformospora indica with Arabidopsis thaliana roots represents a novel system to study beneficial plant-microbe interactions and involves early plant protein modifications in the endoplasmatic reticulum and at the plasma membrane. Physiol Plant 122: 465-477.
4. He ZH, He DZ, Kohorn BD (1998) Requirement for the induced expression of a cell wall associated receptor kinase for survival during the pathogen response. Plant J 14: 55-63.
5. Lally D, Ingmire P, Tong H-Y, He Z-H (2001) Antisense expression of a cell wall-associated protein kinase, WAK4, inhibits cell elongation and alters morphology. Plant Cell 13: 1317-1332.
6. Verica JA, He Z-H (2002) The cell wall-associated kinase (WAK) and WAKlike kinase gene family. Plant Physiol 129(2): 455-459.
7. Hou X, Tong H, Selby J, DeWitt J, Peng X, He Z-H (2005) Involvement of a Cell Wall-Associated Kinase, WAKL4, in Arabidopsis Mineral Responses. Plant Physiol 139(4): 1704-1716.
8. Baluška, Šamaj J, Wojtaszek P, Volkmann D, Menzel D (2003) Cytoskeleton-Plasma Membrane-Cell Wall Continuum in Plants. Emerging Links Revisited. Plant Physiology 133(2): 482-491.
9. Urao T, Yakubov B, Satoh R, Yamaguchi-Shinozaki K, Seki M, et al. (1999) A transmembrane hybrid-type histidine kinase in Arabidopsis functions as an osmosensor. Plant Cell 11(9): 1743-1754.
10. Desikan R, Cheung MK, Clarke A, Golding S, et al. (2004) Hydrogen peroxide is a common signal for darkness- and ABA-induced stomatal closure in Pisum sativum. Funct Plant Biol 31: 913-920.
11. Kanneganti V and Gupta AK (2008) Wall associated kinases from plants-an overview. Physiol Mol Biol Plants 14(1-2): 109-118.
12. Barre A, Herve C, Lescure B, Rouge P (2002) Lectin receptor kinases in plants. Critical Reviews in Plant Sciences 21: 379-399.
13. Nishiguchi M, Yoshida K, Sumizono T, Tazaki K (2002) A receptor-like protein kinase with a lectin-like domain from lombardy poplar: gene expression in response to wounding and characterization of phosphorylation activity. MGG 267: 506-514.
14. Wan JR, Zhang XC, Neece D, Ramonell KM, Clough S, et al. (2008) A LysM receptor-like kinase plays a critical role in chitin signaling and fungal resistance in Arabidopsis. Plant Cell 20(2): 471-481.
15. Bouwmeester K, de Sain M, Weide R, Gouget A, Klamer S, et al. (2011a) The Lectin Receptor Kinase LecRK-I.9 is a novel phytophthora resistance component and a potential host target for a RXLR effector. PLoS Pathog 7: e1001327.
16. Verma S, Varma A, Rexer KH, Hassel A, Kost G, et al. (1998) Piriformospora indica, gen. et sp. nov., a new root-colonizing fungus. Mycologia 90: 896-903.
17. Zuccaro A, Basiewicz M, Zurawska M, Biedenkopf D, Kogel KH (2009) Karyotype analysis, genome organization and stable genetic transformation of the root colonizing fungus Piriformospora indica. Fungal Genetics and Biology 46(8): 543-550.
18. Zuccaro A, Lahrmann U, Güldener U, Langen G, Pfiffi S, et al. (2011) Endophytic Life Strategies Decoded by Genome and Transcriptome



**How to cite this article:** Nivedita, Malik Z A. Exploring the Role of Wall Associated Receptor like Kinases (Waks) During Plant-Fungal Mutual Interaction. Curr Trends Biomedical Eng & Biosci. 2017; 4(3): 555638. DOI:10.19080/CTBEB.2017.04.555638

Analyses of the Mutualistic Root Symbiont Piriformospora indica. PLoS Pathog 7(10): e1002290.

19. Franken P (2012) The plant strengthening root endophyte Piriformospora indica: potential application and the biology behind. Appl. Microbiol. Biotechnol. 96: 1455e-1464.

20. Deshmukh S, Hückelhoven R, Schäfer P, Imani J, Sharma M, et al. (2006) The root endophytic fungus Piriformospora indica requires host cell death for proliferation during mutualistic symbiosis with barley. Proc Natl Acad Sci USA 103(49):18450-18457.

21. Schäfer P, Pfiffi S, Voll LM, Zajic D, Chandler PM, et al. (2009) Manipulation of plant innate immunity and gibberellin as factor of compatibility in the mutualistic association of barley roots with Piriformospora indica. Plant J 59: 461-474.

22. Wawra S, Fesel P, Widmer H, Timm M, Seibel J, et al. (2016) The fungal-specific b-glucan-binding lectin FGB1 alters cell-wall composition and suppresses glucan-triggered immunity in plants Nature Communications. Nat Commun 7: 13188.

23. Miya A, Albert P, Shinya T, Desaki Y, Ichimura K, et al. (2007) CERK1, a LysM receptor kinase, is essential for chitin elicitor signaling in Arabidopsis. Proc Natl Acad Sci U S A 104: 19613-19618.

24. Wan J, Patel A, Mathieu M, Kim SY, Xu D, et al. (2008) A lectin receptor-like kinase is required for pollen development in Arabidopsis. Plant Mol Biol 67(5): 469-482.

25. Brutus A, Sicilia F, Macone A, Cervone F, De Lorenzo G (2010) A domain swap approach reveals a role of the plant wall-associated kinase 1 (WAK1) as a receptor of oligogalacturonides. Proc Natl Acad Sci U S A 107: 9452-9457.

26. Cayrol B, Delteil A, Gobbato E, Kroj T, Morel J-B (2016) Three wall-associated kinases required for rice basal immunity form protein complexes in the plasma membrane. Plant Signaling & Behavior 11(4): e1149676.

27. Wagner T, Kohorn B (2001) Wall-associated kinases are expressed throughout plant development and are required for cell expansion. Plant Cell 13: 303-318.

28. Decreux A, Messiaen J (2005) Wall-associated kinase WAK1 interacts with cell wall pectins in a calcium-induced conformation. Plant Cell Physiol 46(2): 268-278.

29. Park AR, Cho SK, Yun UJ, Jin MY, Lee SH, et al. (2001) Interaction of the Arabidopsis receptor protein kinase Wak1 with a glycine-rich protein AtGRP-3. J Biol Chem 276(28): 26688-26693.

30. Hynes NE, MacDonald G (2009) ErbB receptors and signaling pathways in cancer. Curr Opin Cell Biol 21: 177-184.

31. Schlessinger J (2002) Ligand-induced, receptor-mediated dimerization and activation of EGF receptor. Cell 110(6): 669-672.

32. Boller T, Felix G (2009) A renaissance of elicitors: perception of microbe-associated molecular patterns and danger signals by pattern-recognition receptors. Annu Rev Plant Biol. 60: 379-406.

33. Shibuya N, Nakane R (1984) Pectic polysaccharides of rice endosperm cell walls. Phytochemistry 23: 1425-1429.

34. Montesano M, Brader G, Palva ET (2003) Pathogen derived elicitors: searching for receptors in plants. Mol Plant Pathol 4: 73-79.

35. Vadassery J, Ranf S, Drzewiecki C, Mithöfer A, Mazars C, et al. (2009) A cell wall extract from the endophytic fungus Piriformospora indica promotes growth of Arabidopsis seedlings and induces intracellular calcium elevation in roots. The Plant Journal 59: 193-206.

36. Delteil A, Gobbato E, Cayrol B, Estevan J, Michel-Romiti C, et al. (2016) Several wall-associated kinases participate positively and negatively in basal defense against rice blast fungus. BMC Plant Biology 16: 17.

37. Nivedita, Verma PK, Upadhyaya KC (2017) Lectin protein kinase is induced in plant roots in response to the endophytic fungus Piriformospora indica. Plant Mol Biol Rep.



**DOI:** 10.19080/CTBEB.2017.04.555638



 **How to cite this article:** Nivedita, Malik Z A. Exploring the Role of Wall Associated Receptor like Kinases (Waks) During Plant-Fungal Mutual Interaction. Curr Trends Biomedical Eng & Biosci. 2017; 4(3): 555638. DOI:10.19080/CTBEB.2017.04.555638